NEPAL ELECTRICITY AUTHORITY

(An Undertaking of Government of Nepal)
Project Management Directorate

NEW BUTWAL & KUSHMA SUBSTATION EXPANSION PROJECT

(A Component of Energy Transmission and Distribution Strengthening Project)

BIDDING DOCUMENT
FOR

Procurement of Plant for

Design, Supply, Installation and Commissioning of transformer & bays (220 kV, 132kV, 33kV & 11kV) for the Expansion of New Butwal & Kushma Substation

Single-Stage, Two-Envelope
Bidding Procedure

Issued on:	**25 March 2025**
Invitation for Bids No.:	**PMD/ETDSP/NBKSEP–081/82 – 01**
OCB No.:	**PMD/ETDSP/NBKSEP–081/82 – 01**
Employer:	**Nepal Electricity Authority**
Country:	**Nepal**

VOLUME – II OF III
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New Butwal & Kushma Substation Expansion Project
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Preface

This Bidding Document for Procurement of Plant – Design, Supply, and Installation has been prepared by Nepal Electricity Authority and is based on the Standard Bidding Document for Procurement of Plant – Design, Supply, and Installation (SBD Plant) issued by the Asian Development Bank dated December 2021.

ADB's SBD Plant has the structure and the provisions of the Master Procurement Document entitled "Procurement of Plant – Design, Supply, and Installation", prepared by multilateral development banks and other public international financial institutions except where ADB-specific considerations have required a change.

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PROJECT SPECIFIC REQUIREMENT (PSR)

1.0 GENERAL

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

Nepal Electricity Authority (NEA) has established 220 kV AIS Substations at Sunwal-13, Nawalparasi (Bardaghat Susta-West) District and at Kushma of Parbat District of Nepal under Kaligandaki Transmission Corridor Project. The above project is being implemented by Nepal Electricity Authority, Project Management Directorate funded by Asian Development Bank (ADB).

Nepal Electricity Authority has intention for the expansion of above mentioned 220 kV New Butwal and Kushma Substations with the addition of transformer bays. The project is also being funded by Asian Development Bank (ADB). The specification describes the requirements for the construction of additional transformer bays in a turnkey basis.

2.0 INTENT OF SPECIFICATION:

This specification covers design, engineering, manufacture, fabrication, testing at manufacturers works, delivery, unloading at site, storage, erection and installation, testing and commissioning and dismantling of existing ICT (100 MVA, 220/132/11 kV) and related switchgears at site complete for the execution of substation works for Extension of 220 kV AIS Substation at New Butwal Substation, Nawalparasi (Bardaghat Susta-West) and Kushma Substation, Parbat. Above package, includes supply, delivery, installation, testing and commissioning of (a) 2 nos. of 315 MVA, 3-phase, 220/132/11 KV autotransformer (one at new ICT bay and another at existing ICT bay), 2 nos. of 63 MVA, 3-phase, 132/33 kV power transformers, 2 nos. of 24 MVA, 3-phase, 33/11 kV power transformers and expansion of 3 nos. of 220 kV bays (2 future line bays and 1 ICT Bay), 12 nos. of 33 kV and 8 nos. of 11 kV VCB switchgear panels at New Butwal Substation with 33 kV switchgear control building (b) 1 no. of 30 MVA, 132/33kV power transformer and 5 nos. of 33 kV VCB switchgear panels at Kushma substation and 33 kV switchgear control room. It is the intent of this specification to describe primary features, materials, and design & performance requirements and to establish minimum standards for the work. The specification is not intended to specify the complete details of various practices of manufactures/ bidders, but to specify the requirements with regard to performance, durability and satisfactory operation under the specified site conditions. The detailed scope of work is brought out in subsequent clauses of this section.

3.0 SCOPE OF WORKS:

The scope of this specification covers the following:

3.1 New Butwal Substation

The specification includes design, engineering, manufacture, fabrication, testing at manufacturers works, supply & delivery, unloading at site, storage, erection and installation, testing and commissioning of the addition of 220kV transformer bay in available space at the site adjacent to existing 220kV gantry structures, dismantling of existing 100 MVA, 220/132 kV ICT and related switchgears, addition of 220 kV line bays (only gantry structures and busbar expansion) for future, supply and installation of 220/132kV ICT, 132/33kV and 33/11kV power transformers, control & protection panels, Substation Automation System and other electrical and mechanical auxiliary systems, VCB switchgear panels (33kV and 11kV), 33kV switchgear control room building with separate 33 & 11 kV switchgear rooms, associated civil works, internal roads, drains, necessary buildings etc. as described below:

3.1.1 Expansion of 220/132 kV (AIS) substation at New Butwal Substation with the provision of following bays as per Single Line Diagram:

3.2.1.1 220 kV line bays- 2 nos. for future expansion (Gantry and Bus Bar Extension only)

3.2.1.2 220 kV transformer bay, 1 no. to connect 220/132/11 kV, 315 MVA Inter-

Connecting Transformer (ICT).

3.2.1.3 Existing 220 transformer bay, 1 no. to dismantle the 220/132/11 kV, 100 MVA ICT and connect new 220/132/11 kV, 315 MVA ICT on the same bay along with related switchgears.

3.2.1.4 Supply, installation, testing and commissioning of 2 nos. of 220/132/11 kV, 315 MVA, 3 phase ICT (autotransformer) with design identical in vector group and impedances for parallel operation Online dissolved Gas (Multi-gas) and Moisture Analyzer as specified.

3.2.1.5 Supply and installation of 2 Nos. of three phase 132/33 KV, 63 MVA Power Transformers in available space of 132kV transformer bays made by the previous contract along with Online dissolved Gas (Multi-gas) and Moisture Analyzer as specified.

3.2.1.6 Supply and installation of 2 nos. of three phase 33/11 kV, 24 MVA Distribution Transformers (DT) and associated cabling works along with Online dissolved Gas (Multi-gas) and Moisture Analyzer as specified.

3.2.1.7 Supply and installation of 12 nos. (8 distribution feeder and 2 incomers for 33kV side of 132/33kV transformer and 2 transformer panels for 33/11kV transformer) indoor 33 kV VCB panels and associated cabling works.

3.2.1.8 Supply and installation of 8 nos. (6 distribution feeder and 2 transformer incomer) indoor 11 kV VCB panels and associated cabling works.

3.2.1.9 Substation Automation System (SAS) & Communication System:

Supply and installation of Substation Automation System (SAS), Tele-protection & Communication Equipment with complete work including all required hardware and software for remote control along with associated equipment for 220kV, 132kV, 33kV & 11 kV bays as per Single line diagram & as indicated in BPS and as per technical specification under the scope of this bid.

The Contractor shall be fully responsible for supply, installation, testing and commissioning of Substation Automation system (SAS) components for expansion work mentioned in this bid and shall be responsible for interconnection with the NEA SCADA system. The Contractor shall be fully responsible for complete integrating and interconnecting with the existing SAS system (**GE T&D make**). The interfacing works include the integration of the relevant data (associated with the scope of work in this bid) into the SINAUT Spectrum (**SIEMENS make**) of the Load Dispatch Center, Kathmandu by necessary addition/modification and parameterization.

3.2.1.10 Fire Protection system:

Fire Protection System for 33 kV switchgear control room Building and transformers as per technical specification.
HVW spray system for 220/132/11 kV, 132/33 kV & 33/11 kV ICT and Power Transformer should be extended from existing Fire Protection system. Hydrant system extension, modification and upgradation complete work with all required pumping arrangement for maintaining required pressure, U/G & O/G piping and accessories for ICT, Power Transformers and equipment as per technical specification

3.2.1.11 Supply of 160 kVA DG set with acoustic enclose for back up supply. The scope of also includes installation in the diesel generator in the existing space in the switchyard where previous diesel generator was installed in the earlier contract. The power and auxiliary connections related to the diesel generator also in the

scope.

3.2 Kushma Substation

The specification includes design, engineering, manufacture, fabrication, testing at manufacturers works, supply & delivery, unloading at site, storage, erection and installation, testing and commissioning at site of the addition of 132 kV power transformer bay in the available space in adjacent to existing 132kV gantry structure, supply and installation of power transformer, control & protection panels, Substation Automation System, communication System and other electrical and mechanical auxiliary systems, 33kV VCB switchgear panels, 33kV switchgear control room building, associated civil works, internal roads, drains, necessary buildings etc. as described below:

3.2.2 Expansion of 220 /132 kV (AIS-extension) substation at Kushma withthe provision of following bays as per Single Line Diagram:

3.2.2.1 132 kV transformer bay, 1 nos. to connect 132/33 kV, 24/30 MVA Power Transformer (PT).

3.2.2.2 Supply and installation of 1 No. of three phase 132/33 KV, 24/30 MVA Power Transformer along with Online Dissolved Gas (Multi-gas) and Moisture Analyzer as specified.

3.2.2.3 Supply and installation of 5 nos. (4 distribution feeder and 1 transformer incomer) indoor 33 kV VCB panels and associated cabling works.

3.2.2.4 Substation Automation System (SAS) & Communication System:
Sub-station Automation System (SAS), Tele-protection & Communication Equipment with complete work including with all required hardware and software for remote control along with associated equipment for 132kV & 33 kV bays as per Single line diagram & as indicated in BPS and as per technical specification under the scope of this bid.

The Contractor shall be fully responsible for supply, installation, testing and commissioning of Substation Automation system (SAS) for expansion work in this bid and shall be responsible for interconnection with the NEA SCADA system. The Contractor shall be fully responsible for complete integrating and interconnecting with the existing SAS system (**ABB make**). The interfacing works include the integration of the relevant data (associated with the scope of this work) into the SINAUT Spectrum (**SIEMENS Make**) of the Load Dispatch Center, Kathmandu by necessary addition/modification and parameterization. Existing RTU based SCADA and its data acquisition is given in annexure V.

3.2.2.5 Fire Protection system:

Fire Protection System for 33 kV & 11 kV switchgear control room building and transformers as per technical specification.

HVW spray system for 220/132/11 kV & 132/33 kV ICT and Power Transformer should be extended from existing Fire Protection system. Hydrant system extension, modification and upgradation complete work with all required pumping arrangement for maintaining required pressure, U/G & O/G piping and accessories for ICT, Power Transformers and equipment as per technical specification

4.0 DETAILED SCOPE OF WORK:

Detailed scope of work for each substation is brought out in subsequent clauses of this chapter.

4.1 New Butwal Substation:

Design, engineering, manufacture, testing at the manufacturer, supply including transportation & insurance, storage, erection and installation, testing and commissioning at site of following equipment and items at 220/132/11 kV New Butwal AIS substation complete in all respect:

A. 220/132 kV AIS System :

Existing New Butwal 220/132 kV Substation has 220 kV double main with transfer bus arrangement. The switchgear and necessary components are to be installed for transformer bays which shall be complete with all necessary terminal boxes, interconnecting power and control wiring, grounding connections and support structures along with base plate & foundation bolts for fixing the equipment with foundations complete in all respect and consisting of the following major items:

A.1. The 220kV substation Bus Bar Scheme is Double Main and Transfer Bus. The necessary extension, augmentation, connection and reinforcement of existing 220 kV busbar arrangements for two (2) future bays shall be under the scope of Contractor.

A.2. The 220 kV ICT Bay on HV (220 kV) side consists of the following items identical to existing systems:

1. 1 nos. of 245 kV, 3150 A, 3-phase, SF6 Circuit Breaker for auto transformer, three pole operation type, complete with support structure & all accessories as per specification
2. 1 nos. of 245 kV, 1600 A, 3-phase Disconnecting Switch with two (2) Earth Switch complete with all accessories as per specification
3. 1 nos. of 245 kV, 1600 A, 3-phase Disconnecting Switch with one (1) Earth Switch complete with all accessories as per specification
4. 2 nos. of 245 kV, 1600 A, 3-phase Disconnecting Switch (Tandem Isolator) without earth Switch complete with all accessories as per specification
5. 3 nos. of 245 kV, 1600 A, 5 core Current Transformer complete with all accessories as per specification (1-Phase)
6. 3 nos. of 216 kV, 10 kA, lightning arrestor including discharge counter complete with all accessories as per specification (1-phase)
7. Post insulators for necessary supports and road crossing

A.3. The ICT Bay on LV (132 kV) side consists of the following items identical to existing systems:

1. 1 no. of 145 kV, 2500 A, 3 phase, SF6 Circuit Breaker for LV side of auto transformer, three pole operation type, complete with support structure & all accessories as per specification
2. 2 nos. of 145 kV, 2500 A, 3 phase Disconnecting Switch with two (2) Earth Switch complete (one for replacement and another for new ICT Bay) with all accessories as per specification
3. 4 nos. of 145 kV, 2500 A, 3 phase Disconnecting Switch (Tandem Isolator) without earth Switch complete (two for replacement and another two for new ICT Bay) with all accessories as per specification
4. 2 nos. of 145 kV, 2500 A, 3 phase Disconnecting Switch with one (1) Earth Switch complete (one for replacement and another for new ICT Bay) with all accessories as per specification
5. 3 nos. of 145 kV, 1600A, 5 core Current Transformer complete with all accessories as per specification (1-Phase)
6. 120 kV, 10 kA, lightning arrestor including discharge counter complete with all accessories as per specification (1-phase)

7. Post insulators for necessary support and road crossing

B. **132 kV (AIS) /33 kV (Indoor) System:**

Existing New Butwal 220/132 Substation has 132 kV double main with transfer bus arrangement. The 132kV switchgears and necessary components have already been installed for transformer bays in the previous contract. The scope under this bid includes in LV side (33 kV) equipment which consists of the following items:

1. 2 nos. of 33 kV transformer incomer module (2500A) including CTs, Control & Relays with all accessories as per specification
2. 1 nos. of 33 kV Bus Coupler module (2500A) including CTs, Control & Relays with all accessories as per specification.
3. 2 nos. of 33 kV transformer feeder (1250A) for 33/11kV transformers including CTs, Control & Relays with all accessories as per specification
4. 8 nos. of 33 kV Feeder module (630A) including CTs, Control & Relays with all accessories as per specification
5. 2 nos. of 36 kV PT module with all accessories as per technical specification
6. 1500 mtr of 33 kV HT armored Copper Cable (Double run 1CX400 sq.mm. for each phase + one double run spare) for 2 nos. of 33 kV transformer incomers (132/33kV transformers) along with 8 ladder cable trench and termination equipment at both end joints, with all accessories complete.
7. 2500 mtr of 33 kV HT armored Copper Cable (1CX400 SQmm) for 6 nos. of 33 kV feeder line along with 6 ladder cable trench and termination equipment at both end joints, with all accessories complete.

C. **11 kV Indoor Panel System:**

11 kV Indoor Panel System consists of following items:

1. 2 nos. of 11 kV transformer incomer module (2000A) (IP-2) including PT module (IP-3) with all accessories as per specification
2. 6 nos. of 11 kV Line Module(1250A) (IP-1) with all accessories as per specification
3. 1 no. of 11 kV Bus Coupler Module (2000 A) (IP-2) with all accessories as per specification
4. 2 no. of 12 kV PT module with all accessories as per technical specification
5. 12 kV, 600 sq. mm. 3 x single core XLPE Copper Power Cable including termination joints and accessories for both ends, from LV sides of 33/11 kV Power Transformers to indoor 11 kV Switchgear Room
6. 12 kV, 300 sq.mm. 3 core (3C X 300 Sq.mm) XLPE Aluminium Power Cable armoured including termination joints and all accessories for both ends complete for 6 nos. of outgoing feeder

D. **Control and Relay Panel with Substation Automation System (SAS) comprising of:**

1. 1 no. of 220/132/11 kV transformer protection panel complete with all accessories as per specification identical to existing one.
2. 2 nos. of 132/33 kV transformer protection panel complete with all accessories as per specification.
3. 2 nos. of 33/11 kV transformer protection panel complete with all accessories as per specification.

The existing 100 MVA, 220/132/11 kV C&R Panel should be arranged to be compatible with the upgraded 315 MVA transformer.

E. **Transformer:**

a) **2 Nos. of 315 MVA, 220/132/11 kV**, 3-Phase Outdoor Power Transformers with RIP Bushing, online DGA (minimum 8-gas), online drying system as per technical specifications including all materials/ fittings/ accessories/ surge protection device/ bushing CT/ Digital RTCC Panel/MB/ Cables including special cable (if any), etc.

b) **2 Nos. of 40/51.5/63 MVA, 132/33 kV**, 3-Phase Outdoor Power Transformers with RIP Bushing, online DGA (minimum 8-gas), as per technical specifications including all materials/ fittings/ accessories/ surge protection device/ bushing CT/ Digital RTCC Panel/ MB/Cables including special cable (if any), etc.

c) **2 Nos. of 20/24 MVA, 33/11 kV**, 3-Phase Outdoor Power Transformer including online DGA system (minimum 8-gas) as per technical specifications, all materials / fittings /accessories/ Digital RTCC panel/ MB/ Cables including special cable (if any) etc.

The existing **100 MVA, 220/132/11 kV** 3-phase Interconnecting transformer should be dismantled by unmounting the conservator tank, draining the transformer oils in non-returnable drums and should be stored in a safe place within the substation premise with top up of transformer oil inside transformer tank.

F. **Substation Automation System (SAS) & Communication system:**

Substation Automation System (SAS) including necessary hardware and software to integrate and interconnect with the of existing GE T&D make SAS system of New Butwal Substation and SIEMENS (SINAUT Spectrum) at Load Dispatch Centre, Kathmandu along with associated equipment for following 220 kV, 132kV, 33kV & 11 kV bays as per Single line diagram (bay as defined in Technical Specification, Section - Substation Automation) under the scope of this bid. Further, the contractor shall also supply necessary BCUs (Bay Control Units) for monitoring & control of Auxiliary System.

S.No.	Description	Unit	Quantity
1.	**220 kV bays**	Nos.	01
2.	**132 kV bays**	Nos.	03
3.	**33 kV bays**	Nos.	12
4.	**11 kV bays**	Nos.	08

The contractor shall supply and install necessary computers along with table (desk) and furniture in the 33 kV switchgear control room to operate 33kV and 11kV switchgears locally by the NEA distribution operators. The 33kV and 11kV switchgears shall be operated and controlled in parallel with main control room of 220 kV substation as required.

G. Relay and protection system as per section – Control and Relay (C & R) Panels identical to the existing system

H. The existing busbar protection shall be extended to 220kV and 132kV bays supplied under this bid.

I. Extension of existing Fire Protection System for 33kV Control Building and power transformers as per technical specification.

J. Lattice or pipe structures or Fasteners (galvanized): Switchyard gantry structures, Beams and equipment support structure, support structure for 220 kV and 132 kV equipment, 33kV & 11 kV XLPE power cable termination shall be provided as per design and drawings to be developed by the contractor but identical to the existing one. However, the supply of support structure for circuit breaker is under scope of CB manufacturer. 220kV gantry structures shall be expanded and supplied as per existing structural drawings. Structural and foundation drawings for 220kV gantry shall be provided to the contractor after the award of the contract.

K. Bus post Insulators, insulator strings and hardware, clamps & connectors, Equipment terminal connectors including for 33 kV, 11 kV XLPE Power Cable, spacers, Aluminum tube, conductor, Earth wire, Bus bar and earthing materials, auxiliary earth mat, Bay marshalling box, cable supporting angles/channels, Cable trays and covers, Junction box, buried cable trenches for lighting, PVC pipes for cabling of equipment etc. as per requirement.

L. Air Conditioning System should be installed for control room, 33 & 11 kV indoor switchgear room.

M. Bidder shall use existing water storage tank for fire protection of transformers to be supplied under this bid. The scope of piping arrangement includes for the fire protection of transformers to be supplied under this contract and shall be included in the respective part of the price schedule.

N. Ventilation system must be installed for control room building.

O. Use of AC and DC source from existing AC/DC board. If spare not available addition of AC and DC board required.

P. 160 KVA, 400/230 V, 50 Hz Silent type DG Set with acoustic enclosure, control panel & AMF panel as per technical specification.

Q. 1.1 kV grade PVC/XLPE insulated power and lighting cable (Copper) & PVC insulated Control cable (Copper) Control cables along with complete accessories. Auxiliary Power supply and control cables from the control room / switchyard panel room and RTCC (Remote Tap Changer Control) panel to common marshalling box of transformer / reactor are also in present scope of work.

R. Lighting and illumination of the Switchyard, occupancy sensor and Street lights etc. and Emergency DC lighting system complete for switchyard to complete the specified scope of works as per technical specification in the present scope of works. Also lighting and illumination for the 33kV Switchgear control room also part of the scope.

S. Earthing of extended part of the substation under the scope of this bid with conductors, electrode, grounding materials complete. Earthing inside the control building for 33 and 11 kV indoor switchgears and outdoor switchyards, earthing of all outdoor equipment including Transformers with all required accessories to complete the specified scope of works. EARTH RESISTIVITY TEST (ERT) Report will be provided by the employer. However, the contractor shall carry out any ERT test for confirmation. The cost of such test shall be included in the respective item in price schedule.

T. Galvanized E.H.S. steel wires of size 7/3.35 for lightning shield wire in take-off and internal structures with all accessories to complete the specified scope of works.

U. Design, engineering, manufacture, testing, supply including transportation, insurance & storage at site of mandatory spares as per BPS.

V. Any other equipment/material required for completing the specified scope, shall be included in the scope of supply and the offer should be complete & comprehensive.

W. **Civil works - The scope of work shall include but shall not be limited to the following based on design and drawings to be developed by the contractor**

(a) General soil investigation has been carried out. NEA will provide Geotechnical investigation Report of the substation area for reference. However, the contractor shall carry out any soil investigation (tests) for confirmation. The cost of such test shall be included in the respective item in price schedule.

(b) Drawings of Master/General Layout Plan, Earthworks, typical drawing of 33kV Switchgear Control building. Employer will provide drawings of the existing system for reference purpose only.

(c) Foundation for 2 nos. of 220/132/11 kV, 3-Phase, 315 MVA ICT, 2 Nos. of 132/33 kV, 3-Phase, 40/51.5/63 MVA power transformers and 2 Nos. of 33/11 kV, 3-Phase, 20/24 MVA, power transformers along with jacking pads, rail track, Oil soak pit, sump pit, pylon support and fire-resistant wall (s) as required.

(d) Dismantling of existing 100 MVA, 220/132/11 kV foundation along with adjustment of rail.

(e) Construction of One (1) Switchgear control room building for 33 & 11 kV indoor switchgear panels as per specification and drawings. Building design shall be in the scope of Contractor. Employer will provide such drawings for reference purpose only. Getting statutory approval of the building design and maps at local levels government office of Nepal shall be responsibility of the contractor. Project will provide necessary assistance to the contractor.

(f) Construction of 220 kV switchyard extension.

(g) Construction of septic tank & soak pit with external sewerage system for the 33kV Switchgear control room building.

(h) Foundation for equipment supports structures and other equipment as per specification, drawings and NEA norms.

(i) Construction of Cable trenches inside and outside control room building and within substation area. The cable trench layout shall be prepared by the contractor for the present scope of works.

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

(k) Construction of Side Drain along Boundary wall, Cross Drain with cover etc. all complete. Layout shall be developed by the contractor as per design on various type of drains.

(l) All roads including switch yard within boundary wall and approach Road shall be RCC Roads as per specifications and shown in GA drawing.

(m) Approach road (Outside NEA boundary) with proper Subgrade having required longitudinal and transverse slope for strengthening of Road as per respective items of BPS.

(n) Construction of RCC Box culvert of size 6 m length, 5 m width and 2.5 m height (if required) in the approach road shall be as per specifications and drawing. Culvert design and drawings shall be prepared by the contractor. Employer will provide such drawing for reference purpose only.

(o) Strengthening of approach road: Strengthening of approach road/bridges, if required during transportation of equipment, shall be included in respective item of price schedule. Employer will not be liable for any additional payment for such work.

(p) Anti-weed treatment, PCC (1:5:10) and Stone spreading in the switchyards and control room area. Layout detail drawings shall be developed by the contractor.

(q) Switch yard Chain link fencing and gates for the present scope of works.

(r) Boundary wall along substation property line and main gates for the portion under the present scope of works.

(s) Foundation for lighting poles, Bay marshalling box, panels and control cubicles of equipment wherever required

(t) Surveying, contouring, leveling and filling. The leveling and filling (to an approximate depth as per requirement) in the area under present scope of work inside substation is to be carried out to achieve finished ground level. The finished ground level shall be provided during detail engineering.

(u) Dismantling of existing structure, foundation etc., if required, shall be included with the bid prices elsewhere in the price schedule.

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

X. The bidders are advised to visit the substation site and acquaint themselves with the topography, infrastructure and also the design philosophy. Before proceeding with the construction work of the new Substation and existing substations, 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 shall be supplied by the Contractor. The cement and steel shall also 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. Drawings enclosed with tender drawings are for information only. Drawings shall be developed by the contractor as per his design and has to be approved by the project office.

Y. 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.

Z. 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 for approval of Employer within three months from the date of award.

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

BB. Design of substation and its associated electrical & mechanical auxiliaries systems includes preparation of single line diagrams and electrical layouts including layout arrangement for foundation layout, cable trench layout, earth mat layout, erection key diagrams, electrical and physical clearance diagrams, design calculations for earthing and lightening protection system (including Direct Stroke Lighting Protection), control and protection schematics, wiring and termination schedules, civil designs (as applicable) and drawings, air conditioning system, indoor/outdoor 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.

CC. Any other items not specifically mentioned in the specification but which are required for erection, testing and commissioning and satisfactory operation of the substation are deemed to be included in the scope of the specification unless specifically excluded.

DD. Employer has standardized its technical specification for various equipment and works for different voltage levels. Items, which are not applicable for the scope of this package as per schedule of quantities described in Schedules of Rate sand Prices, the technical specification for such items should not be referred to.

EE. The Quantities listed in the Schedule of Prices represent the estimated quantities for Tender purpose only. The Contractor shall carryout detail design and shall submit

final bill of quantity for approval within 120 days from the signing of contract or 60 days after effective date of contract. The actually required quantity may vary from the quantity as listed in price schedule. The Contractor shall agree to make no claim for anticipated profits or for alleged losses because of any difference between the quantities actually furnished and installed and the estimated quantities as indicated in the price schedule at the original quoted unit prices within the total price variations limit of +/- 15% as per the tender conditions.

FF. Project Level Environmental Management Plan: The scope of work shall include implementation of the EMP mentioned in the Annexure VI of the PSR. For contract related costs the Schedule of Prices represent costs based on an estimate of the construction and installation cost, since the contracts are subject to competitive bidding it will be for the contractor to reflect in their BOQ and ensure adequate budget is provided in their bids for the EMP implementation.

4.2 Kushma Substation:

Design, engineering, manufacture, testing, supply including transportation & insurance, storage, erection, testing and commissioning of following equipment and items at 220/132 kV Kushma AIS substation complete in all respect:

A. 132 kV (AIS) /33 kV (Indoor) System :

Existing Kushma 220/132 kV Substation has 132 kV double main bus arrangement. The switchgears and necessary components are to be installed for Transformer bay. The scope under this bid includes mainly of the following items:

1. 1 no. of 145 kV, 1600 A, 3-phase, SF6 Circuit Breaker, three pole operation type, complete with support Structure & all accessories as per specification
2. 1 no. of 145 kV, 1600 A, 3-phase Disconnecting Switch with two (2) Earth Switch complete with all accessories as per specification
3. 1 no. of 145 kV, 1600 A, 3-phase Disconnecting Switch with one (1) Earth Switch complete with all accessories as per specification
4. 3 nos. of 145 kV, 1600 A, 3-phase Disconnecting Switch without earth Switch (for bus and bypass isolator) complete with all accessories as per specification
5. 3 nos. of 145 kV, 800A, 5 core Current Transformer with 120% extended current rating complete with all accessories as per specification (1-Phase)
6. 3 nos. of 120 kV, 10 kA, lightning arrestor including discharge counter complete with all accessories as per specification
7. 1 no. of 33 kV Transformer incomer module (1250 A) including CTs, Control & Relays with all accessories as per specification
8. 4 nos. of 33 kV Feeder module (630 A) including CTs, Control & Relays with all accessories as per specification
9. 1 no. of 36 kV PT module with all accessories as per technical specification
10. 600 mtrs of 33kV XLPE Insulated, armored Copper Cable (1CX400 sq.mm.)
11. 2400 mtrs of 33kV XLPE Insulated, armored Copper Cable (1CX240 SQmm)

B. Control and Relay Panel with Substation Automation System comprising of:

1. 1 no. of 132/33 kV transformer protection panel complete with all

accessories as per specification identical to existing one.

C. Transformer:

a) **1 Nos. of 24/30 MVA, 132/33 kV**, 3-Phase Power Transformer with RIP Bushing, online DGA (minimum 8-gas) as per technical specifications including all materials/fittings/accessories/surge protection device/bushing CT/Digital RTCC panel/MB/cables including special cable if any, etc.

D. Substation Automation System (SAS) & Communication system:

Sub-station automation system (SAS) including necessary hardware and software to interface and interconnect with the existing ABB make SAS of Kushma Substation and SIEMENS (SINAUT Spectrum) at Load Dispatch Centre, Kathmandu along with associated equipment for following 132kV, 33kV bays as per Single line diagram (bay as defined in Technical Specification, Section - Substation Automation). Further, the contractor shall also supply necessary BCUs (Bay Control Units) for monitoring & control of Auxiliary system.

S.No.	Description	Unit	Quantity
1.	**132 kV bays**	Nos.	01
2.	**33 kV bays**	Nos.	05

E. Relay and protection system as per section – Control and Relay (C & R) Panels identical to the existing system

F. The existing busbar protection shall be extended to 132kV bays suppled under this bid.

G. Extension of existing Fire Protection System for control Building and transformers as per technical specification.

H. Lattice or pipe structures or Fasteners (galvanized): Switchyard gantry structures, Beams and equipment support structure, support structure for 132 kV, 33kV equipment and XLPE power cable termination shall be provided as per design and drawings to be developed by the contractor but identical to the existing one. However, the supply of support structure for circuit breaker is under scope of CB manufacturer.132kV gantry structures shall be expanded and supplied as per existing structural drawings. Structural and foundation drawings for 132kV gantry shall be provided to the contractor after the award of the contract.

I. Bus post Insulators, insulator strings and hardware, clamps & connectors, Equipment terminal connectors including for 33 kV XLPE Power Cable, spacers, Aluminum tube, conductor, Earth wire, Bus bar and earthing materials, Auxiliary earth mat, Bay marshalling box, cable supporting angles/channels, Cable trays and covers, Junction box, buried cable trenches for lighting, PVC pipes for cabling of equipment etc. as per requirement.

J. Air Conditioning System should be installed for control room building, 33 kV indoor switchgear room.

K. Ventilation system must be installed for control room building.

L. Use of AC and DC source from existing AC/DC board. If spare not available addition of AC and DC board required.

M. 1.1 kV grade PVC/XLPE insulated Power and lighting cable (Copper) & PVC insulated Control cable (Copper) Control cables along with complete accessories. Auxiliary Power supply and control cables from control room / switchyard panel room and RTCC (Remote Tap Changer Control) panel to common marshalling box of transformer / reactor are also in present scope of work.

N. Lighting and illumination of the Switchyard, occupancy sensor and Street lights etc. and Emergency DC lighting system complete for switchyard to complete the specified scope of works as per technical specification for the present scope of works.

O. Earthing extension of substation with conductors, electrode, grounding materials

complete. Earth mat, inside the AIS Control building for 33 and 11 kV indoor switchgears and outdoor switch yards, earthing of all outdoor equipment including Transformers with all required accessories to complete the specified scope of works. EARTH RESISTIVITY TEST (ERT) Report will be provided by the employer. However, the contractor shall carry out any ERT Test for confirmation. The cost of such test shall be included in the respective item in price schedule.

P. Galvanized E.H.S. steel wires of size 7/3.35 for lightning shield wire in take-off and internal structures with all accessories to complete the specified scope of works.

Q. Design, engineering, manufacture, testing, supply including transportation, insurance & storage at site of mandatory spares as per BPS.

R. Any other equipment/material required for completing the specified scope, shall be included in the scope of supply and the offer should be complete & comprehensive.

S. Civil works - The scope of work shall include but shall not be limited to the following based on design and drawings to be developed by the contractor

(a) General soil investigation has been carried out. NEA will provide Geotechnical investigation Report of the substation area for reference. However, the contractor shall carry out any soil investigation (tests) for confirmation. The cost of such test shall be included in the respective item in price schedule.

(b) Drawings of Master/General Layout Plan, Earthworks, typical drawing of Control room cum administrative building. Employer will provide such drawings for reference purpose only.

(c) Foundation for 1 no. of 24/30 MVA, 132/33 kV, 3-Phase Power Transformer along with jacking pads, rail track, Oil soak pit, sump pit, pylon support and fire-resistant wall (s) as required.

(d) Construction of One (1) Control room building for 33 kV indoor switchgear panels as per specification and drawings. Building design shall be in the scope of Contractor. Employer will provide such drawings for reference purpose only. Getting statutory approval of the building design and maps at local levels government office of Nepal shall be responsibility of the contractor. Project will provide necessary assistance to the contractor.

(e) Construction of septic tank & soak pit with external sewerage system for control Room building.

(f) Foundation for equipment supports structures and other equipment as per specification, drawings and NEA norms.

(g) Construction of Cable trenches inside and outside control room building and within substation area. The cable trench layout shall be prepared by the contractor.

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

(i) Construction of Side Drain along Boundary wall, Cross Drain with cover etc. all complete. Layout shall be developed by the contractor as per design on various type of drains.

(j) All roads including switch yard within boundary wall and approach Road shall be RCC Roads as per specifications and shown in GA drawing.

(k) Approach road (Outside NEA boundary) with proper Subgrade having required longitudinal and transverse slope for strengthening of Road as per respective items of BPS.

(l) Construction of RCC Box culvert of size 6 m length, 5 m width and 2.5 m height (if required) in the approach road shall be as per specifications and drawing. Culvert design and drawings shall be prepared by the contractor. Employer will provide such drawing for reference purpose only.

(m) Anti-weed treatment, PCC (1:5:10) and Stone spreading in the switchyards and control room area. Layout detail drawings shall be developed by the contractor.

(n) Switch yard Chain link fencing and gates.

(o) Boundary wall along substation property line and main gates

(p) Foundation for lighting poles, Bay marshalling box, panels and control cubicles of equipment wherever required

(q) Surveying, contouring, leveling and filling. The leveling and filling (to an approximate depth as per requirement) in the area under present scope of work inside substation is to be carried out to achieve finished ground level. The finished ground level shall be provided during detail engineering.

(r) Pumps: Dewatering Pumps, booster pump for Fire Fighting water Tank, underground water tank of township (staff quarters).

(s) Dismantling of existing structure, foundation etc., if required, shall be included with the bid prices elsewhere in the price schedule.

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

T. The bidders are advised to visit the substation site and acquaint themselves with the topography, infrastructure and also the design philosophy. Before proceeding with the construction work of the new Substation and existing substations, 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 shall be supplied by the Contractor. The cement and steel shall also 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. Drawings enclosed with tender drawings are for information only. Drawings shall be developed by the contractor as per his design and has to be approved by the project office.

U. 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.

V. 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 for approval of Employer within three months from the date of award.

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

X. Design of substation and its associated electrical & mechanical auxiliaries systems includes preparation of single line diagrams and electrical layouts including layout arrangement for foundation layout, cable trench layout, earth mat layout, erection key diagrams, electrical and physical clearance diagrams, design calculations for earthing and lightening protection system (including Direct Stroke Lighting Protection), control

and protection schematics, wiring and termination schedules, civil designs (as applicable) and drawings, air conditioning system, indoor/outdoor 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.

Y. Any other items not specifically mentioned in the specification but which are required for erection, testing and commissioning and satisfactory operation of the substation are deemed to be included in the scope of the specification unless specifically excluded.

Z. Employer has standardized its technical specification for various equipment and works for different voltage levels. Items, which are not applicable for the scope of this package as per schedule of quantities described in Schedules of Rate sand Prices, the technical specification for such items should not be referred to.

AA. The Quantities listed in the Schedule of Prices represent the estimated quantities for Tender purpose only. The Contractor shall carryout detail design and shall submit final bill of quantity for approval within 120 days from the signing of contract or 60 days after effective date of contract. The actually required quantity may vary from the quantity as listed in price schedule. The Contractor shall agree to make no claim for anticipated profits or for alleged losses because of any difference between the quantities actually furnished and installed and the estimated quantities as indicated in the price schedule at the original quoted unit prices within the total price variations limit of +/- 15% as per the tender conditions.

BB. Project Level Environmental Management Plan: The scope of work shall include implementation of the EMP mentioned in the Annexure VI of the PSR. For contract related costs the Schedule of Prices represent costs based on an estimate of the construction and installation cost, since the contracts are subject to competitive bidding it will be for the contractor to reflect in their BOQ and ensure adequate budget is provided in their bids for the EMP implementation.

5.0 SPECIFIC EXCLUSIONS

i) Employer's site office.

6.0 PHYSICAL AND OTHER PARAMETERS:

6.1 Location of the Substation:

The site of 220/132 kV AIS New Butwal substation is located at Sunwal, ward no. 13 of Sunwal Municipality, Nawalparasi (Bardaghat-Susta West) district, Lumbini Province. It lies approximately 0.3 km South from the Suryabasti chowk along the East- West Highway. Google Map coordinates of proposed substation location is 27°34'31.21" North Latitude and 83°41'22.32" East Longitude.

Similarly, the site of 220/132 kV AIS Kushma substation is located at Kushma, Parbat district, Gandaki Province. It lies approximately 0.3 km South from the Kushma Bajar. Google Map coordinates of proposed substation location is 28°14'37.36" North Latitude and 83°38'52.78" East Longitude.

6.2 Meteorological data:

	New Butwal Substation	**Kushma Substation**
a) Altitude above sea level:	121 m from MSL	927 m from MSL
b) Ambient Air Temperature	26 degree C	15.1 degree C
c) Annual average	28 degree C	40 degree C

temperature		
d) Average Humidity (in %)	100(max), 40(min)	100(max), 40(min)
e) Substation location lying in the wind speed zone	4 i.e., 47m/s.	4 i.e., 47m/s.
f) Ice or snow expected thickness	0	0
g) Atmospheric pollution	Light	Light
h) Isokeraunic level (thunderstorm days)	50	50
i) Monsoon season	June- September	June- September
j) Seismic Requirement for Substation equipment	0.5g	0.5g
k) Seismic Requirement for civil works	0.36g	0.36g

However, for design purposes, existing system should be considered.

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

S. No.	Voltage Level	Fault Level
1	220 kV	40 kA for 1 Sec
2	132 kV	31.5 kA for 1 Sec
3	33 kV	25 kA for 3 Sec
4	11 kV	25 kA for 3 Sec

Note:

The insulation and Radio Interference Voltage (RIV) levels of the equipment shall be as per values given in the respective chapter of the equipment.

7.0 SCHEDULE OF QUANTITIES:

The requirement of various items/equipment and civil works are indicated in Bid price Schedules.

All equipment/items and civil works, whose bill of quantity has been indicated in BPS (Bid Price Schedules) 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 indicated in LS/Lot/Set, the bidder is required to estimate the quantity required for entire execution and completion of works and incorporate their price in respective Bid price schedules. 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 Bid price schedules. 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 BPS, as may be required shall be deemed to be included in the module itself.

The detailed bill of quantities of the mandatory spares is as per BOQ.

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 included in the bid price and shall be provided at no extra cost to the Employer.

8.0 BASIC REFERENCE DRAWINGS:

8.1 Single line diagram and general arrangements drawings are enclosed with the bid documents for reference, which shall be further engineered by the bidder.

8.2 The reference drawings, which form a part of the specifications, are given at **Annexure-I.** The bidder shall maintain the overall dimensions of the substation, phase to earth clearance, phase to phase clearance and sectional clearances.

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 Employer.

9.0 ORDER OF PRECEDENCE OF DIFFERENT PARTS OF TECHNICAL SPECIFICATION

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

Section – 1	Project Specific Requirement	Rev. 00(NEA)
Section – 2	General Technical Requirements	Rev. 00(NEA)
Section – 3	Power and Distribution Transformers	Rev. 00(NEA)
Section – 4	Outdoor Circuit Breaker	Rev. 00(NEA)
Section – 5	Disconnecting Switches/Isolators	Rev. 00(NEA)
Section – 6	Instrument Transformers	Rev. 00(NEA)
Section - 7	Lightning Arrester	Rev. 00(NEA)
Section – 8	Control & Relay Panel	Rev. 00(NEA)
Section - 9	33 kV & 11 kV Indoor Switchgear	Rev. 00(NEA)
Section – 10	Lightning System	Rev. 00(NEA)
Section – 11	Power and Control Cable	Rev. 00(NEA)
Section – 12	Fire Protection System	Rev. 00(NEA)
Section – 13	Air Conditioning System	Rev. 00(NEA)
Section – 14	DG Set	Rev. 00(NEA)
Section – 15	Switchyard Erection, Hardware and Miscellaneous Materials	Rev. 00(NEA)
Section – 16	LT Switchgear	Rev. 00(NEA)
Section – 17	Substation Automation System	Rev. 00(NEA)
Section – 18	Structures	Rev. 00(NEA)
Section – 19	Civil Works	Rev. 00(NEA)
Section – 20	Inspection Testing and Commissioning	Rev. 00(NEA)
Section – 21	Payment of Works.	Rev. 00(NEA)
Section – 22	Tender Drawings	Rev. 00(NEA)
Section – 23	Technical Data Sheet (Guaranteed Technical Particulars)	Rev. 00(NEA)

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 chapters.

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

10.0 SPARES: 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 BOQ and shall be considered for evaluation of bid. It shall not be binding on the Employer to procure all of these mandatory spares.

The bidder is clarified that 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 contractor.

11.0 SPECIAL TOOLS AND TACKLES:

The bidder shall include in his proposal the supply of all special tools and tackles required for operation and maintenance of equipment. The special tools and tackles shall only cover items which are specifically required for the equipment offered and are proprietary in nature. However a list of all such devices should be indicated in the relevant schedule provided in the BOQ. 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**.**

12.0 FACILITIES TO BE PROVIDED BY THE OWNER

12.1 Employer shall make available the auxiliary HT power supply from NEA on chargeable basis at a single point in the Substation (if possible). The prevailing energy rates of the stateshall 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 Employer shall in no case be responsible for any delay in works because of non-availability of power.

12.2 Employer shall make available construction water supply at a single point in the substation (If possible). All further distribution for the same shall be made by the Contractor. In case of non-availability or inadequate availability of water for construction work, the contractor shall make his own arrangement at his own cost and the Employer shall in no case be responsible for any delay in works because of non-availability or inadequate availability of water.

12.3 All the cost required for facilities mentioned above shall be borne by contractor.

13.0 SPECIFIC REQUIREMENT:

a. The ICT transformers (315 MVA, 220/132/11 kV) should meet all the criteria for parallel operation for New Butwal Substation.

b. The Bidders are advised to visit Substation site and acquaint themselves with existing facilities, the topography, infrastructure, etc.

c. The bidder shall be responsible for safety of human and equipment during the working. It will be the responsibility of the Contractor to coordinate 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.

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, wastage and damages shall be to the account of contractor.

d. Augmentation and integration work related to SCADA System

The 220, 132, 33, 11 kV bays under present scope at the substation shall be integrated by the contractor into existing SCADA system of GE T&D make SAS of Existing New Butwal Substation/ ABB make of existing Kushma Substation and Siemens 'SINAUT Spectrum' (version 4.3.2) installed at Master Station i.e. Nepal Electricity Authority Load Dispatch Centre (located at 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 stations viz. The manufacturers of the existing SCADA system are:

- LDC facilities: Siemens Germany
- RTU facilities: ABB Germany

e. Erection, testing and commissioning of Substation automation system, Control and protection Panels, Transformer, and communication equipment etc. shall be done by the contractors under the supervision of respective equipment manufacturers. Charges for the above supervision shall be included by the bidder in the erection charges for the respective equipment in the BPS.

f. The civil construction drawing for above shall be developed by the contractor during detail engineering. All RCC shall be of M-25 grade (Minimum) with mixed design conforming to relevant international standard/BS. All Reinforcement steel shall be of Fe-500 (Minimum) grade conforming to international standards /BS.

g. The Frequency range for the earthquake spectra shall be as per IEC-62271- 300 for Circuit Breaker.

h. Transmission line side insulator String (including Hardware) i.e. tension insulator on the line side of the takeoff gantry for 132 and 33 kV lines termination is under the present scope of specification.

i. One number portable fire extinguisher (CO_2 type) of 4.5 kg shall be provided for each switchyard panel room as per Bid proposal sheet (BOQ).

j. The Contractor shall provide AC/DC feeders for **complete future bays** also as per single line diagram in addition to bays under present scope.

k. The short description has been used in the bid price schedule. The details of all such short description are given in **Annexure-IV** of this project specification requirement. The bidder shall refer these detailed descriptions for clarity.

l. One number each Energy meter for the record and revenue purpose is to be provided for each 132/33/11 kV bays (transfer & Bus coupler bays to be excluded) under present scope of contract, meeting the requirement as specified at **Annexure – III.**

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

n. Non CFC refrigerant shall be utilized for Air conditioning system, offered for Control room buildings and switchyards are under the scope of contract.

o. Separate protection relay (IED) shall be provided for 132 kV Class Transformer directional over current and earth fault relay (for both HV & LV side). Inbuilt function in any other protection IED/BCU is not acceptable.

p. In the Substation automation system, each AIS shall be monitored individually per phase basis. In case it is not possible to monitor in one BCU, the contractor shall supply additional BCU for the monitoring without any additional cost implication to NEA.

q. 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.

r. Nuts, Bolts and washers for all non-standard structures shall be payable as per BPS.

s. For Design of MSB/ACDB/DCDB/MLDB/ELDB, future 220 kV lines/ transformer has to be considered.

t. Illumination for Township covers all necessary conduiting, wiring for lighting & Power sockets for Television/ Telephone Box, Distribution board, Switchboard with and without 6A Socket, Television/ Telephone point, Bell, Air Conditioner/ Room Heater point of 15A and all other necessary items for Quarters, transit camps, Security room etc.

u. LIST OF PREFERED SHORTLISTED MAKE/MANUFACTURER:

"It is preferred that the equipment be supplied from the manufacturers listed in **ANNEXURE- II** for mentioned equipment/items.

The bidders may offer equipment/brands other than those listed in **ANNEXURE-II**, that are better or equivalent with regard to quality and performance substantiated with appropriate documents.

14.0 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 Chapters

(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, continuous72 (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 Chapter-'Substation Automation System.'

15.0 SITE SPECIFIC ENVIRONMENT MANAGEMENT PLAN

The Contractor shall prepare Site Specific Environment Management Plan to be implemented during execution of the Project. The following major activities shall be considered:

Labour recruitment: The Contractor shall give preference to the use of local and regional labour provided that it is consistent with the requirement of good workmanship based on the need of the project.

Staff training and sensitization: At the beginning of works the Contractor shall organize training and awareness-raising workshops intended for his teams to improve their understanding to prevent or minimize the impact of their activities on the environmental and social aspects to promote good relations with the local people. Among others topics addressed should also include the following:

Likely environmental impact of works, good practices, preventive and corrective measures to be adopted; Rules and procedures for waste management at construction sites; Safety risks associated with the works, and preventive attitude to adopt; First aid and what to do in case of accident; General standards concerning relations with the local people; Risks and prevention of sexually transmitted diseases. The training and awareness sessions should be organized regularly and specifically when new workers are recruited. Feedback and training during the works and after the monitoring and control exercise. Moreover, in conditions that previous sessions have failed to achieve desired results additional training and awareness activities can be considered.

Demarcation, signing and closing of worksites: Setting up warning signs at worksites to limit the access of persons, machinery and equipment into construction areas and confine the works related to the construction process to the allocated areas.

Access to private property: Contractor shall coordinate with the Employer for the access of private property, if required. Crossing of private property shall be subject to prior notification to the owners and conducted in such a manner as to minimize damage to crops or other property on the land.

Discovery of relics of historical and archaeological importance: In the unlikely event of discovery of historical relics, the works will be interrupted temporarily and the discovery notified to the local authority responsible for cultural heritage in order to determine the appropriate course of action.

Restoration of sites: After the infrastructure has been put in place and the construction sites and equipment depots cleared, the sites should be rehabilitated without undue delay in the original condition or better, unless there are plans for future use requiring that such sites be left in their current state.

Storage and handling of hazardous substances: Hazardous substances such as oils, lubricants or other hazardous substances likely to contaminate surface or ground water and soil should be stored or handled in premises specially designed for this purpose, in order to protect the environment and human health. If the handling of oils and fuels is necessary, demarcated and waterproofed areas that may contain any spills must be provided.

Maintenance of equipment: Maintenance of equipment should not be performed immediately at the work site as far as practicable.

Air quality and noise pollution: Care must be taken to ensure that all equipment, machinery and vehicles used for works and equipped with a combustion engine are in good working conditions to limit undesired emission of air pollutants and noise nuisance.

Construction works that could cause noise should be performed only outside normal rest hours near residential areas. When noisy works must be carried out close to schools or other noise- sensitive receptors, working hours should be so scheduled as to limit the nuisance caused.

It is forbidden to burn in the open any kind of household, industrial and toxic or hazardous waste, project induced waste and all types of scrap metal.

Transportation of equipment: Equipment for overhead lines will be transported by existing roads up to the point nearest to the installation site. Thereafter, it will be transported manually to the site without opening up any access paths. When crossing the land between roads and installation sites, care should be taken not to damage vegetation, agricultural land or any other property on the land.

Unrolling of cables: When cables are being unrolled, necessary precaution should be taken to prevent impact on tree vegetation, crops and other property on the land crossed by the cables. If necessary, temporary gantry-like structures should be used to facilitate crossings.

Restoration or damage compensation: If the works on private property cause damage to crops or other property, the Contractor must proceed with the repair of such damage or, where this solution is not sustainable, with the fair and timely compensation of the owners.

Management of material from digging trenches: Uncontaminated soil from excavations will be reused to backfill the trenches of underground lines. Any such soil that cannot be reused is deemed to be waste and must be conveyed to its final destination. Its uncontrolled spread is prohibited in places where it could cause damage. Minimum dust on ground policy is to be used to prevent dust associated pollution after the construction.

Sensitive Areas: From an environmental point of view, wetlands, swamps, and bogs should be avoided when planning underground cable as these habitats may suffer severe or even irreparable harm. Also sensitive water flows and archaeological sites should factor in route planning process.

Disruption of pedestrian and automobile traffic: When trenches are opened along the road, they should be barricaded, fenced off and warning signs placed at the worksites to ensure the safety of pedestrians, motorists and the staff carrying out the works.

There must be continued access to land and buildings located along trenches through installation of secure and clearly signalled temporary structures. This also applies to trenches that cut across the roadways.

Upon completion of the underground cable installation, the trenches should be

resealed and the pavement repaired as soon as possible, to ensure its durability and the absence of irregularities that may present a traffic hazard.

Regular sprinkling of water shall be done to avoid dust pollution till the roads/sidewalks are reinstated.

Public information on electrical hazards, behavior and preventive measures: Before switching on the infrastructure installed as part of the project, the neighboring population should be informed in good time, through public meetings and/or distribution of information leaflets. The information provided to them should focus on the electrical hazards associated with the infrastructure and the behavior that would allow them to avert such hazards. The population of these areas should be particularly targeted.

Unanticipated Impacts identified during the construction should be mitigated in coordination with environmental and social monitors employed by Contractor, Consultant and Government separately.

16.0 SAFETY OF PERSONNEL

The maximum safety consistent with good erection practices in the case of work above ground must be afforded to personnel directly engaged under this contract. Reasonable measures shall be taken to afford adequate protection against material falling from a higher level onto personnel below. Requirement for Environmental Health and Safety Management Plan also specified in Vol I under 1.3.6.1 and Section 4 as Environmental Health and Safety Management Requirement.

17.0 SERVICE LEVEL AGREEMENT (SLA)

Support services (including Maintenance) for 3 years:

After the successful commissioning of the entire project, the contractor shall provide the support services which shall include maintenance of the system installed under the project for a period of 3 (three) years from the date of issuance of operational acceptance of the project.

The Scope of Work shall include the power infrastructure operation and maintenance support to be provided by the Contractor in respect of the system supplied under this project for a period of three years along with Supervision & Operation of the power distribution infrastructure along with communication network after the Operational Acceptance of the entire project, however during the execution of the infrastructure work it is expected that certain portion of the work if completed and put to service before the actual completion and commissioning of the entire project, then in that case also the support services including O&M shall be the responsibility of the contractor in accordance with this document, at no additional/ extra cost towards payment of support services (O&M) during this intervening period.

17.1 Single window service: The bidder shall provide a single window service to maintain SLA and in case of a joint bid only one organization shall be held responsible & accountable for the performance of the system as per defined SLA.

17.2 The bidder shall provide 24x7 support to NEA to comply with SLAs in case of any problem.

17.3 It shall be the responsibility of Contractor to resolve any related issues of underground system including HT, LT, DTs, RMUs and OPG Cable.

17.4 The Contractor is required to work with the Employer's technical personnel during whole SLA period. The Contractor shall support and build the capacities of local counterparts in the day- to-day management, operation and maintenance of the network. Contractor shall conduct on the job training for these counterparts to ensure

that they are able to maintain and operate the network in a stable and reliable manner in accordance with established Prudent Utility Practices.

17.5 The Contractor is required to provide field personnel for support service including Engineers, Supervisors etc. The numbers of field personnel shall be negotiated.

17.6 Scope of work includes but not limited to:

i. Operation and running of the Power Distribution Network.

ii. Maintenance and Repair/ replacement of defective equipment installed under the project.

iii. Predictive and preventive maintenance of the infrastructure.

iv. Additions and deletions after the commissioning of the entire project in the power distribution network is a dynamic phenomenon and shall be catered by the contractor. The network analysis with respect to the additions/ deletions in the power distribution network and designing of the network configuration shall also be carried out by the contractor.

v. Services to bring up any or all power distribution systems upon its failure and to restore the functioning of the same etc.

vi. Any future planning, estimation, augmentation and execution work for strengthening of the existing system shall be done by the contractor during the O&M period. Any material required for the above work shall be provided by the contractor on the same rates as per the award of original project.

vii. On the Job Training for NEA's Staffs for operation and maintenance for equipment and system installed under the project.

17.7 The cost for the SLA shall be deemed to be included in the cost of equipment in BPS.

18.0 GUARANTEE/ WARRANTY

The Contractor shall correct, without any delay and at its own expense, at any portion of the Work during defect liability period and extended defect liability period including any required correction in defective design, errors, omissions, or changes in documentation, or by providing a non-defective replacement within 3 days of notification of the problem.

The costs of replacement shall be at the Contractor's expense and shall include all shipping costs, duties, fees, and taxes, both to and from the Contractor's facility, and the appropriate technical advice and direction for removal of the defect and installation of the corrected Work including On-Site Services as required. In the event the System or any portion thereof, is down, the Contractor will begin the dispatch process of appropriate personnel as specified.

The Contractor's liability shall be limited to adjusting, repairing, or replacing the defective article(s) and providing technical support and direction in the correction of the Work. In case of replacement of the equipment on or after 2 year a new warranty period shall apply, such new warranty period shall expire on the date 12 months from the date of such replacement, repair, or modification.

If the Contractor shall fail to correct any defect within a reasonable time, Employer shall have the right to employ others to do so. The Contractor shall be liable for all costs and expenses thereby incurred by Employer.

The Contractor shall furnish Employer with a Deficiency incident report upon completion of each visit by such Staff and upon resolution of each inquiry.

The Contractor shall provide to Employer, within 15 Days of the end of each calendar

quarter, a list and description of all potential or actual problems.

ANNEXURE-I

List of Drawings

ANNEXURE- II

LIST OF PREFERED (SHORTLISTED) MAKE

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

(i) **The main protection relays from:** ABB, AREVA, SIEMENS, Fuji and Reyrolle / EusunReyrolle, Toshiba, Mitsubishi or equivalent.

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

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

(iv) **VCB from:** ABB, AREVA, CGL, Hitachi, Siemens, Mitsubishi, LG, Fuji, GE, Schneider 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 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.

ANNEXURE-III
Specification for Revenue Meter & Metering (Instrument) Transformer

General

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

Energy Meter

The Energy Meter shall have the following minimum requirement

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

ANNEXURE IV: DESCRIPTION OF ITEM IN BPS GIVEN IN SHORT

Sl. No.	As Given In BPS	Detailed Description
1	Erection hardware etc. as per technical specification	Insulator strings, Disc Insulators, Hardware, conductor, Al tube, bus-bar materials, cable trays, Bay MB, clamps, spacers, connectors including equipment connectors, Junction box, earth wire, earthing material risers, auxiliary earth mat (excluding main earth mat) buried cable trenches/PVC pipe equipment & lighting, all accessories etc. for the following:
2	Substation Automation System for 220/132KV substation (New) as per technical specification	Substation automation system for 132kV substation including hardware and software for remote control station along with associated equipment and switchyard Panel Room for following Bays (Bays as defined in the Technical Specification, Chapter 17 Substation Automation System) as per technical specification:
3	Pumping arrangement inside pump house as per technical specification	Pumping arrangement for HVW system & hydrant system complete with all piping, valves, fittings etc. inside pump house
4	Hydrant System outside pump house as per technical specification	Hydrant system, complete U/G & O/G piping and accessories etc. outside the Pump House except Hydrants for Transformer and Reactors.
5	HVW spray system, Hydrant system as per specification for Transformer / Reactor:	HVW spray system, Hydrant system and complete U/G & O/G piping and accessories etc. outside the pump house for Transformer / Reactor:
6	Lighting fixtures and Receptacles as per technical specification	Lighting fixtures and Receptacles (including accessories/ materials etc. as per requirement like junction box, cable/wires, flexible conduit (if required) from junction box to lighting fixture, mounting arrangements)
7	Heavy duty PVC conduit for light, fan points etc as per technical specification	Heavy duty PVC conduits as of 20/25/32 mm size complete with all accessories for Point wiring for Light points, Fans power points 5/15 amps with 2.5 sq.mm /4 sq.mm/6.0 Sq mm copper for circuit wiring and 1.5 sq.mm copper earth wire PVC insulated in green color including wiring for sub mains i.e., wiring from Lighting Panel to Switch boards.
8	Wiring for lighting panel to switchboard, fan etc as per technical specification	Wiring from lighting panel to switch boards, from switchboards to junction boxes for Light Points, Sub main, Power and Fan points with 2.5/4.0/6.0 Sq mm Copper wire as per technical specifications, complete in all respects.1.5 sq mm copper wire (Green) will be used for earthing inside conduits
9	Telephone junction box/tag block for exchange as per technical specification	Telephone Junction boxes/tag blocks to suit requirement of 32 telephone connections within the control room building , administrative block and firefighting building
10	Excavation as per Technical specification	Excavation in all types of soil and rock including backfilling disposal etc. for all leads and lifts
11	P/L of RCC(M25) as per specification	Providing and laying of Reinforced Cement Concrete (M25) including pre cast, shuttering, Grouting of pockets & underpinning but excluding steel reinforcement
12	Misc. Structural steel as per technical specification	Misc. Structural steel including rails, embedment, edge protection angles, gratings etc. but excluding the reinforcement steel and steel for lattice and pipe structures.

13	Construction of Rail cum Road as per technical specification	Construction of rail cum road as per drawing including all item such as excavation, compactions, rolling watering, WBM etc. but excluding concrete reinforcement and structural steel

Annexure V: Existing RTU Based SCADA and its Data Acquisition

1.0 GENARAL INFORMATION

1.1 Remote Terminal Units

The Load Dispatch Centre (LDC) controls and monitors the network of Integrated Nepal Power System (INPS) via RTUs located at its various outstations.
In addition to the above, two local RTUs have been installed at the LDC: one to handle local-control-center status inputs and analog inputs and outputs; and the other for training, maintenance and testing purposes.
Manufacturers of existing SCADA system are:
LDC facilities: SIEMENS, Germany
RTU facilities: ABB, Germany

1.2 Data acquisition principles for existing Substation

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

Remote Control

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

Status indications

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

Table 1.4: Alarms to be acquired from each type of bay

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

Measurements

- ❖ Busbar voltages (separate for each busbar and section) of all 220/132/33 kV Busbars.
- ❖ Active/reactive power for
  - All 220kV & 132kV Line feeders.
  - All 220kV, 132kV and 33kV Transformer feeders.

- Single phase current measurements for all 33kV lines participating in load shedding Scheme.

ANNEXURE VI :

Nepal: South Asia Sub regional Economic Cooperation Electricity Transmission and Distribution Strengthening Project

Project-level Environmental Management Plan

Output 2(i) New Butwal and Kushma Substations Expansion

Version: 3.0
Date: September 2024

Table of Contents

Acronyms and Abbreviations

ADB	-	Asian Development Bank
CFC	-	Chlorofluorocarbon
dB	-	Decibel
EHS	-	Environmental Health and Safety
EMP	-	Environmental Management Plan
EPC	-	Engineering Procurement Construction
GRM	-	Grievance Mechanism
H&S	-	Health and Safety
IFC	-	International Finance Corporation
LAeq	-	A-weighted Leq sound level
LARP	-	Land Acquisition and Resettlement Plan
OHS	-	Occupational Health and Safety
PCB	-	Polychlorinated Biphenyl
PMC	-	Project Management Consultant
PPE	-	Personal Protective Equipment
SEMP	-	Specific Environmental Management Plan
SF_6	-	Sulfur Hexafluoride
SPS	-	Safeguard Policy Statement
T&D	-	Transmission and Distribution
WBG	-	World Bank Group
WHO	-	World Health Organization

Introduction

ADB's Safeguard Policy Statement (SPS) 2009 requires that an Environmental Management Plan (EMP) be prepared to ensure construction and operation of the Nepal Electricity Authority (NEA) New Butwal and Kushma Substation expansion activities will be undertaken in accordance with its safeguard requirements.

This EMP provides the overall Project-level environmental management framework for the two substation expansion activities including new 132/33 kV and 33/11 kV transformers and new 33 kV and 11 kV feeders to increase distribution capacity. Table 1 provides details of these activities and their locations.

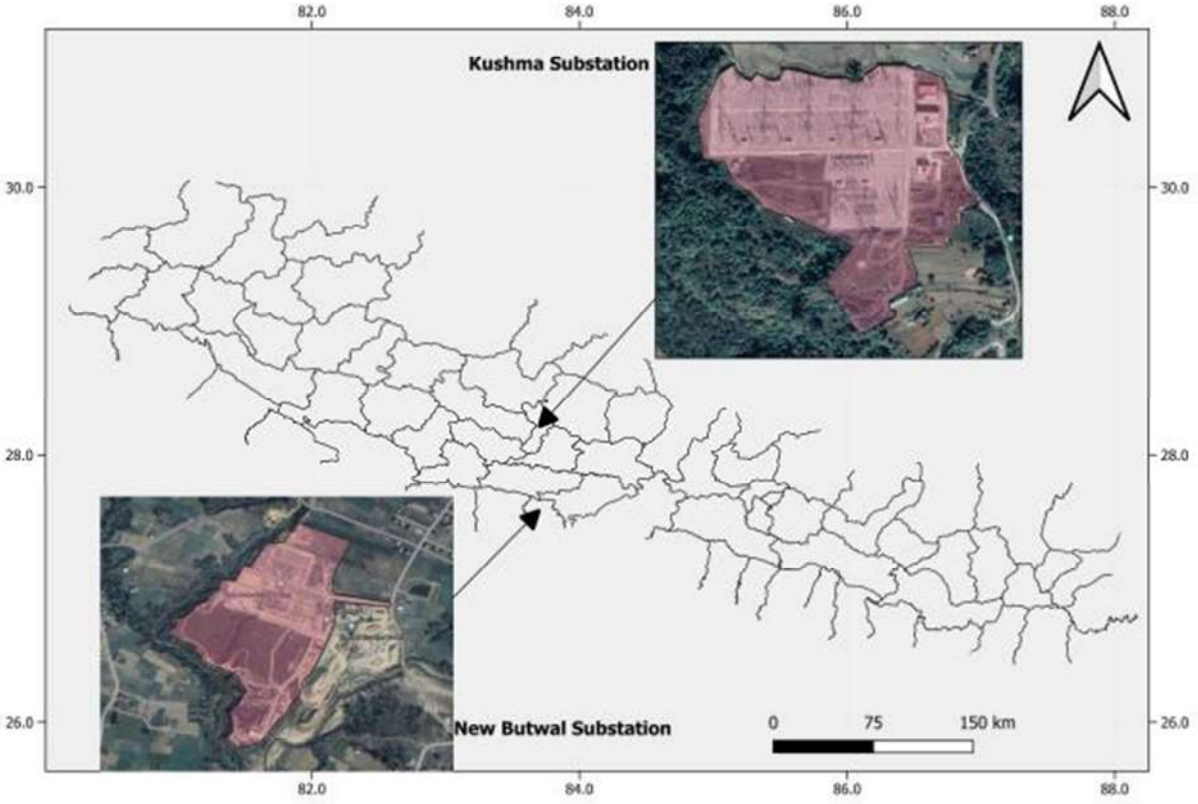
Table 1: Project Sub-components

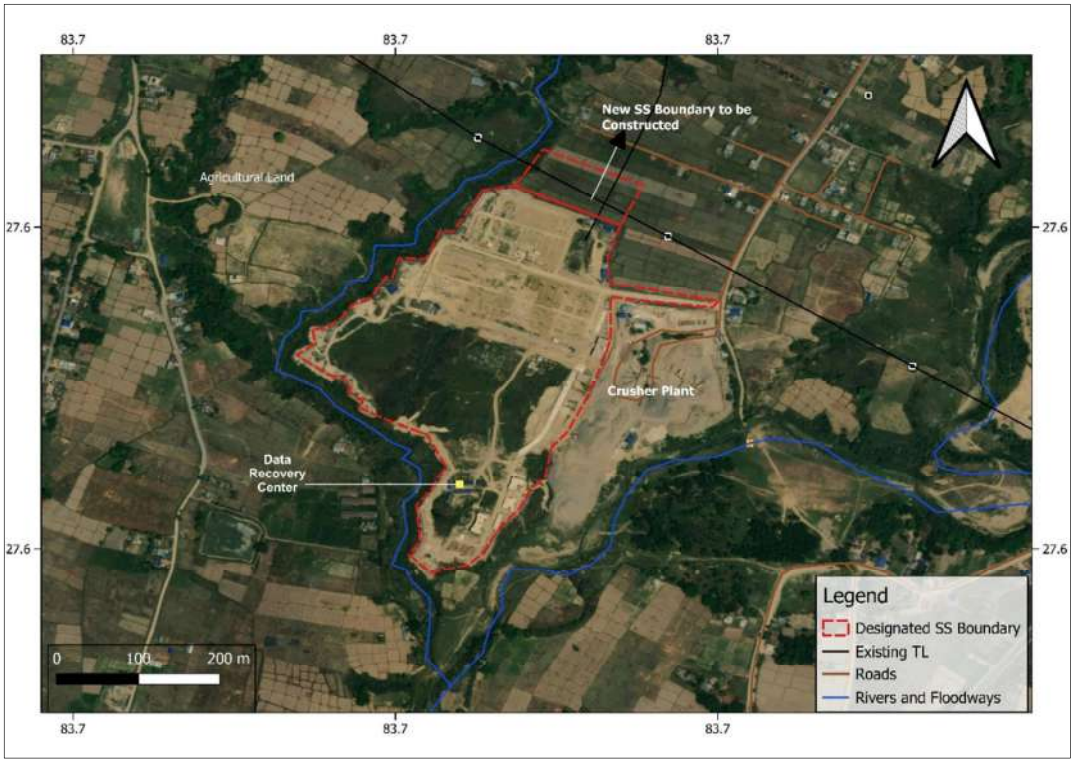
#	Project Details	Location details	District	Type of Land	Land Area (ha)	International or National Biodiversity Sites
1	New Butwal Substation	Sunwal Municipality of Ward No. 13	Nawalparasi West District	Agricultural land	12.2 ha (extension in 0.8 (total area 13 ha)	Located inside Nawalparasi Forests IBA
2	Kushma Substation	Ketichaur, Khurkot, Kushma Municipality of Ward No. 2	Parbat District	Switchyard Area	10.7 ha	None

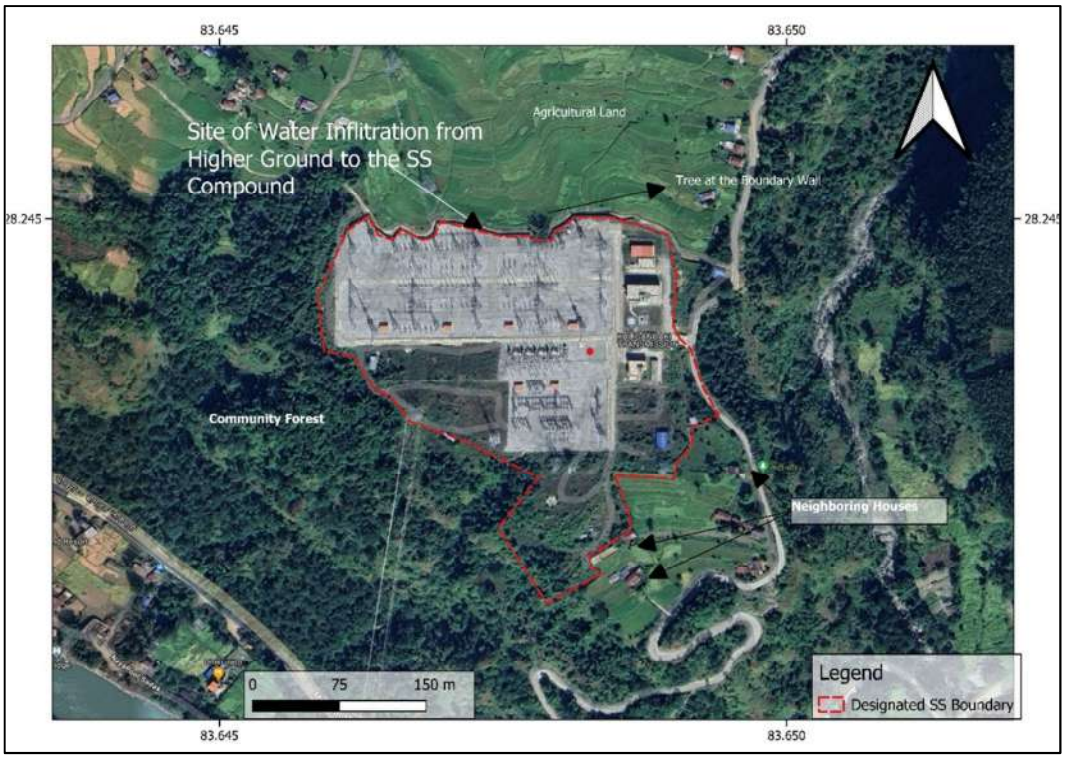
The existing New Butwal Substation is located in Sunwal Municipality-13, Nawalparasi West of Lumbini Province, in the Terai Plain, south of the East West Highway. The substation compound borders a natural stream (*kholsi*) and agricultural land to its west, agricultural land to the north, a stone crusher plant to the east, and Bhumahi river confluence to the south. The existing Kushma Substation is located in Ketichaur village, Khurkot, Kushma Municipality ward no 2, Parbat District of Gandaki Province. NEA has constructed an access road of approximately 1.5 km to the site from the Pokhara-Baglung Highway. The western boundary wall of the substation supports a local pathway that connects to the Kalibanjar Ketichaur Community Forest. The northern boundary of the substation has an old *Ficus religiosa* tree which requires regular trimming and maintenance. The agriculture land in the north is at higher elevation while the agriculture land to the south is at lower elevation. There are 6 houses near the southern boundary more than 100 m away from the switchyard.

Both activities involve expansion and strengthening of the existing 220 kV AIS substations. The works at New Butwal includes switchyard expansion (Figure 1) with fill and levelling work, installation of two 220 kV line bays, 2 three phase 220/132/11 kV, 315 MVA inter connecting transformers, 2 three phase 132/33 kV 63 MVA power transformers in existing bays, two 33/11 kV 24 MVA distribution transformers, transformer firewalls, swtichgear control room building, cable trenches, 12 indoor 33 kV VCB panels (8 distribution feeders and 2 incomer for 33 kV side of 132/33 kV transformers and 2 transformer panels for 33/11 kV transformers), 8 indoor 11 kV VCB panels (6 distribution feeders and 2 transformer incomer), substation automation and communication system, fire protection system (for 33 kV control room building and transformers), lighting protection system, relay and protection system, 160 kVA diesel generator set with acoustic enclosure, a boundary wall, side and cross drains and strengthening of the approach road. Likewise, the work at Kushma SS includes one 132 kV transformer bay, 1 three phase 132/33 kV 24/30 MVA power transformer, control room building, cable trenches, 5 indoor 33 kV VCB panels (4 distribution feeders and 1 transformer), substation automation and communication system, expansion of bus bar protection system, lattice or pipe structures, fire protection system, lighting protection system, relay and protection system, boundary wall, drainage system, pumps (dewatering pumps and booster pumps for firefighting water tanks) and underground water tanks for staff quarters.

Figure 1: Location of Substations Proposed for Substation Expansion







Method and Approach

The project-level EMP is an overarching document that will guide environmental management implementation, supervision, and monitoring of NEA and their EPC Contractor's activities under this component. It aims to ensure compliance with (i) ADB's Safeguard Policy Statement 2009 requirements and international good practice as set out in the related International Finance Corporation (IFC) Environment, Health and Safety (EHS) general and Electric Power Transmission and Distribution guidelines, and ILO's Safety and Health and Construction and worker accommodation guidelines, and (ii) applicable environmental, health and safety requirements of the Government of Nepal (GoN), including the international agreements which the GoN is a signatory too, as well as having cognizance of the sensitivity of local ecological and human receptors in the project area of influence.

The EMP provides summary information of the types of impacts and risks anticipated because of the substation expansion activities and provides detailed information about the required mitigation and monitoring measures with respect to the following stages: (i) design, (ii) pre-construction, (iii) construction, (iv) operation and maintenance as well as implementation arrangements and reporting requirements.

Prior to the approval of designs NEA will consult ADB regarding the need to update the IEE based on the final site layouts and designs put forward by the contractors. As required, the IEE will be updated for review, clearance and disclosure by ADB before design approval and the start of any related works including construction site establishment. To ensure the mitigation and monitoring measures are implemented a program of environmental supervision and monitoring will be undertaken during the project implementation by NEA and their Project Implementation Supervision Consultant (PISC).

The definitive version of the project-level EMP cleared by ADB is the most recent version disclosed on its website. The EMP is dynamic and can be updated as appropriate during the project implementation. However, any update to the EMP will first need to be reviewed and cleared by ADB.

The EMP will form part of all bidding and contract documents for all contract packages/lots and during design and pre-construction, construction and commissioning the contractors will be responsible for implementing all relevant measures for the works in their contract under supervision of the NEA. Any updates to it will be incorporated into the contract document. The contractors must always follow the definite version of the EMP which is the version disclosed on ADB's website. This includes any updates in response to unanticipated impacts. In addition, for any requirements for corrective action due to non-compliance, appropriate action will be agreed with ADB and taken by NEA and their

contractors to bring project implementation back on track. The contractors will cover the costs where corrective action is required due to non-compliance on behalf of the contractor, its subcontractors or third parties with the EMP.

Impacts and Risks

The main impacts of the substation expansion work include land degradation, soil erosion, surface and ground water contamination, ambient air quality deterioration, increased noise levels, and solid and hazardous waste generation. Pollution risks will remain during operation. Occupational health and safety risks and to a lesser extent, given the substations are fenced, community health and safety risks will be present during both the construction and operational phases.

New Butwal substation is located inside Nawalparasi Forests IBA, designated primarily due to its nesting population of white rumped vultures. The substation expansion works themselves will not directly impact on the notable bird species but they are associated with new distribution feeders to be installed by NEA outside the scope of the project. Many electrocutions of vultures have been recorded on the distribution network in Nepal. NEA need to ensure all new overhead distribution feeders emanating from the substation expansion and over the surrounding area to connect into existing lines adopt a bird sensitive design with covered conductor and adequate spacing or insultation at the poles.

Corrective Actions

This EMP sets out a broad framework for the management of potential impacts and risks that may occur at the expanded substation sites. Where necessary, site-specific actions will be required, including corrective actions for the existing substations at New Butwal and Kushma to be implemented through a corrective action plan (CAP) which is provided in Appendix A. The CAP has been developed following a site inspection/environmental audit by an external environment expert.

NEA will be responsible to apply any short-term corrective actions or delegate them to the EPC Contractor through the scope of the contract before access is granted for works on new substations located within existing substations. NEA will be responsible for submitting a report on the status of the short-term corrective actions to ADB for clearance prior to the EPC Contractor being given access to the existing substation in question to undertake works including site establishment. NEA will also be responsible for complying with any long-term corrective actions before commissioning of the substations by the EPC Contractors; NEA will undertake corrective actions that may involve works as either a separate undertaking or include it in the scope of the contract so that the EPC Contractor is responsible to address them. NEA will submit a report on status of long-term corrective actions to ADB prior to commissioning of substations by the EPC Contractors. EPC Contractors will be responsible for implementing any site-specific actions required at new substations as part of their contractual obligations, including corrective actions delegated to them, in addition to the general requirements of this EMP which are to be followed.

Environmental Mitigation Plan

The following tables provide the feasible and cost-effective environmental mitigation and project standards required during the design, pre-construction, construction and operation and maintenance phases for the project component activities listed in Tables 2 to 4 to reduce potentially significant, adverse environmental impacts and risks to acceptable levels and generally ensure international good practice, and national environmental, health and safety requirements are followed.

Some commitments that must be commenced during the design and pre-construction phase will continue to be implemented by the contractor during the construction phase. Operational phase mitigation measures are primarily for NEA. However, all maintenance works during this phase, including by the EPC Contractors during their defect liability period and any contractual operation or maintenance obligations, will also be undertaken following the construction mitigation measures.

Table 2: Design Phase EMP

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
Location of New Butwal SS in IBA	Electrocution and collision risk to birds from associated distribution feeders emanating from substation and future expansion of the distribution network	• NEA to ensure the associated distribution feeders follow applicable national laws and regulations including safety clearances • NEA to ensure the associated distribution feeders use covered conductors and are designed with adequate spacing or insultation at the poles [as per APLIC guidelines and distribution line components of the project in the short-term and, and the SOP to be developed under the project for distribution lines in IBA] • NEA to ensure future expansion of the distribution network uses covered conductors or ABC with adequate spacing or insultation at the poles per the SOP to be developed under the project for distribution lines in IBA	• ADB SPS (2009) • APLIC guidelines[1]	NEA NEA Associated Costs During installation of associated distribution feeders and expansion of the distribution network	NEA PMU / PISC
SS expansion at locations within and adjacent to existing SS	Corrective action	• Corrective action plan is provided in Appendix A and will be implemented.	• ADB SPS (2009) • IFC EHS General Guidelines • IFC EHS Electric Power T&D Guidelines	NEA NEA Counterpart Funds Before the contractor is given access to the SS	NEA PMU / PISC
		• Contractors at request of NEA to address any short-term or long-term corrective actions as part of their scope of works in construction of SS expansion works at locations which are also supporting existing substations.		EPC Contractor Include in EPC contract cost Before design approval for further implementation during construction phase	NEA PMU / PISC
	Removal of asbestos at	• If demolition of existing buildings or structures is required, then they will be surveyed by a	• ADB SPS (2009) • ADB Good Practice	EPC Contractor	NEA PMU / PISC

[1] https://www.aplic.org/documents

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
	existing substations	competent asbestos surveyor employed by the contractor during the design phase to confirm the risk of asbestos being present. The findings and recommendations of the survey will be submitted to NEA for approval. • If asbestos is found a method statement (Asbestos Management Plan) for its management and/or safe removal and disposal of asbestos as hazardous waste following international good EHS practices will be prepared and submitted to NEA for approval. • Removal and disposal of asbestos will be in accordance with the asbestos management plan. Site will need to be confirmed "clean" by a competent asbestos surveyor before any works on the new SS will be started.	Guidance for the Management and Control of Asbestos: Protecting Workplaces and Communities from Asbestos Exposure Risks	Include in EPC contract cost Before design approval	
	Contaminated Land	• New substations making use of existing substations will be surveyed by a contaminated land professional employed by the contactor during the design phase to assess the potential for soil contamination to be present in the area proposed for works (Phase 1 Site Investigation). • If signs of potential contamination are present in this area, e.g., oil storage tanks, old leaking transformers, oil staining, etc. soil sampling and testing shall be undertaken in the proposed work area to determine the level of soil contamination. • The findings and recommendations of the survey will be submitted to NEA for approval. • If soil contamination is noted in the work area, a method statement for the management and/or removal and disposal of the contaminated soil as	• IFC EHS Guidelines: Contaminated Land (2007) • IFC EHS Guidelines: Hazardous Materials and Waste Management • Stockholm Convention	EPC Contractor Include in EPC contract cost Before design approval	NEA PMU / PISC

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		hazardous waste following international good EHS practices will be prepared and submitted to NEA for approval.			
Siting and design of Project infrastructure	Finalization of substation design and layout	• Design and layout to reflect the requirements of the EMP and international engineering best practices/good EHS practice • Comply with all applicable national and state environment, health, and safety (EHS) regulatory requirements in addition to the mitigation measures set out in the EMP – if there is any conflict between national requirements and measures set out in the EMP the most stringent provisions will take precedence • Ecologist to undertake a habitat survey and tree inventory per the EMoP checking against the findings of the IEE • Design to minimize visual impact and clutter, buildings will be designed In keeping with the existing substation and/or local vernacular • Design to minimize visual impact and clutter, buildings will be designed In keeping with the existing substation buildings and/or local vernacular, albeit structurally sound etc. • Utilize landscape screening to screen the boundary wall and fences; these will need to be set back from the actual boundary to accommodate space for the vegetation. • In undertaking design, contractor with NEA to consult with communities in 500m of the site	• ADB SPS (2009) • IFC EHS General Guidelines • IFC EHS Electric Power T&D Guidelines • ILO Worker Accommodation[2] • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before design approval for further implementation during construction phase	NEA PMU / PISC

[2] https://www.ilo.org/media/340691/download

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		boundaries to get their views and input into the site layout (records of consultations are to be kept) • Cut and fill requirements shall be minimized by design to reduce changes in topography and the extent of earthworks and thus dust generation during construction. Contractor shall quantify the extent of earthworks required and locations for disposal of excavated spoil such as through landscaping within SS site. • Quantify the extent of earthworks required and locations for disposal of excavated spoil such as through landscaping on site. Landscaping must ensure the resulting slope design/topography does not exacerbate soil erosion. • Designs will keep new impermeable surfaces to a minimum. • Cable trenches will be kept fully covered at all times to prevent H&S incident or small wildlife falling into them. • Design to provide spill prevention kits (sorbent pads, loose sorbent material, etc.) at storage areas and other at-risk locations within clearly labelled containers. • Locate new transformers; storage areas; and septic tanks/soak away at least 50m from waterbodies and borewells to reduce pollution risk, if closer proximity is required due to site layout further assessment to be carried out to demonstrate using a source-pathway-receptor model there will be no adverse impact on aquatic ecology or human health.			

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		• Septic tanks/soak always will be placed away from drainage routes, waterlogged areas and shallow groundwater. • Internal access roads to be surfaced with asphalt or concrete. • For control buildings provide adequate natural and/or artificial lighting levels to meet the IFC EHS Guidelines on Occupational H&S (Table 2.3.3. Minimum Limits for Workplace Illumination Intensity) and take a life-cycle approach to detailed design, considering the use of construction materials and the energy and water efficiency of the building during operation adopting the "green building" concept e.g., using natural ventilation for reducing the need for air conditioners. Exhaust fans to be provided in kitchens and toilets. Detailed design is to include rainwater harvesting and enable NEA to readily fit solar panels on building rooftop once operational. • Control building design will provide for sanitation and welfare facilities as per national regulations and international GIIP including indoor toilets with hand washing facilities (minimum of 1 unit to 6 males and 1 unit for 6 females shall be provided, it should not be necessary to go outside to use the toilets) connected to septic tank/soakaway and a dedicated cooking area with provision for non-wood cooking / clean eating area / rest area / segregated sleeping area for staff on-site etc. ILO worker accommodation guidelines to be followed - see annex on permanent accommodation provisions.			

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		• Dedicated shelter to be provided at the site entrance for use by security guards, shielding them from rain, wind, and extreme (hot / cold) temperatures. Separate accommodation will be provided for security guards on break. • All wastewater to be connected to existing sewerage system or septic tank with soak away so no untreated wastewater will be disposed of to surface water or ground in operation, septic tank/soakaway effluent to meet national general wastewater standards or IFC wastewater discharge limits, whatever is the most stringent. • Use of pit latrines and disposal of untreated sanitary wastewater is prohibited. • Design to ensure all lighting is of energy efficient LED type with solar powered LED lighting where practical Use of fluorescent/HPSV lamps will be avoided since they are less energy efficient/classed as hazardous waste for purposes of disposal. • Minimal outdoor lighting for H&S purposes to be installed to minimize disturbance to nocturnal wildlife. Outdoor lighting to be installed must be of low intensity with little or no blue wavelength and operated using passive infrared (PIR) technology movement sensors set at person height so as not to be kept permanently on overnight, it must be directional and shielded, so light does not fall outside substation boundaries. If lit externally buildings will be designed with non-reflective dark colored cladding materials to avoid reflecting light. • Ensure conductors and/or jumpers are fitted with			

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		"bird sensitive" design measures e.g. adequate separation between live and ground or and insultation.			
	Water supply	• Potable water will be supplied that meets national drinking water standards (full suite) as part of the design. • For on-site sources proposed undertake baseline water quality sampling per the EMoP to confirm suitability and as necessary design is to include additional water treatment, purification and storage facilities to facilitate safe drinking water supply. • Where a new drinking water supply for operation is required or additional water will be taken from an existing source the location, depth and other details of borewell to be informed by a detailed hydrogeological study also describing the availability of water taking into account climate change, mapping existing groundwater users, the current water abstraction rates and the additional volume of water required to be abstracted and the residual water balance at the end of the dry season. • Groundwater abstraction must avoid creating a water stress situation during the dry season for existing groundwater users and must ensure the baseflow of streams is not reduced. • If water supply is unavailable on site, ensure regular supply of bottled water meeting drinking water standards to be secured.	• ADB SPS (2009) • IFC EHS General Guidelines • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before design approval for further implementation during construction phase	NEA PMU / PISC
	Waste management	• Provide well designed, covered, segregated materials and waste storage area of sufficient size	• ADB SPS (2009) • IFC EHS General	EPC Contractor	NEA PMU / PISC

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		to accommodate all anticipated storage requirements, ensure storage areas can be locked, are well-ventilated and will not reach extreme temperatures. Ensure space also provided in the storage area for solid and hazardous waste garbage bins to be stored. Fuel/oil/chemical/waste storage areas must have an impervious floor and be bunded so that the capacity of each bund is sufficient to contain at least 110% of the maximum design storage capacity within storage area, bund will not be connected to the surface water drainage system. • Disposal of waste on-site is prohibited and adequate volume of waste storage areas including for used oil drums etc. need to be provided in the design. Garbage bins for the disposal of waste during O&M to be provided, they are to be enclosed with lids enabling waste to be segregated into compostable, recyclables by type, residual solid waste and hazardous waste. Composting of biodegradable waste may be permitted, thus design to incorporate enclosed composting facilities (enclosed to avoid attraction of vermin etc.) located away from the control building and any properties outside site boundary. Given the distance to solid waste management facilities incineration may be permitted on site if design incorporates an enclosed, small volume solid waste incinerator with stack and pollution control (containerized) that is designed for residence time and temperatures that minimize incomplete combustion for waste disposal and	Guidelines • GoN laws and regulations (Chapter 2 of IEE)	Include in EPC contract cost Before design approval for further implementation during construction phase	

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		GON emission standards, to reduce the volume of solid waste to be removed off-site given limited suitably engineered and licensed sanitary waste facilities in Nepal. The volume will be no more than 50 kg/hour. • Design will include provision for compactors to be used to reduce the volume of solid waste to be removed off site given limited suitably engineered and licensed sanitary waste facilities in Nepal.			
	Health and safety	• For all construction works undertake facilitated H&S risk assessment through a workshop during the design (and at other key stages) so it can inform both design and pre-construction preparations, considering both occupational and community H&S risks resulting from subsequent stages of the project. • Facilitated workshop will involve the design and construction team of the contractors and NEA operational staff. • All electrical hazards will feature written and visual warning signs that meet the IEEE standards to include the ISO 7010 "Hazard Type: Electrical Symbol" warning of the risk of electrocution with an internal fence for high-risk equipment • Design to include lightening protection and earthing including earth mats in control buildings • Design of control building to include emergency exits with emergency exit signage • Provide fully stocked, in-date first aid kit installed in a prominent, signed position, first aid posters and emergency contacts to also be displayed	• ADB SPS (2009) • IFC EHS General Guidelines/Occupational and Community Health and Safety • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before design approval	NEA PMU / PISC

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		• Provide eye wash station and water supply to shower located near storage areas for fuel/oil/chemicals			
	Fire safety	• All substation buildings and other project facilities will be designed and constructed according to national fire safety standards, emergency response planning and response as well as international engineering best practice/good EHS practices • Separation walls or fire barrier walls shall be provided between the transformers and between transformer and nearby building. • Buildings including security cabin and high-risk locations outdoors to include smoke and/or heat detectors • Provide automatic fire alarm and fire suppression system in control building and at high-risk locations outdoors. • Provide sand buckets, full of sand, placed in a prominent, signed location near to fire-risk locations such as transformers and oil storage areas • Provide fire extinguishers (including for oil and electric fires) in a prominent, signed location in all buildings and security cabin and near to fire-risk locations such as transformers, DG sets, and oil storage areas with service and expiration dates clearly labelled along with posters on fire safety.	• ADB SPS (2009) • IFC EHS General Guidelines • IFC EHS Electric Power T&D Guidelines • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before design approval	NEA PMU / PISC
	Access to substation	• Include a secure boundary fence or wall that is sufficiently high it cannot be climbed over to prevent illegal access, provide a gated, surfaced vehicular access for entry/exit off public highway	• ADB SPS (2009) • IFC EHS General Guidelines	EPC Contractor Include in EPC contract cost	NEA PMU / PISC

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		having adequate sight lines for all drivers and warning signs of entranceway for road users. • In addition to secure boundary fence the switchyard and transformers in it to be securely fenced to prevent unauthorized access to electrical equipment. • Fencing designs for safety to and from wildlife. Stronger, higher walls with spikes, to prevent small mammals such as monkeys and also unauthorized person's intrusion.	• IFC EHS Electric Power T&D Guidelines • GoN laws and regulations (Chapter 2 of IEE)	Before design approval	
	Access roads	• No new permanent access roads will be constructed. • Existing access roads to the substations will be surfaced with asphalt or concrete prior to the commencement of works to minimize dust impact, the contractor will be responsible for surfacing the roads - the road level must not be increased without adequate drainage being provided to avoid surface water entering adjacent properties where present. • Road safety signs including speed limits to be placed on the access roads. • Speed limits for traffic once turning off the highway will be capped at 20 km/hr. • National speed limits to be followed on the highways.	• ADB SPS (2009) • IFC EHS General Guidelines • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before design approval	NEA PMU / PISC
	Geohazards, slope stability and climate hazards	• Identify presence of any unstable land/steep slopes and avoid these during the detailed design. • Select an appropriate design for all civil and structural components including foundations	• ADB SPS (2009) • IFC EHS General Guidelines • IFC EHS Electric Power T&D Guidelines	EPC Contractor Include in EPC contract cost Before design	NEA PMU / PISC

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		considering climate factors, seismic and slope stability risk • All buildings will be designed in accordance with national building safety codes and standards for earthquake resistance plus international good practice seismic design standards. • Designs to be checked for seismic safety by design team and by an independent expert, separate to design team, to confirm international good practice seismic design standards are met. • Identify any unstable land/steep slopes and avoid these in the layout. • If SS sites are not on flat land conduct geotechnical/slope stability analysis with slopes to be graded with drainage installed to minimize landslide risk. Ensure resulting slope design/topography does not exacerbate surface erosion and/or trigger a landslide; all disturbed areas are to be revegetated. Bioengineering methods can be considered for providing slope protection. • Project components on slopes must incorporate slope stability measures such as bioengineering methods and retaining walls with adequate drainage to avoid exacerbating surface erosion and/or triggering a landslide. All designs for works in steep topography to be checked by design team and an independent geotechnical engineer, separate to design team, to confirm national standards and international good practice are met. • Identify presence of floodplain, drainage routes or	• GoN laws and regulations (Chapter 2 of IEE)	approval for further implementation during construction phase	

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		depressions that get waterlogged in the rainy season and avoid these during detailed design. • Conduct flood and drainage risk assessment and incorporate effective drainage design (at 1 in 100 years allowing for climate change) to prevent possible flooding or waterlogging of SS equipment during the wet season. • Final surface level of substation will be at least 0.5 m above the existing ground level or highest flood level including an allowance for climate change based on the findings of the climate change assessment prepared for the Project (whichever is higher) • Place electrical equipment above the flood level whilst ensuring that surface runoff from the project site is no more than the greenfield runoff rate through attenuation on site (retention ponds) to avoid exacerbating flooding of the adjacent land. • All designs shall incorporate climate change adaptation measures per the climate risk assessment for the project.			
	Drainage	• Identify and inventory the presence of surface water including streams/ponds and groundwater sources including springs/wells/pumps within the site boundary and adjacent, confirming if any are used by the local communities for drinking water or other purposes • No surface drainage will be permitted to discharge directly to surface water bodies, detailed design to include sediment traps and oil interceptors to be fitted. • Provision of oil-water separator on all surface	• ADB SPS (2009) • IFC EHS General Guidelines • IFC EHS Electric Power T&D Guidelines • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before design approval for further implementation during construction phase	NEA PMU / PISC

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		water drainage before discharge off-site. • Internal roads will have a camber to allow surface water to run off with side and cross drainage provided.			
Equipment specifications and design parameters	Polychlorinated Biphenyls (PCB)	• PCBs will not be permitted for use in any transformers at substations or in any other project facilities or equipment. • Transformers will have supplier certification starting they are PCB free with an MSDS provided for the transformer oil confirming it. • Existing transformers will be tested to confirm they are PCB free. • New transformers and existing SS transformers (once the PCB testing is complete) will be labelled as PCB free. • Processes, equipment, and systems not to use chlorofluorocarbons (CFCs) including halon.	• ADB SPS (2009) • IFC EHS General Guidelines • IFC EHS Electric Power T&D Guidelines • Stockholm Convention • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before design approval for further implementation during construction phase	NEA PMU / PISC
	Exposure to electromagnetic interference	• Designs to comply with the reference and peak levels of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) for EMF occupational and community exposure will be achieved within the substation and outside of the fence line respectively. • Contractor to provide EMF calculations to the PISC for review and approval. • Use of shielding equipment/materials to decrease electromagnetic field exposure included at any substation where calculations identify levels above ICNIRP reference levels at properties close to the substation.	• ADB SPS (2009) • IFC EHS General Guidelines • IFC EHS Electric Power T&D Guidelines • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before design approval for further implementation during construction phase	NEA PMU / PISC

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
	Exposure to noise	• Ensure maximum sound power level of equipment at 1 m is 70 dBA through use of sound attenuation. The quietest available equipment with manufacturer supplied noise mitigation will be installed. In areas where 85 dBA will be exceeded OHS noise warning signage identifying that ear protection to be worn must be installed as part of design. • Layout substations so transformers, diesel generators and other noise sources are the furthest distance possible from the adjacent receptors to minimize corona noise/transformer hum experienced. Contractors to ensure that the design enables operation to always comply with 1-hour LAeq 70 dB(A) at the site boundary plus 55 dB(A) at the nearest commercial receptor, 45 dB(A) at the nearest non-rural residential properties, and 40 dB(A) at the nearest rural residential properties and outside the fence line in a quiet area. If levels are already exceeded the level is not to increase by more than 3dB(A) above the background. • Given transformers are generally in the range 60-80 dBA at 1m they are to be located at least 5 m inside the substation site boundary but this distance will need to be increase to between 20m – 100m depending on the land use adjacent to the substation for noise limits to be met without additional attenuation. DG sets will similarly need to be located away from the SS boundaries. • If the noise levels at the site boundary or receptors cannot be met through siting alone,	• ADB SPS (2009) • IFC EHS Guidelines – Noise Management (2007) • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before design approval for further implementation during construction phase	NEA PMU / PISC

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		then an acoustically designed enclosures or fences will be installed around either the noise source and/or substation boundary to enable the required noise level to be met as a permanent installation as part of the design. • If residential properties or other sensitive receptors are near the substation boundary, then measurements must be carried out during detailed design and baseline noise calculations (modelling) considering low frequencies associated with transformer hum will be undertaken by the Contractor to demonstrate that the noise standards/guidelines can be met. If background noise levels already exceed the standards/guidelines the design must ensure that noise levels result in a <3dBA increase in background.			
	Hazardous Materials	• No asbestos containing materials of any type will be used in the design and construction of project facilities.	• ADB SPS (2009) • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before design approval for further implementation during construction phase	NEA PMU / PISC
	Oil Management	• Secure oil storage areas bunded to 110% of capacity with an impervious floor of sufficient size to accommodate all anticipated oil storage requirements will be provided. Ensure these storage areas covered, can be locked, are well-ventilated, will not reach extreme temperatures and are not connected to the surface water drainage system.	• ADB SPS (2009) • IFC EHS General Guidelines • IFC EHS Electric Power T&D Guidelines • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before design approval for further implementation during	NEA PMU / PISC

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		• Adequate volume of oil storage areas needs to be provided in the design to accommodate all anticipated oil storage requirements. • Substation transformers to be mounted on impermeable surface extending beyond the transformer footprint, bunded to 110% capacity and not connected to the surface water drainage system to collect oil spill, leaks, and overflows; transformers to be sited in a separately fenced area that can be kept locked.		construction phase	
	Batteries	• DC batteries will use lithium-ion in preference to lead acid or cadmium nickel to minimize the use of heavy metals. • Separate room for SS batteries to be provided with ventilation and exhaust fan for taking out fume gases in case of leaks. • Design to comply with GIIP for handling, storage and management of batteries.	• ADB SPS (2009) • IFC EHS General Guidelines • IFC EHS Electric Power T&D Guidelines • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before design approval for further implementation during construction phase	NEA PMU / PISC

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
	SF6	• Instead of SF6 insultation use of alternative insultation medium (such as Hydrophobic Cycloaliphatic Epoxy) to be considered as a preferred option. If no alternative use of SF6 in gas insulated equipment must be minimized as part of design. Design of any gas insulted equipment to comply with GIIP for handling, storage and management of SF6. • SF6 equipment to be hermetically sealed "sealed for life" units and be tested and guaranteed by the supplier to less than 0.1% leakage rate. Installation design and operated so that any leakage will raise an alarm requiring O&M staff to rectify the situation immediately. • Provide SF6 leakage detector at each substation • SF6 in fire extinguishers provided at substations to be avoided.	• ADB SPS (2009) • IFC EHS General Guidelines • IFC EHS Electric Power T&D Guidelines • Reducing SF6 Emissions in Electric Power Systems: Best Industry Practices – USEPA • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before design approval for further implementation during construction phase	NEA PMU / PISC
	Diesel generators	• Only "green" DG sets are to be used with supplier certification on meeting the project noise standards and GON emission standards. • DG sets shall be installed outside in an acoustic enclosure or housed in a separate building away from other buildings. DG sets to be provided with visco damper type vibration dampening pads (suitable for the loads and vibration they are to carry) with minimum vibration transmitted to the surface the DG rests on. • Stack emissions of DG set to comply with national emission standards with the stack height designed according to both national and the IFC EHS guideline requirements.	• ADB SPS (2009) • IFC EHS General Guidelines • IFC EHS Electric Power T&D Guidelines • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before design approval for further implementation during construction phase	NEA PMU / PISC

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
Detailed designs	Community Consultations	• Contractors to undertake and document meaningful consultations with potentially affected persons and local communities within 500m of the substations as well as other stakeholders including local authorities and public utilities during design in order that any concerns raised can be reflected in the choice of SS site layout and construction method.	• ADB SPS (2009)	EPC Contractor Include in EPC contract cost Before design approval for further implementation during construction phase	NEA PMU / PISC
	Review of documentation, update of the IEE	• Detailed designs will be reviewed by the contractor and NEA to confirm all measures required by the IEE/EMP have been adequately incorporated and that they reflect international engineering best practice/good EHS practice before they are approved. • Prior to NEA approval of the designs and commencement of construction, ensure that NEA have updated the IEE as required to reflect the final design, seeking ADB clearance of any updated IEE before works start by contractor.	• ADB SPS (2009)	EPC Contractor Include in EPC contract cost Before design approval for further implementation during construction phase	NEA PMU / PISC

Table 2: Pre-construction Phase EMP

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
Management Planning	General, unanticipated impacts and corrective actions	• Comply with the definite version of the EMP which is the version disclosed on ADB's website. This includes any measures in an updated IEE following design or any updates in response to unanticipated impacts. • Comply with all applicable national and state environment, health, and safety (EHS) regulatory requirements in addition to the mitigation measures set out in the EMP – if there is any conflict between national requirements and measures set out in the EMP the most stringent provisions will take precedence • Comply with any corrective action plan required by NEA, contractor to cover the costs where corrective action is required due to non-compliance on behalf of the contractor, its subcontractors or third parties. • Do not engage in any activities described on the ADB Prohibited Investment Activities List in Appendix 5 of ADB's SPS (2009) • Ensure all subcontractors and third parties, irrespective of being formally or informally employed also comply with the EMP and any updates to it, as well as the CSEMP and that this responsibility is cascaded down any chain involved. • Put in place appropriate incentives and/or penalties for (non-) compliance by workers related to use of PPE, and any violations of the Contractors Code of Conduct.	ADB SPS (2009)	EPC Contractor Include in EPC contract cost Before the start of any related works including site establishment, preparation and clearance works then ongoing through project implementation	NEA PMU / PISC
	CSEMP	• Preparation for NEA approval and implementation of the CSEMP and its associated management sub-plans reflecting the EMP	• ADB SPS (2009) • IFC EHS General	EPC Contractor Include in EPC	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		requirements and international engineering best practice/good EHS practices-CSEMP shall include: 1 **Construction Method Statement** Identifying all construction activities, schedule, access routes, anticipated traffic volumes, and construction methods to be used as well as temporary construction facilities needed and their location e.g., laydown areas, stores, worker rest areas, toilets/washrooms, worker overnight accommodation etc. 2 **Pollution Prevention Plan and Emergency Response Plan(s)** Covering dust and emissions to air management, noise management, the protection of water resources and environmentally sound and safe storage, use, and disposal of all fuels, chemicals and oils used on site and an emergency preparedness and response plan in the event of any leaks or spills (e.g., of oil, etc.) or an incident such as flood. Particular attention to receptors in 500m and along access roads. Include clear schedule for damping of site and access roads, description of water resources requirement, and time and activity restraints. Include pollution monitoring procedures and pre-construction data. Including emergency response plan to be prepared for construction to deal with event of an accidental spill leak, including leakage of SF6 as a greenhouse gas. 3 **Occupational Health and Safety Plan including Risk Assessment and Emergency Response Plan(s)** See annex, H&S plan to include emergency preparedness and response plan including flow chart and contact details to deal with situation should any construction worker or community member be	Guidelines/Electric Power T&D Guidelines • ILO Safety and Health in Construction	contract cost Before the start of any works including site establishment, preparation and clearance works for NEA approval then implement throughout construction phase	

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		impacted. 4 **Community Health and Safety Plan including Risk Assessment and Emergency Response Plan(s)** Outlining all the relevant measures in this EMP relating to community health and safety. Community Health and Safety Plan shall include flow chart and contact details to deal with situation should any community member be impacted. 5 **Biodiversity Management: Invasive Species Control Procedures and Wildlife Encounter Protocol** Including (i) prohibitions on hunting, poaching, collection of firewood, restricted areas etc. (ii) a wildlife incident reporting procedure and emergency fauna rescue and handling procedure including contractors of forest officials, nearest veterinary etc. (iii) measures to avoid the spread of invasive species, and (iv) a chance find procedure for routine findings of small animals encountered in work areas. 6 **Solid and Hazardous Waste Management Plan** Dealing with all solid and hazardous waste as well as wastewater generated in an environmentally sound and safe manner. Where possible it will ensure surplus materials will be reused or recycled, disposal will be the last resort. Plan shall also set out waste monitoring procedures. 7 **Traffic Management Plan** Including detailed site access route and receptors adjacent, parking areas, traffic controls e.g., speed limits, delivery timings, ensuring use of well-maintained vehicles, access road improvements, driver training and permits etc. Considering both the			

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		safety of pedestrians and vehicles and need to avoid traffic congestion; it is to be developed in consultation with relevant local authorities to ensure proper execution of traffic controls including where temporary blockage of a road or footpath is needed for installation. 8 **Labor Management Plan** Addressing employment of migrant workers, sanitation and welfare, gender-based violence/sexual exploitation, abuse, and harassment prevention etc. Including details of construction camp site/overnight accommodation meeting the requirements of ILO for labor accommodation, see annex. 9 **Code of Conduct** 10 **Chance Find Procedure for physical cultural resources** Measures for coming across unknown archaeology during works including stop works and reporting to the Department of Archaeology. 11 **Communication Plan** Outlining stakeholder consultation for the construction period. Provides a schedule for regular meetings, includes different communication methods as identified in the IEE. 12 **Training and Induction Plan** Describing the types of EHS training required during construction for staff, schedule of training to be included. • CSEMP and its associated management sub-plans will be living documents, to be updated as required and re-approved by NEA as construction proceeds, if construction methods or site conditions change, in response to an incident, near miss etc.			

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		• CSEMP will identify all temporary construction facilities needed e.g., laydown and storage areas, temporary workers facilities etc.			
Regulations, permits etc.	Permits and Licenses	• Acquire all requisite environment, health, safety and labor permits and licenses for construction activities or construction plant as required by national laws and regulations, prior to the commencement of works and then maintain them. • Statutory H&S and labor requirements including permits, licenses, and insurances for all workers to be obtained and maintained. • Medical insurance will be provided for all workers with sick leave allowance of at least 12 days to ensure symptomatic workers do not attend site due to no work-no pay policies. • Insurance to include a community liability clause for payment of compensation in case of any accidents because of construction. • Where tree cutting cannot be avoided required clearances to be obtained from Department of Forests and all pre-construction conditions of clearances complied with prior to the start of related works. Since trees and vegetation are not to be cleared unless essential to allow construction the areas of vegetation to be retained must be marked off from the working zones.	• ADB SPS (2009) • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before the start of any works including site establishment, preparation and clearance works then implement throughout construction phase	NEA PMU / PISC
Temporary facility	Selection of temporary construction facilities	• Local communities within 500m to be consulted when selecting sites for temporary project facilities prior to finalization. • Provide a central covered warehouse for storage of construction materials etc.	• ADB SPS (2009) • Project LARP • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		• Only volumes of material required for the day's work will be stored on-site • No borrow pits or quarries will be established and only licensed off-site materials will be used. Due diligence will be undertaken before the contractor signs any contract with an existing borrow pit or quarry for fill material etc. This includes a review of the location, licensees etc. • No concrete batching or hot mix will be established. • All temporary facilities including material and waste storage areas and offices will be sited in agreement with NEA • Contractor to seek to locate all temporary construction facilities required including laydown and storage areas within the boundaries of NEA land (substations) except for overnight accommodation that could be provided in existing properties off-site. • If other public or private land is required for temporary construction facilities noisy and dusty facilities or those that may generate sediment laden runoff or wastewater (e.g., refueling areas, maintenance yards, storage areas, temporary worker camps) must be sited 500m from residential property and other sensitive receptors (houses, schools, clinics, temples, etc.) and 100m from surface water or groundwater resource. • Laydown and storage areas that are not potential pollution sources may be located 50m distant but must not block accesses or road use. • No temporary facilities will be established in forest or other natural habitat.		Before the start of any works including site establishment, preparation and clearance works then implement throughout construction phase	

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		• No public or private land requiring clearance of vegetation or supporting forest habitat or having waterbodies is to be used. No cutting of trees or mature vegetation clearance will be allowed for temporary facilities. • Temporary land use to be negotiated with private landowner and compensated by the Contractor in line with the LARP entitlement matrix, submit land ownership papers and copy of agreement for temporary land use with a photographic record of pre-project condition. • A photographic record will be made of the pre-construction condition of land used for temporary facilities before construction to inform the reinstatement works. • After completion of the construction work the temporary structures shall be completely removed and the land will be restored to its earlier condition.			
Staffing	Inadequate staff to provide supervision and oversight	• NEA, PISC and contractor are to appoint a suitably qualified and experienced, dedicated environment, health and safety staff as per the EMP requirements • Ensure each active construction site and subcontractor has adequate health and safety supervision to ensure the H&S of all workers and local communities • Do not discriminate and proactively encourage the employment of (i) suitably skilled women, and (ii) local employment for unskilled roles whilst ensuring suitably qualified and experienced workers for skilled roles; noting that all workers must be appropriately skilled given the hazardous nature of works.	ADB SPS (2009)	EPC Contractor Include in EPC contract cost with BOQ line for staff Staff in place prior to the start of construction and ongoing through project Implementation	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		• No child will be employed, and no under 18s will be engaged on construction site (hazardous work). • Provide medical/accident insurance for all workers (formal and informal) for the duration of their contracts as well as at least 12 days of sick leave for all construction workers. • National Policy of Labor Act 2074 (2017) to be abided.			
	Induction and Orientation	• NEA to prepare a detailed training plan upon loan effectiveness detailed how training and awareness raising activities required by the EMP will be conducted. • NEA to conduct training with support of PISC. Ensure all members of contractor's safeguards team, design team, and construction management team attend NEA EMP trainings. • Contractor to conduct their own trainings for their construction management and provide all workers and visitors on site, irrespective of them being formally or informally employed by the contractor, subcontractor or third party with an EHS induction before being allowed on site – induction to cover orientation on EHS requirements and roles and responsibilities in relation to EMP implementation, dos and don'ts in relation to the construction site, employer provided staff accommodation, code of conduct and interaction with local communities, IBA, forest habitat, interaction with wildlife etc. • Ensure topics covered by training and induction include, but are not limited to, good housekeeping at all times; environmentally safe and sound waste management practices;	ADB SPS (2009)	EPC Contractor Include in EPC contract cost Before the start of any works including construction site establishment then on an ongoing basis	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		hygiene and communicable disease prevention including HIV/AIDS; gender-based violence and sexual exploitation, abuse and harassment prevention; code of conduct, interaction with local communities and culturally acceptable practices; biodiversity conservation awareness; fire safety prevention; forest fire risk; prohibition on firewood and NTFP collection by workers; prohibition on trapping, hunting, fishing, or poaching by workers; chance find procedures; H&S including use of PPE; etc. • Contractors to carry out awareness raising for all construction workers about the GRM at the start of their employment on site including disseminating GRM contact details on noticeboards at construction site offices and at employer provided staff accommodation. Suggestion boxes to be provided for construction workers at construction site offices and at employer provided staff accommodation. • Prepare with guidance of health experts HIV/AIDS and communicable disease information video/brochures/leaflets for distribution to all workers during induction, covering factual health issues as well as behavior change issues around the transmission and infection of HIV/AIDS and other communicable diseases including improved sanitation. • Prepare with guidance of labor experts a worker Code of Conduct and information video/brochure/leaflet for distribution to all workers during induction addressing culturally acceptable practices etc. Code must be informed by the CSEMP and address the following			

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		aspects: ○ Zero tolerance in respect of health and safety ○ Requirement on always wearing PPE on site ○ Zero tolerance of bribery or corruption ○ Respect for local community and customs, avoiding community conflict situations especially for vulnerable groups ○ Zero tolerance of illegal and unacceptable activities/behavior, including but not limited to engagement in: prostitution; gender-based violence/sexual exploitation, abuse, and harassment; illegal sale or purchase of alcohol; sale, purchase, or consumption of drugs; gambling; fighting ○ Alcohol and drugs policy and testing regime ○ Role of workers in good housekeeping ○ Role of workers in maintaining good hygiene ○ Respect of wildlife and the environment ○ Description of disciplinary measures for infringement of the code of conduct and other employer rules (e.g., immediate removal from site, fine etc.)			
Communications	Advance Notice and Consultation on Works Schedule	• No works will start until NEA has locally disclosed the IEE and any update to it with executive summary translated into Nepali and any other relevant local languages via the NEA website, NEA offices, existing substations, and construction site offices.	• ADB SPS (2009)	EPC Contractor Include in EPC contract cost Before the start of	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		• Brochures and posters on the main findings of the IEE and where the full version can be accessed, as well as a translation of the executive summary of the IEE, will be printed in local language and made available/displayed for public scrutiny at places easily accessible to affected persons. • Directly liaise one-on-one with receptors immediately adjacent to site boundary and access roads to specifically notify them about the commencement of work etc. • Undertake face-to-face consultations with all communities, residents, schools, clinics, temples in 500m of the site and along access roads to notify them one month prior to the commencement of works of the intended start date and schedule • Prior to the commencement of works all activities will be announced in local papers and on site and local community notice boards at least once month prior to works • Provide information to the general public about the scope and schedule of construction activities and expected disruptions and access restrictions at least 72 hours before they occur. • Local communities as well as individual property owners within 500m are to be consulted when selecting sites for temporary construction facilities outside of substations prior to finalization of their location. • Road authorities will be notified when oversize heavy loads need to be transported and they will be escorted by the police		any works including site establishment, preparation and clearance works then implement throughout construction phase	

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
	GRM	• NEA with support of contractor to inform all potentially affected persons and local communities within 500m of substations as well as the GRM process and means of submitting project grievance to Inform all residents and businesses of the GRM in advance of works (at least one month). • Community awareness raising of the GRM will be undertaken verbally, through community meetings, one-on-one consultations with landowners; through the distribution of notices/pamphlets/posters; and through other media outlets. • Provide notice boards at all substations, construction site offices and active work sites including details of the GRM including the name, designation, contact numbers including phone/SMS/What's App, address of both the NEA and contractor's GRM focal persons plus the timeline and process of redressal together with a suggestion box that will be regularly checked for any grievances received.	• ADB SPS (2009) • Project GRM	EPC Contractor Include in EPC contract cost Before the start of any works including site establishment, preparation and clearance works then implement throughout construction phase	NEA PMU / PISC
Hydrology	Water Use	• Any piling, drilling or excavation works within 50m of boreholes and wells used as a drinking water source by local communities will require pre-construction and post construction water quality monitoring against GoN drinking water standards to ensure there is no contamination of the supply. • Construction water to ideally be sourced from an existing licensed commercial supplier (preferred option especially for potable water supplies) where available or rainwater harvesting. • If using an existing surface water or an existing	• ADB SPS (2009) • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before the start of any works including site establishment, preparation and clearance works then implement throughout	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		borewell for construction water, permissions to be obtained from authorities together with the agreement of local communities. • Prior agreement is required from local community users to use any existing surface water/borewell or local piped water either temporarily during construction or permanently for substations; in cases where use of local water source is not agreed contractor to import tanked water to the project area. • No groundwater will be used in districts without additional groundwater capacity – in other districts groundwater will not be used only after it has been confirmed through assessment there will be no additional stress on groundwater resources as a result.		construction phase	
	Water Pollution	• If any surface waterbodies or groundwater sources are within 500m, undertake a baseline water quality sampling as per the EMoP to confirm their current water quality status at least one week prior to the commencement of any activity onsite. • Plan for designated impermeable fuel/oil/chemical hazardous materials/waste storage areas bunded to 110% capacity and located at least 50m from surface water and groundwater sources. • Storage areas should be capable of storing all the hazardous materials used and waste materials generated. • Storage areas shall be well ventilated. • Fuel and diesel storage tanks will be sited in suitably sized and constructed bunded areas that are designed to be impervious to water and fuel.	• ADB SPS (2009) • IFC EHS Guidelines: wastewater and ambient water quality • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before the start of any works including site establishment, preparation and clearance works then implement throughout construction phase	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		The bund volume will be designed to no less than 110% of the tank volume. Loading and off-loading connections will be located over secondary containment. All health and safety provisions will be made for fire hazard etc. • Refueling procedure will be developed, which will include a restriction on refueling within 50m of any watercourse. Designated areas with impermeable surface will be assigned for refueling to minimize spillage to soil.			
Utilities and Infrastructure	Disruption to supply	• Check with relevant local authorities (electric, water, telecoms) whether there are known pipes, cables, or other utility lines and carry out a scan using cable avoidance tool to identify any unknown underground utilities prior to excavation. • Contractors to identify in consultation with service providers appropriate measures to minimize period of disruption to utilities and reduce health and safety risks during installation. If services must be disrupted contractors (via service providers if appropriate) to notify affected communities well in advance of any power outage etc. • Should utilities need relocating or required to be removed consult with the relevant utilities and local community to ensure that there is no change in supply because of these changes. • Obtain necessary clearances consistent with the regulatory requirements from other utilities that could be affected by the Project (municipality for street furniture, electric, water, sewerage, telecommunications, road, rail etc.) • All electricity and gas supply networks in the	• ADB SPS (2009) • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before the start of any works including site establishment, preparation and clearance works then implement throughout construction phase	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		Project area will be kept operational, particularly during the winter months. Liaise with the relevant utilities operators to ensure they remain operational. • In relation to cumulative impact liaise with other utilities regarding the timing and extent of other construction works in the same location and ensure plans for construction works are coordinated so emissions/disruption/ disturbance are minimized. • For private property or public utilities/street furniture that may be damaged during construction, including from potential breaking/drilling vibration damage (buildings, roads, drains etc.) photographic and/or structural pre-condition surveys are to be completed and agreed with NEA prior to any works, including site establishment. To be documented in a pre-project condition report, which will serve as baseline in case any inadvertent damage or vibration impact to property occurs. If risk of structural damage to adjacent properties from vibration identified due to current condition, consider alternative construction methods or temporary relocation of occupants during works if at risk.			
Occupational Health and Safety	General	• Strictly implement all the OHS measures outlined in the annex and all the measures outlined below. • Informed by risk assessment prepare H&S plan for approval by NEA in accordance with the IFC EHS General Guidelines on OHS, considering occupational and community H&S and including adherence to electrical safety standards and	• ADB SPS (2009) • Project GRM • IFC EHS Guidelines: Electrical Power and Distribution (2007) • IFC General EHS Guidelines: Occupational	EPC Contractor Include in EPC contract cost Before the start of any works including site establishment,	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		emergency preparedness and response plan with communication systems and protocols to report an emergency. • For all pre-construction and construction works comply with GoN rules and regulations for the protection of workers. • During construction works, ensure qualified first aider and trained fire marshal is always available on-site with an appropriately equipped first aid kit and appropriate fire extinguisher and other firefighting equipment immediately available for use. • Contractors will set up an accident reporting system for any health and safety incidents (near miss, minor, lost time, fatal) involving workers or community to be reported to NEA within 24 hours of occurrence with a response plan detailing the incident and how its reoccurrence will be avoided within 48 hours. Record of all incidents and response taken should include date, time, details of incident, treatment given and outcome, and lessons learnt for the future. Contractors will ensure all workers are covered by insurance to pay out in the event of a disability or fatality. • Emergency contact number and details for medical, fire, etc. are to be displayed in all construction sites. • Plan to include emergency drills to be held to ensure prompt response to medical incident or natural hazard that did occur.	Health and Safety • IFC General EHS Guidelines: Community Health and Safety • ILO safety and health in construction • GoN laws and regulations (Chapter 2 of IEE)	preparation and clearance works then implement throughout construction phase	
	Labour and accommodation	• Design of temporary worker camps/overnight accommodation to conform to national requirements and international good practice per the annex.		EPC Contractor Include in EPC contract cost	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		• Contractors to provide all basic requirements (beds and beddings, mosquito nets, artificial lights, natural light, windows and ventilation, fans, emergency exits, firefighting equipment, kitchen and dining halls, mobile charging points, toilets and washing facilities, potable drinking water, recreational space etc. The contractor shall ensure the camps established for providing accommodation to laborers engaged in construction activities meet the requirements which are set out in the annex. • No temporary worker camps/overnight accommodation will be established in forest or other natural habitat. • Shaded rest area that is accessible and can accommodate the number of workers at the active works site • Source water from an existing licensed commercial supplier (preferred option) where available		Before the start of any works including site establishment, preparation and clearance works then implement throughout construction phase	
	Sub-contractors	• All subcontractors and third parties irrespective of being formally or informally employed will comply with the EMP and updates to it, as well as this CSEMP, and this responsibility must be cascaded down any chain involved through their subcontract • All sub-contractors will be supplied with copies of the EMP and CSEMP. • Provisions will be incorporated into all works sub-contracts to ensure compliance with the CSEMP at all tiers of the sub-contracting. • All works subcontractors in the chain will be		EPC Contractor Include in EPC contract cost Before the start of any works including site establishment, preparation and clearance works then implement throughout	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		required to appoint an EHS representative who will be available on each work site at all times when their workers or their subcontractors are working during construction to support the main contractor in providing oversight of the subcontracted activities. • Use of work gangs and daily labor is highly discouraged due to less control over health and safety -- if used by any subcontractor in the chain the contractor will be required to provide additional environment, health and safety supervision.		construction phase	
	Grievance	• Establish a formal Grievance Mechanism for workers. • Carry out awareness raising amongst formally and informally employed workers including those of sub-contractors about the GRM at the start of their employment, including details of how to submit a grievance to the PMU/PISC and/or to the Contractor.		EPC Contractor Include in EPC contract cost Before the start of any works including site establishment, preparation and clearance works for NEA approval then implement throughout construction phase	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
Community Health and Safety	Dust, noise and vibration	• Contractor to undertake baseline noise and air quality monitoring per the EMoP to confirm current background levels in the project area at least one week prior to the commencement of any actively on-site. • Contractor will be required to measure and confirm the distance from their construction works to sensitive receptors to confirm if the noise standards can be met based on their construction methods or if temporary acoustic barriers are required. • Contractor to avoid soil compaction, piling, blasting and other vibration inducing activities as much as possible • If piling, blasting or other vibration inducing activities are to be undertaken for construction a detailed construction noise/vibration assessment is to be undertaken by the contractor to demonstrate how construction noise and vibration levels/guidelines can be achieved at the site boundary and nearest receptors and a piling/blasting management plan is to be prepared for approval. • In locations where this is unavoidable Contractor to identify properties within the zone of influence and undertake pre-construction structural surveys to identify level of risk. If risk of structural damage to properties identified due to current condition, consider alternative construction method or temporary relocation of occupants during works if at risk. Consider need to install monitors during construction to monitor structural movement. Structural or cosmetic damage to be repaired by Contractor to at least pre-project	• ADB SPS (2009) • IFC EHS General Guidelines/Electric Power T&D Guidelines • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before the start of any works including site establishment, preparation and clearance works for NEA approval then implement throughout construction phase	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		condition at their own cost.			
	Community Safety Awareness	• In conjunction with the local municipality or village head in rural areas plus the media organize health and safety campaigns including the distribution of posters, leaflets, and safety booklets to all households in Nepali or local language with strong use of graphics for construction and electrical safety community awareness raising activities in local communities and schools within 500 m of the new substations prior to construction and then again prior to commissioning of substations about how to avoid electrical incidents having greater emphasis on operational hazard and risks, etc. Materials will be written in non-technical language and will provide illustrations where practical. • Deliver face-to-face electrical safety awareness training to local children including their parents and/or their teachers at all educational facilities within at least 500m. • Provide construction work site safety awareness sessions at all educational facilities within 500m	• ADB SPS (2009) • IFC EHS General Guidelines/Electric Power T&D Guidelines • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before the start of any works including site establishment, preparation and clearance works for NEA approval then implement throughout construction phase	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		of any work zone and along access roads used by construction traffic. • Provide EMF awareness sessions at villages within 500m of substations. The awareness sessions should provide information regarding the findings of the IEE on EMF and specifically discuss best practice reference limits for EMF and how they have been applied to the Project. • Develop and distribute leaflets/pamphlets/posters to the local community especially those living close to construction camps covering (i) health awareness including HIV/AIDS/STDs and other communicable diseases, and (ii) the conduct of construction workers that can be expected. Materials will be written in non-technical language and will provide illustrations where practical. • Keep a record of the number of leaflets distributed and their locations.			
Physical Cultural Resources	Chance Finds	• In consultation with the local community contractor will maintain an inventory of above ground physical cultural resources adjacent to the site and along the access roads checking against the findings of the IEE, including any trees where prayers/rituals are performed, and take measures to protect them during construction. • A chance find procedure will be developed for implementation in the event physical cultural resources are found, to include the following procedures: o If suspected physical cultural resources are encountered, all works at the find site should be immediately halted;	• ADB SPS (2009) • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before the start of any works including site establishment, preparation and clearance works for NEA approval then implement throughout construction phase	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		○ The find should be assessed by a competent local official managing cultural issues, and procedures to avoid, minimize or mitigate impacts to such physical cultural objects should be agreed in writing with them. ○ Work should not begin until the procedures to avoid, minimize or mitigate impacts to the physical cultural resources have been agreed and implemented in full. ○ If avoidance is not feasible, and no alternatives to removal exist, and the project benefits outweigh the anticipated cultural heritage loss from removal which is unlikely unless in case of resource of local value, following clearance of Department of Archaeology and ADB the physical cultural resources should be removed and preserved using the best available technique in accordance with relevant provisions of national heritage protection laws and decrees. ○ Records should be maintained of all finds, including chain of custody instructions for movable finds. • All construction workers to be made aware of the chance-find procedure and types of finds to be reported.			

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
Biodiversity	Project Footprint	• Per the EMoP Contractors will employ an ecologist to undertake tree enumeration to quantify the number, size and species of trees to be cut by them. • Demarcation of the working area and avoid encroachment outside the agreed corridor of impact. Mature trees and sensitive habitats that need to be avoided during construction (e.g., specific trees that are to be retained) will be marked for protection. Do not clear any vegetation unless it is essential to allow construction. • Follow design drawings and implement careful construction practices to avoid damage to trees and vegetation. Only marked trees within the site are to be felled after joint verification with NEA and approval of the tree lists and confirmation contractor is meeting all permits etc.	• ADB SPS (2009) • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before the start of any works including site establishment, preparation and clearance works then implement throughout construction phase	NEA PMU / PISC
Waste Management	Old Equipment	• Disposal of old transformers and other hazardous wastes shall be per national regulations. Other wastes will be recycled using authorized vendors or suitably engineered and licensed waste management facilities for inert or solid waste. • If any PCB contaminated transformers are to be disposed of the use of facilities capable of safely transporting (closed trucks) and disposing of hazardous waste containing PCBs will be a requirement. • Any areas of oil leaks beneath existing equipment to be removed will be excavated, stored in labelled metal drums and returned to the Contractors facilities for storage according to method statements. The labelled containers will	• ADB SPS (2009) • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before the start of any works including site establishment, preparation and clearance works then implement throughout construction phase	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		include a reference number which correlates with the removed transformer which will be tested for PCBs using rapid test kits. • If the PCB tests indicate that the transformer oil is contaminated, the container containing the soils will be labelled as PCB waste. PCB waste shall be stored, handled and disposed of in line with national regulations.			
Procurement	Material Sourcing	• Considering relevant technical and commercial considerations, the Project will seek to purchase goods and services from within Nepal. • Environmental considerations will be included in the procurement process. • Contractors will use locally sourced materials as far as practical to reduce transportation, but all raw materials will be sourced only from existing licensed sources. • Only already existing state licensed borrow pits for land raising will be allowed for use. Provide copies of the borrow pit operator's license and permit before any materials from the borrow pit are delivered to site. • Materials will not be sourced from quarries in the beds or rivers or other permanent watercourses even if they are licensed. • Records to be kept of all the materials used and source with copies of licenses etc. • Procedures will be established to determine the acceptability of material storage conditions and to promote the minimization of storage volumes on-site.	• ADB SPS (2009) • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Before the start of any works including site establishment, preparation and clearance works then implement throughout construction phase	NEA PMU / PISC
Economy Employment and	Employment	• Targets for local recruitment from the local communities will be agreed with NEA based on	• ADB SPS (2009)	EPC Contractor	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
Livelihoods		initial assessment of the labor market for unskilled and semi-skilled work force. • Seek to manage employment expectations by explaining the number and type of opportunities in advance to local communities. • Applications for employment will only be considered if submitted via the official application procedure. • Recruitment procedures will be transparent, public, and non-discriminatory and open with respect to ethnicity, religion, sexuality, disability or gender. • Clear job descriptions will be provided in advance of recruitment and will explain the skills required for each post. • Job vacancies will be advertised in the local communities through appropriate and accessible media. • For unskilled use a 'ballot' system to ensure that employment is fair and not weighted to connected people for unskilled roles.	• GoN laws and regulations (Chapter 2 of IEE)	Include in EPC contract cost Before the start of any works including site establishment, preparation and clearance works then implement throughout construction phase	
	Workers' Rights	• Contractor to allow collective bargaining and ensure that ILO core labor standards to which Nepal is a signatory are upheld. • All employees will receive at least the minimum wage as defined by national legislation. • All workers will have contracts describing their job description and conditions of work and will have the contents explained to them.			
	Worker Rights	• Employee Code of Conduct will prohibit the workforce from participating in illegal activities, including use of illegal drugs, bribery and corruption or requesting or receiving gifts from			

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		communities. • Policy limiting alcohol consumption in construction camps will be applied • Workforce training will include a briefing on camp rules and awareness of local social issues and sensitivities. • No unauthorized access to, or use of, any camp facilities will be allowed. • Review measures to mitigate community health and safety impacts regularly, and consult community leaders every six months, informing them on the status of implementation and results, and discussing any changes needed to the Pollution Prevention Plan or the Community Health and Safety Plan in advance of proposed changes.			

Table 3: Construction Phase EMP

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
Training	Pollution Prevention	• Conduct bi-monthly training of workers on pollution prevention control including good housekeeping and how to clean up oil/fuel spills and dispose of contaminated sorbent material which would be treated as a hazardous waste. Include emergency preparedness and response procedures (drills) in case of spill. To include training for subcontractors before commencement of works. • Information will also be incorporated into the site induction process and will outline the role of personnel in the management of waste and emissions from site and spill response procedures. • Site induction training will be supplemented by regular toolbox talks with relevant personnel if inspections or audits highlight failings in waste management.	• ADB SPS (2009) • IFC EHS General Guidelines/Electric Power T&D Guidelines • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC
	OHS	• Conduct daily toolbox talks on pertinent topics related to the day's work and weekly training on occupational health and safety for all construction workers including refreshers. To	• ADB SPS (2009) • IFC EHS General Guidelines/Electric	EPC Contractor Include in EPC	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		include training for subcontractors before commencement of works. • Ensure workers with a specific role have attended specialized health and safety trainings related that role e.g., health and safety stewards, first aiders, fire safety officers, as well as ensuring workers have received task-specific trainings for working at height, demolition, working with electricity, etc. • Only allow suitably trained and qualified workers to work on electrical equipment and at height, these workers must have training record of attending suitable training course on electrical safety and working at height and be provided with and wear the appropriate PPE for their role. • No workers shall be allowed to work at height unless they have passed a vertigo test • Untrained workers must not be permitted to work with live electricity or to work at height.	Power T&D Guidelines • ILO safety and health in construction • GoN laws and regulations (Chapter 2 of IEE)	contract cost Throughout construction	
	Emergency Response	• Conduct monthly training involving all workers on emergency preparedness and response procedures (drills) in case of an occupational or community health and safety incident during construction works including fire, natural disaster, disease outbreak etc. To include training for subcontractors before commencement of works. • Emergency preparedness and response training for construction management will include modules on first aid and fire safety including include training on how to use first aid and firefighting equipment provided on-site, and scenario of potential or confirmed infection.	• ADB SPS (2009) • IFC EHS General Guidelines/Electric Power T&D Guidelines • ILO safety and health in construction • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC
	Driver Training	• Driver training, monthly, to include advice on behaviors to reduce the potential for disturbance, including use of horn, loud radios with windows open, switching engines off when	• ADB SPS (2009) • IFC EHS General Guidelines/Electric	EPC Contractor Include in EPC contract cost	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		not in use, strictly observing speed limits and not accelerating or braking aggressively.	Power T&D Guidelines • ILO safety and health in construction • GoN laws and regulations (Chapter 2 of IEE)	Throughout construction	
Communications	GRM	• Contractor's safeguards team will act as site GRM Focal and keep affected persons and local communities informed of the status of work and be readily available onsite to receive, document and deal with grievances at site level. • Encourage use of the GRM and clarify that this does not prevent affected persons from pursuing any legal action, if they feel it is needed, and inform communities about the ADB Accountability Mechanism and their possibility to resort to it if any grievance is not resolved by the project level GRM.	• ADB SPS (2009) • Project GRM • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC
	Worker GRM	• GRM will be available to all workers for receiving and handling complaints about unfair treatment or unsafe living or working conditions, ensuring no coercion nor reprisal. • Construction workers will be given access to register any grievances with the contractors or direct access to the NEA GRM Focal			
Air Quality	Release of Exhaust Gases and Fugitive Emissions	• Emission sources (vehicles such as excavators) shall be positioned as far as is practical from sensitive receptors. • Equipment and vehicles will be regularly maintained in accordance with the manufacturer's recommendations to maximize fuel efficiency and help minimize emissions; keep log of maintenance records. • Use diesel fuel that has a low sulfur content, less than 0.1% • Construction equipment and vehicles will meet national	• ADB SPS (2009) • IFC EHS Guidelines: Air Emissions and Ambient Air Quality (2007) • GoN laws and regulations	EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		emissions standards. • Hold valid emission certificates of all construction vehicles • Belching of black smoke is prohibited. • Limit engine idling to maximum 5 minutes. • The open burning of wastes generated by project-related activities is strictly prohibited. • Avoid the use of diesel- or petrol-powered generators and use mains electricity or battery-powered equipment where practicable. • Stack emissions of temporary diesel generator set or hot mix to comply with national emission standards with the stack height designed according to both national requirements and IFC EHS General Guidelines.	(Chapter 2 of IEE)		
	Siting of Equipment	• Stationary emission sources (e.g., portable diesel generators, compressors, etc.) shall be positioned as far as is practical from sensitive receptors.			

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
	Dust	• Construction entrance/exit wash bays shall be provided to control sediment, dust, invasive species spread and avoid scattering of mud on the access roads • Ensure an adequate supply of bowsers and carry out watering for dust control at least twice a day on the work site, more if needed, and within 500m of work sites in dry weather with temperatures of over 25°C, or in windy weather. Dust control measures will also be implemented on all access roads within 50m of receptors. Avoid overwatering as this may make the surrounding area muddy. • Vehicle movements will be restricted to defined access routes and demarcated working areas (unless in the event of an emergency). All internal roads and access roads to substations off the highway will be asphalt or concrete surfaced. • A strict speed limit of at most 20 km/hr will be enforced for construction vehicles. • A solid temporary fencing shall be installed around the boundary/works area to minimize the dispersion of dust, it will also function as a temporary acoustic noise fence to minimize the noise and visual impact. • Keep stockpiles of soil, aggregate and waste materials covered with canvas or tarpaulin when spoil heaps are not active to avoid suspension or dispersal of fine soil particles during windy days and to prevent disturbance by stray animals. • Earthwork operation will be suspended when the wind speed exceeds 20 km/h in areas within 500 m of any community. • Vehicles carrying fine aggregate materials will be sheeted with canvas or tarpaulin to help prevent dust blow and spillages.			

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		• Only use cutting, grinding, or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction, e.g., suitable local exhaust ventilation systems. • Undertake sequenced construction method and revegetate areas immediately construction activities are completed in one area rather than undertaking earthworks on all parts of the site to minimize the area of bare ground exposed at any one time. • Undertake weekly dust soiling checks of surfaces of adjacent properties during earthworks and help with cleaning of external surfaces of property if dust is evident. • If there is an increase in existing background air pollution or complaints are received contractor will be required to implement additional dust or noise mitigation e.g., barricading/isolating sources of dust, use of wheel wash etc. • Provide workers with N95 dust masks to be worn when ambient conditions are dusty or when dust generating activities take place.			
Hydrology	Water resources	• Construction activities must not limit the availability of or restrict access to water sources (e.g., wells) used by local communities. • Natural flow of waterbodies must not be obstructed or diverted to another direction. • No works to be undertaken within 20m of the banks of waterbodies to avoid bank slippage and loss of soil that would increase the turbidity of water. • Ensure that no construction materials or construction waste block existing drainage channels. Channels shall be kept open at all times to avoid disruption.	• ADB SPS (2009) • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
	Water pollution	• Follow liquid management and storage requirements listed below under 'soils' • No untreated wastewater will be discharged direct to surface waterbodies or groundwater. • All wastewater to be connected to existing sewerage system or septic tank with soak away, septic tank/soakaway effluent to meet national general wastewater standards or IFC wastewater discharge limits, whatever is the most stringent given the receiving source. • Self-enclosed portable toilets may be used where the wastewater generated is enclosed in a container and will later be taken offsite to a municipal sewage treatment plant for wastewater treatment and disposal. • Use of pit latrines is prohibited as is open defecation and urination and uncivil use of roads or private premises by construction workers. • Treated wastewater will be used for damping down earthworks and road surfaces to mitigate dust generation. • Construction site camps will be located at least 50m from water courses. • Ensure no hazardous materials are placed where there could be spill or leak into surface water. • Locate mobile generators and site construction equipment at least 50m from groundwater resources and surface waters. • Discharge of sediment laden surface water runoff directly into surface water forbidden. Construction of sedimentation ponds is required to allow sediment to settle out of surface water runoff before release of water into the downstream environment. Sedimentation ponds for treating surface water runoff to be adequately sized for the volume of runoff, contractor to provide design calculations for approval.	• ADB SPS (2009) • IFC EHS Guidelines: Hazardous Materials Management (2007) • IFC EHS Guidelines: Wastewater and ambient water quality • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		• Dumping of construction waste including excess spoil and concrete sludge into streams and drains will be prohibited to minimize siltation. • Provide spill prevent kits (sorbent pads, loose sorbent material etc.) at storage areas and other at-risk locations within clearly labelled containers.			
Soils	Soil compaction, topsoil and excavated materials	• Avoid compaction impacts outside the cleared areas i.e., vehicle movements will be restricted to working areas. In wet conditions minimize use of heavy machinery and consider temporary installation of removable steel plates to protect soil and vegetation. • Minimize removal of existing vegetation and topsoil. Topsoil disturbed will be separately stored and used to restore the surface of the excavated area. • On completion of works, stockpiled topsoil will be spread over the surface of disturbed areas (if not under hard surfaces) and used in the restoration of temporary construction facilities. Once the topsoil has been replaced it will be stone picked to remove any large stones which are not in keeping with the surrounding soil texture. • Revegetation of the soils will follow using native seed mixes to Nepal and the project area. • Records of excavated soil, generated waste, and transfer records will be kept. • If topsoil is stored for more than six months, the stacks will be monitored for anaerobic conditions and manual aeration will be undertaken if they develop. • Stored subsoil and topsoil will be segregated in a manner that avoids mixing.	• ADB SPS (2009) • IFC EHS General Guidelines • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		• Topsoil stacks will be free draining. Topsoil will be stored outside the running track used by construction plant, equipment and vehicles. • Soil storage areas will be protected from vehicle movements to avoid soil compaction. • Excavation will be limited to within the agreed corridor of impact. • Infertile and rocky material will where possible be reused as fill material around foundations. If it needs to be taken off site, it will be disposed of by licensed waste management operator at designated disposal area suitable for accepting inert wastes. No spoil shall be removed from site until the disposal locations have been approved by NEA. • Under no circumstances will excess materials be dumped on private lands, dumped or pushed into any river, stream or drain at any location. • Upon completion of subsoil and topsoil reinstatement, disturbed areas will be inspected jointly for signs of erosion, slope instability, topographic diversity, surface water drainage capacity and function, and compaction with the contractor implementing remedial measures where required.			

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	Soil erosion	• Schedule works during the dry season where practical to minimize any exposed areas subject to erosion by surface water runoff. • Temporary erosion control measures will be developed and implemented after initial land disturbance and if construction activity on the working areas is suspended over the wet season before full reinstatement of the site has been completed. • Rehabilitate any disturbed areas beyond footprint of the substation infrastructure footprint to at least original condition through revegetation using native species. • Slope stability measures to be implemented during construction to minimize landslide risk. • Temporary access tracks will be graded and sloped to prevent unnecessary flow of water across them and to minimize soil erosion.		EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC
	Soil Pollution	• Fuel, oil, and chemicals used to be kept under lock and key and stored in labelled, sealed containers on drip trays to provide secondary containment. They will be located on an impermeable surface and be under cover. This will be located at least 50m from any surface water course or seasonal water channel. • Mount plant containing oil and diesel on drip trays to catch leaks. • Refueling operations, equipment servicing and washdown to take place on an impermeable surface at least 50m from watercourses, springs and wells, with drainage directed through oil and grease interceptors before being discharged into a settling pond prior to discharge offsite. • Regular inspections and maintenance will be carried out of secondary containment areas to confirm that they are functioning effectively.		EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		• Provide sufficient absorbent materials (e.g., sorbents, dry sand, sandbags) on-site for soaking up fuel, oil or chemical leaks/spills. • Spill response equipment (absorbents etc.) will be available in hazardous materials storage areas. • All material safety data sheets (MSDS) are kept on site with the relevant materials. • Materials that can potentially react with each other will be segregated during storage. • Hazardous chemicals will be securely stored on site in a designated storage area. • Relevant personnel will be trained in safe use and handling of hazardous materials. • Relevant construction personnel will be trained in use of spill kits and disposal practices. • Vehicles delivering fuel or hazardous liquids will carry appropriate spill kits to allow an initial response to any spill to be deployed. • All mobile plant (excluding vehicles) will be integrally bunded or will be equipped with a bund or drip tray which will be regularly inspected and emptied to prevent rainwater accumulating.			
	Contaminated Land and asbestos	• Soil exposed to oil leakage from transformer equipment is to be removed from site for disposal as a hazardous waste. • Any soils within work sites that appear to be contaminated by leaked oil or fuel shall be removed and disposed of as hazardous waste, similarly asbestos will be managed per the Asbestos Management Plan.		EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC
Biodiversity	Project footprint	• Temporarily disturbed areas will be revegetated on completion of construction and the entire site will be	• ADB SPS (2009) • IFC EHS General	EPC Contractor	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		maintained free of invasive species. • Ground cover vegetation and trees to be retained where it is not needed to facilitate construction. • Demarcation of the working areas and avoid encroachment outside these areas. • Cut trees and cleared vegetation will be immediately removed off site.	Guidelines • GoN laws and regulations (Chapter 2 of IEE)	Include in EPC contract cost Throughout construction	
	Fauna	• Trees and vegetation to be cleared outside the breeding bird season, unless access to the substation site is limited due to seasonal weather conditions • Before cutting or trimming trees ecologist to check for presence of nesting birds or roosting bats. • On-site check for ground nesting birds by experienced ecologist prior to vegetation clearance if conducted during the bird breeding season. • If nesting birds are found present, work will not take place until the adult birds and young have left the nest. Meanwhile a suitably sized protection zone will be clearly marked around the nest site by the ecologist to prevent any accidental disturbance or damage. • Prior to earthworks, area will be checked by an ecologist for any signs of burrows etc. If occupied work will not take place in that area during the breeding season. Meanwhile a suitably sized protection zone will be clearly marked around the nest site by the ecologist to prevent any accidental disturbance or damage. Outside the breeding season only manual digging under close supervision of the ecologist permitted. • No works from 1 hour before sunset to 1 hour after sunrise to avoid disturbance to fauna. • No fauna to be injured by work, conduct walkover at start of each day to give fauna the chance to move on. Direct			

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		intervention by ecologist if need to relocate fauna outside the works area before start of work. • Excavated pits will be robustly fenced or covered to prevent fauna accidentally falling in, further an escape ramp will be provided to allow their escape. • Keep written record, supported by photographs of any animal relocations or casualties, including a cause of death if known.			
	Disturbance	• Contractor to provide firefighting equipment at work site with compulsory basic fire training for all workers and training drills undertaken in case of forest fire; in case of incident act swiftly to avoid fire spread. • Strict prohibition on workers to enter forest or natural habitat outside the working area, and on the purchase, sale and use of firewood, timber, NTFPs, hunting and poaching of fauna by workers. • Contractor to undertake regular, compulsory awareness raising activities for all workers related to prohibitions including toolbox talks and posting information and warning signs at site officers, accommodation, patrols by security guards employed by the contractor, regular inspections of accommodation, and disciplinary procedures for any contravention by workers etc. • Provide a good standard of worker accommodation with heating and meals to help discourage breaches of prohibition by workers. • Contractor to provide alternative fuel source (LPG) which will be stored in safe conditions in communal kitchen and for heating of accommodation.			
	Invasive species	• Removal and disposal of identified plant species in an ecologically sound manner. • Use wash stations at site entrance to pressure wash			

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		vehicles, plant and equipment before import to site and as needed on leaving site to minimize accidental spread. • Imported materials must be free of invasive plant species.			
	Pesticides	• Use of herbicides or burning to clear vegetation is strictly prohibited.			
Land Use	Damage to Property or cause detriment or inconvenience	• Condition surveys of access roads and adjacent properties to be completed before project commences. • Construction work will make effort to cause as little damage to property or cause detriment and inconvenience. If caused, NEA shall make full compensation. • All unanticipated damage to existing public and private property outside the site boundary shall be restored to pre-project condition and/or compensated at the cost of the contractor in line with the LARP entitlement matrix.	• ADB SPS (2009) • Project LARP	EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC
Waste Management	General impacts	• Excess fill from excavation works across the site to be balanced with fill. • Provide adequate facilities for handling and storage of construction materials to reduce the amount of waste that is caused by damage or exposure to the elements and a system for the collection/storage of wastes generated. • Any plant or equipment that is rejected during the installation and commissioning due to damage or failure to immediately be removed from the site and returned to the supplier. • Ensure that the waste hierarchy is followed including prevention, minimization, reuse and recycling -- maximum reuse and recycling of waste and timely removal of unusable waste according to national waste management regulations. • Restrict use of plastics and polyethene and use recyclable/biodegradable materials during construction to	• ADB SPS (2009) • IFC EHS Guidelines: Waste Management (2007) • IFC EHS Guidelines: Contaminated Land (2007) • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		the extent possible. • In locations where waste is dumped (existing site conditions) the contractor will clean the site and collect the waste for onward disposal before they commence their works. • Ensure sufficiently sized facilities are provided for the environmentally safe and sound collection, segregation and storage of waste (including from overnight accommodation) on-site, maximum reuse and recycling of waste by reputable, legitimate, licensed third parties and timely removal and safe transportation of unusable waste to a suitably licensed and engineered waste management facility with all waste transfer records retained. Keep copies of the waste management company's licenses on file. Document all volumes and types of wastes generated and removed off site (inert, solid, hazardous) using transfer • Leaving or disposing of construction wastes by burying them on-site or disposing of them at unlicensed waste management facilities is strictly prohibited. • Unsanitary open dumps are not to be used by the contractor or their third parties. • Municipal waste collection systems must not be used as this is likely to mean that the waste is open dumped, arrangements should be made for direct disposal to a suitably licensed and engineered waste management facility with all waste transfer records retained. • Burning of waste on-site is also strictly prohibited. • No construction material or waste to be poured or thrown into drains • Provide regular training of staff in waste management issues.			
	Recycling	• All recyclable waste (plastic, metal, paper, etc.) will be sorted on source and sent for recycling where facilities for		EPC Contractor	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		recycling of these materials exist.		Include in EPC contract cost Throughout construction	
	Domestic and Inert Waste	• No domestic waste shall be left at work sites. • Any spoil material from substation foundations will be removed from the site and sent to an appropriate state licensed waste management facility. • Ensure that wastes are not haphazardly dumped within the work sites and adjacent areas		EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC
	Hazardous Waste	• Use containers suitable for each type of waste. • Mark containers adequately specifying the waste types. • Do not mix various waste streams. • Remove waste at the completion of the work day and return it for storage at the appropriate Contractor facility before final disposal via a licensed contractor for hazardous waste removal and keep agreements with hazardous waste management company's active.		EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC
	Waste Tracking	• Keep copies of waste manifests on site. • Keep a record of waste on-site and waste removed.		EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC

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Noise and Vibration	Elevated noise levels and vibration	• Equipment and vehicles will be regularly maintained in accordance with the manufacturer's recommendations to help minimize noise emissions. • Only well-maintained modern equipment conforming with noise standards will be used at site. • Contractor to use suitably designed mufflers or sound reduction equipment on breakers/drills and ensure all leaks in the air line are sealed on them. • Work will be undertaken in daytime hours only – in accordance with IFC EHS definitions (7am – 10pm). • Noisy construction activity at substations (especially earthworks) only between the hours of 8 am - 6 pm except where no receptors in 500m. • Noise generating construction-related activities will be avoided during evenings, school hours, exam periods, prayer times, religious or cultural events near the sensitive receptors (within 500m). • No works on Sundays, holidays or festival days within 500m receptors. • Sensitive receptors within 500m to be consulted with any other special days when they would wish noise levels to be minimized. • Loud construction noise, breaking and drilling activities, must be limited to very short periods of activity adjacent to receptors to minimize disturbance. • On the boundary of the substation construction noise will be limited to 1- hour LAeq 70 dB(A). • Construction noise experienced at rural residences must be limited to 45dB(A), other residences to 55dB(A), commercial buildings 65dB(A), and quiet areas 50dB(A) as 1hour LAeq – if nighttime work is permitted it must be limited to 40dBA in rural residences and quiet areas, 45dBA at other	• ADB SPS (2009) • IFC EHS Guidelines – Noise Management (2007) • IFC EHS Guidelines: Electrical Power and Distribution (2007) • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Throughout project implementation	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		residences and 55dB(A) at commercial buildings as 1hour LAeq • If these noise levels are exceeded, or background levels >3dBA were already exceeded, the contractor will be required to implement additional noise mitigation measures such as adjusting working methods or placing of temporary noise barriers to ensure the noise standard is met. • No piling or blasting is to be undertaken for construction unless a piling/blasting management plan has been agreed. Any rock removal will be undertaken using pneumatic hammer (handheld or excavator mounted). • Use low noise generating equipment e.g., less than 55dBA sound pressure level at 1m. • The use of horns in areas where sensitive receptors are located (houses, schools, clinics, temples, etc.) will be prohibited. • Residents within 500m of substations will be forewarned of planned activities that are considered by the Project to be noisy (e.g., trench excavation / drilling). • If complaints are received from the local population regarding elevated noise levels, temporary noise screens shall be installed around the work site, shielding the identified receptors from the source of noise. In the event of a grievance being received carry out an investigation of noise levels to determine whether they will comply with permitted maximum levels using a hand-held noise monitor mounted on a tripod to measure IEC A-weighting dB(A) LAeq. • Construction workers exposure to noise should not exceed the levels set out in the General EHS Guidelines on Occupational Health and Safety otherwise the hearing protection is to be provided e.g., 85 dB(A) during continuation of 8 working hours without wearing PPE.			

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
Physical Cultural Heritage	Chance Finds	• Implement the chance find procedure, if required.	• ADB SPS (2009) • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC
Utilities and Infrastructure	Outages, damage to utilities and private property	• All unanticipated damage to existing public utilities shall be restored immediately to pre-project condition and/or compensated at the cost of the contractor. • If existing structures (e.g., buildings) and roads, tracks, crops, or, canals, or drains are damaged by works, the Contractor will be required to rehabilitate them to at least their condition prior to construction works to the satisfaction of the property owner having reference to pre-condition surveys.	• ADB SPS (2009) • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC
Occupational Health and Safety	General	• For all construction works comply with GoN rules and regulations for the protection of workers. • Strictly implement all the measures outlined in annexes and all the measures outlined below. • Emergency contact number and details for medical, fire, etc. are to be displayed in all construction sites. • No unaccompanied members of the public shall be allowed on the construction site.	• ADB SPS (2009) • IFC EHS Guidelines General • IFC EHS Guidelines: Electrical Power Transmission and Distribution (2007) • ILO safety and health in construction • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC
	Fatalities	• In the event of any fatality occurring during the construction phase at any work site, provide NEA with the details of the fatality within one day (24 hours) of the event occurring in a Fatality Report (for onward reporting to ADB within 48 hours) and provide within 48 hours an incident report with corrective action detailing how reoccurrence will be		EPC Contractor Include in EPC contract cost Throughout	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		prevented.		construction	
	Work sites	• Contractor is responsible for ensuring H&S of everyone on construction site including visitors and sub-contractor workers regardless they have been formally or informally employed. • Ensure adequate health and safety supervision is always on site (if staff temporarily off sick or on short term leave of less than a fortnight contractor to provide a named alternate in advance; if safeguard staff are on longer term leave, are posted elsewhere, or resign, contractor to ensure replacement CV is submitted to NEA in seven days of the contractor becoming aware with the staff joining the site within one month). • Construction plant and equipment used will be modern and fitted with appropriate safety devices. • Temporary safety fences shall be erected around each work site. • Require workers to confirm they have seen and understood the requirements of the OHS plan before proceeding with the work. • Warning signs will be displayed around work sites to warn workers and members of the local community of potential risks in Hindi and other languages of the workers found on site. • MSDS are to be readily available to any exposed workers and the first-aid personnel. • All crews shall have a competent person responsible for first aid. • Only allow suitably trained and qualified workers to be allowed to work on electrical equipment and at height, these		EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		workers must have training record of attending suitable training course on electrical safety and working at height and have a recent medical checkup to confirm they are fit for work. • Require other workers to observe the minimum approach distances for excavations, tools, vehicles, pruning, and other activities when working around power lines. • Provide personal protective equipment (PPEs) for workers in accordance with national OHS regulations and good international industry practice. • Handwashing facilities with clean running water supply and soap as well as hand sanitizers and closed bins for disposal of hygiene-related wastes to be provided on-site during works. Display posters to promote handwashing and respiratory hygiene etc. • Sanitation and welfare facilities used by construction workers to be regularly cleaned and disinfected by the contractor. • Enforce disciplinary system (e.g., immediate removal from site) for non-compliance with PPE requirements. • Ensure proper grounding and deactivation of live power lines during construction /decommissioning work or before any work near the lines and this will be checked and certified by Health and Safety Officer in advance. • Require workers to observe IFC EHS Guideline on T&D requirements for working at height. • During construction works ensure qualified first aider and trained fire marshal is always available on-site with an appropriately equipped first aid kit and appropriate fire extinguisher and other firefighting equipment immediately available for use. Every crew under one H&S supervisor shall have a first aid box at the worksite. • Since fuel, oil and chemicals will be handled on site provide			

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		emergency eye wash facilities adjacent to the storage facilities. • Arrange with nearest Health Center and/or Hospital for emergency cares of workers with an ambulance transport available on site or on immediate call. • Provide workers with access to an existing functional toilet facility (toilets and hand washing area) or provide a self-contained portable toilet with hand washing facilities (open defecation and use of pit latrines to be prohibited) generated wastewater to be disposed of to wastewater treatment plant. • Toilet facilities to be provided with adequate supplies of hot and cold running water, soap, and hand drying device. • Sufficient toilet facilities should be provided for the number of workers, and there should be an indication of whether the toilet facility is "in use" or "vacant" if not segregated.			
	EMF	• Measure exposure levels to electromagnetic fields (EMF) and provide workers working in zones where EMF levels are above reference levels with personal EMF monitoring device to be attached onto their PPE.		EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC
	Food and drink	• Provide workers with access to clean eating area with supply of drinking water. • Adequate supplies of potable drinking water (at least 4 liters per person per day) meeting national standards should be provided to workers.		EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC
	Forced and Child Labour	• No forced or child labor to be employed in construction with the minimum age for employment on construction site to be 18 given hazardous nature of works involved.	• ADB SPS (2009) • ILO Convention - Minimum Age	EPC Contractor Include in EPC	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		• Verifiable proof of age documentation is maintained for every worker. • Workers operate within the legal working hours and additional work hours are adequately compensated. • All overtime hours are voluntary; coercion, threats or penalties not used to pressure the workers into overtime. • Wages being paid to workers confirms to the minimum wage rated specified under applicable laws. • All wages including overtime are paid within legally defined time limits. • Pay statements shows earned wages, regular and overtime pay, bonuses and all relevant deductions • No unreasonable restraints on the worker's freedom of movement. • Terms of employment outlined at the time of recruitment do not differ from the terms offered during the course of employment.	Convention (1973) • ILO Convention - Worst Forms of Child Labour Convention (1999) • ILO Convention – Forced Labour • ILO safety and health in construction • GoN laws and regulations (Chapter 2 of IEE)	contract cost Throughout construction	
	Labour and Accommodation Camps	• Ensure the camps established for providing accommodation to labors engaged in construction activities meet the requirements specified in the ILO safety and health in construction/worker accommodation guidelines and the requirements of the annex.	• ADB SPS (2009) • World Bank Guidance Note on Managing Labor Influx, 2016 • ILO safety and health in construction/worker accommodation guidelines • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC

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Community Health and Safety	Grievances	• Implement the GRM procedures to provide opportunity for residents to raise concerns. • Provide 72 hours advance notice of any works (not including emergency works) to the local community.	• ADB SPS (2009) • Project GRM • IFC EHS Guidelines: Community Health and Safety (2007) • Voluntary Principles on Security and Human Rights[3] • GoN laws and regulations (Chapter 2 of IEE)	EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC
	Hazardous Work Sites	• Robustly fence and sign immediate working area including stores/stockpiles with security presence to prevent public access during construction works. • Do not allow children to play in or adjacent to the construction site • Do not leave hazardous conditions (e.g., unlit open excavations without means of escape) overnight unless no access from the public can be ensured. • Prevent standing water as it may become a breeding habitat for mosquitoes etc. • Construction site will be labeled / signposted in accordance with national regulations and GIIP to inform the public of the specific safety risks. • All work sites will be appropriately signposted and isolated (through fencing or bunting) to prevent encroachment into these areas. Where there are open excavations then solid fencing barrier must be used.		EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC
	Record Keeping	• Keep a specific record of any community incidents that occur during the construction phase. Report the numbers to NEA monthly.		EPC Contractor Include in EPC contract cost	NEA PMU / PISC

[3] https://www.voluntaryprinciples.org

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
				Throughout construction	
	Conflict with Security Personnel	• The project will implement the 'Voluntary Principles on Security and Human Rights' • During construction, due diligence will be applied to selection of security providers, rules of engagement will be devised, and training provided to all personnel. Performance will be monitored and audited periodically.		EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC
Traffic Management	Traffic and Pedestrian Safety	• Implement agreed traffic management plan. Safe access to property and roads should be maintained and alternative routes and access provided where there are temporary diversions or blockages. Diversion works to be immediately dismantled on completion of works and the footpath and roads restored to their original condition. • Transport equipment only during non-rush hours i.e., avoid the hours of 9am to 11 am and 4pm to 6 pm to minimize traffic congestion. • Stockpiling of spoil and any new equipment (conductor reels, etc.) shall be away from properties and only in designated areas where no access or road use will be blocked. • Allow for adequate traffic flow around construction areas via diversions or temporary access roads. • Provide adequate traffic signs, appropriate lighting, well-designed traffic safety signs, barriers, and flag persons for traffic control. • Ensure that safe access ways to public and private amenities (including schools) are maintained, safe alternative routes provided and clearly signed where there are temporary diversions or blockages.	• ADB SPS (2009)	EPC Contractor Include in EPC contract cost Throughout construction	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
		• Traffic management will need to be done in consultation with the affected communities to ensure they are aware of likely disruption. • Implement traffic management controls during construction works with advance warning signs or flag persons to ensure health and safety of construction workers and road users. • Construction traffic warning signs will be positioned at road crossings and other appropriate locations as determined by the project, for example, along access routes before they are used by construction traffic. • Road safety and warning signs must be posted at 500m, 100m, and immediately in advance of the site entrance at least two days prior to the works commencing to inform the public of the temporary hazard of turning traffic. • For site entrances flagmen should be utilized to warn road users of the situation.			
Training	Pollution Prevention	• Conduct bi-monthly training of workers on pollution prevent control including good housekeeping and how to clean up oil/fuel spills and dispose of contaminated sorbent material which would be treated as a hazardous waste.	• ADB SPS (2009)	EPC Contractor	NEA PMU / PISC
	OHS	• Conduct weekly training on occupational health and safety for all construction workers including refreshers. To include training for subcontractors before commencement of works.	• ADB SPS (2009)	EPC Contractor	NEA PMU / PISC
	Emergency Response	• Conduct monthly training of workers on emergency preparedness and response procedures in case of an occupational or community health and safety incident during construction works. To include training for subcontractors before commencement of works.	• ADB SPS (2009)	EPC Contractor	NEA PMU / PISC

Topic	Impact / Issue	Commitment	Applicable Project Standards / Best Practice	Implementation Responsibility	Monitoring Responsibility
	Driver Training	• Driver training, monthly, to include advice on behaviors to reduce the potential for disturbance, including use of horn, loud radios with windows open, switching engines off when not in use, strictly observing speed limits and not accelerating or braking aggressively.	• ADB SPS (2009)	EPC Contractor	NEA PMU / PISC
GRM	GRM Communication and Implementation	• Disseminate GRM contact details and arrangements to the community through the distribution of pamphlets, prominently posted notices at work sites, community centers etc. • Ensure that throughout construction highly visible signage providing their and GRM Focals names and contact details are prominently displayed at all construction sites, storage areas, temporary worker camps, subproject site offices, road crossing points etc. • To facilitate liaison with the local community the environment safeguards team will need to be supported by a member of staff who can speak the local language.	• ADB SPS (2009) • Project GRM	EPC Contractor	NEA PMU / PISC
		• Encourage affected persons to make use of the GRM yet clarify that this does not prevent them from pursuing legal action, if they feel that it is needed		EPC Contractor / NEA PMU	NEA PMU / PISC
		• Keep a record of all grievances received and their resolution and to report on them.		EPC Contractor	NEA PMU / PISC

Table 4: O&M EMP

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
Substation	General EHS impacts during O&M	• During the operational phase NEA will be responsible for ensuring that all required corrective actions for existing substations continue to be complied with per the Corrective Action Plan. • NEA to develop SOP for pollution control and health and safety management of substation operation and maintenance including inspections schedules etc. SOP to cover pollution control, solid and hazardous waste management, health and safety risk assessments and management plans addressing both occupational and community risks and including permit to work system of critical activities such as electrical or work at height and emergency preparedness and response provisions. • Implementation of SOP environment, health and safety measures, provision of regular EHS trainings to O&M workers on SOP implementation and good housekeeping practices including how to clean up oil/fuel spills and dispose of contaminated sorbent material which would be treated as hazardous waste etc. • Continually improve compliance with national requirements and good international practice for EHS including health and safety and solid and hazardous materials and waste management in particular: o Undertake regular visual and technical inspection of condition of substation equipment and carry out maintenance as required, if SF6 or an oil leak encountered	• ADB SPS (2009) • IFC EHS General Guidelines • IFC EHS Electric Power T&D Guidelines • GoN laws and regulations (Chapter 2 of IEE)	NEA O&M team Throughout O&M phase	NEA PMU / PISC

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		these are to be immediately addressed. o Provide signage detailing NEA contacts in case of grievance. o Provide at least one-month advance notice to local community about the schedule of and details of planned major maintenance works. • Mitigation measures applicable to the construction stage are also applicable to the O&M activities and workers. • During O&M, internal audits will be undertaken by the NEA safeguards staff.			
Climate change	Leakage of SF6 from any gas insulated equipment, especially at PSS	• Inventory to be maintained of all SF6 containing equipment at substation, their make and model, volume of SF6 contained, details of repair works undertaken, dates of SF6 replenishment, leakage incidents etc. Inventory to be used to monitor SF6 leakage. If trend of lowering gas pressure is observed investigate the cause and rectify any leak per the manufacturer's instruction. • SF6 in fire extinguishers provided to be avoided. • During operation, regular visual and technical inspections will be undertaken, SF6 leakage detection kits will be provided at each substation, and remote gas pressure alarms are to be installed where daily inspection is not an option, such that any leaks can be immediately addressed. • NEA do not currently have procedures for safe disposal of SF6. Therefore, SOP must detail disposal at end-of-life. • Ensure SF6 is first removed in accordance with International Electrotechnical Commission (IEC)	• ADB SPS (2009)	NEA O&M team Throughout O&M phase	NEA PMU / PISC

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		standard 61634 to a very low pressure so losses of SF6 are less than 0.5% at end of life and then reused, recycled, or destroyed in a high-temperature incinerator. • Training of all project and O&M staff on the climate change impact of SF6, alternatives, H&S risks during O&M due to presence of toxic byproducts, leakage minimization, and environmentally sound and safe disposal.			

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
Soil and water pollution	Transformers and oil management	• Maintain inventory of transformers on site, make, model, transformer test report, details any maintenance works undertaken, dates oil changes, leakage incidents etc. • Maintain transformers and other noise generating equipment to meet operational noise standards. • Carry out regular inspections and periodic preventive maintenance to minimize oil leakages; ensure values, nuts and bolts are fully functional and tightly secured, ensure rubber seals of radiators are intact • Maintenance of and handling of transformer oil to be carried out only by trained workers using appropriate PPE. • The acceptance of mineral oil to be accompanied with Material Safety Data Sheet and certification that it is PCB free. • Material Safety Data Sheets for all fuel/oil/chemical kept on site to be posted • Maintain spill management materials (sorbent pads, loose sorbent material, sand, etc.) next to storage areas for immediately soaking up any leaks or spills that do accidentally occur • Workers interacting with oil must wear suitable chemical and/or oil-resistant gloves, goggles, and protective clothing. • No untreated wastewater is to be discharged direct to surface water or the ground. • Restrict use of diesel generator to emergency power back-up to minimize air emissions. • Use of herbicides or burning to clear vegetation is strictly prohibited.	• ADB SPS (2009) • NEA laws and regulations (Chapter 2 of IEE)	NEA O&M team Throughout O&M phase	NEA PMU / PISC

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
Training	OHS	• Ensure workers with a specific role have attended specialized health and safety trainings related that role e.g., health and safety stewards, first aiders, fire safety officers, as well as ensuring workers have received task-specific trainings for working with electricity, etc. • Only allow suitably trained and qualified workers to work on electrical equipment these workers must have training record of attending suitable training course on electrical safety and working at height and be provided with and wear the appropriate PPE for their role. • Untrained workers must not be permitted to work with live electricity.	• ADB SPS (2009)	NEA O&M team Throughout O&M phase	NEA PMU / PISC
	Emergency Response	• Conduct monthly training involving all workers on emergency preparedness and response procedures (drills) in case of an occupational or community health and safety incident during O&M including fire, natural disaster, disease outbreak etc. • Emergency preparedness and response training for operational management will include modules on first aid and fire safety including include training on how to use first aid and firefighting equipment provided on-site, and scenario of potential or confirmed infection.	• ADB SPS (2009)	NEA O&M team Throughout O&M phase	NEA PMU / PISC
	Pollution Prevention	• Conduct bi-monthly training of workers on pollution prevent control including good housekeeping and how to clean up oil/fuel spills and dispose of contaminated sorbent material which would be treated as a hazardous waste.	• ADB SPS (2009)	NEA O&M team Throughout O&M phase	NEA PMU / PISC

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
Waste Management	General impacts	• Collect and segregate all O&M wastes including scrap metal, oil, and solid waste; ensure all workers are familiar with this segregation. Store all the wastes produced in an environmentally sound manner in designated, labelled area with separate waste containers (drums, bins, skips) for each type of waste with solid waste in enclosed bins to contain leachate and avoid vermin. • Ensure that the waste hierarchy is followed including prevention, minimization, reuse and recycling -- maximum reuse and recycling of waste and timely removal of unusable waste according to national waste management regulations. • Encourage recovery of recyclable wastes that could be reused or sold to recyclers, rather than disposing of it. • Hazardous wastes (oily rags, etc.) must be disposed of using appropriately licensed waste management company. • Ensure sufficiently sized facilities are provided for the environmentally safe and sound collection, segregation and storage of waste (including from overnight accommodation) on-site, maximum reuse and recycling of waste by reputable, legitimate, licensed third parties and timely removal and safe transportation of unusable waste to a suitably licensed and engineered waste management facility with all waste transfer records retained. Keep copies of the waste management company's licenses on file. Document all volumes and types of wastes generated and removed off site (inert, solid, hazardous) using transfer	• ADB SPS (2009) • IFC EHS Guidelines: Waste Management (2007) • IFC EHS Guidelines: Contaminated Land (2007) • GoN laws and regulations (Chapter 2 of IEE)	NEA Throughout O&M phase	NEA PMU / PISC

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		• Municipal waste collection systems must not be used as this is likely to mean that the waste is open dumped, arrangements should be made for direct disposal to a suitably licensed and engineered waste management facility with all waste transfer records retained. Since it is unlikely any will be available locally use waste management facilities (e.g. compost, incineration) included on-site during the design stage. • Burning of waste on-site is also strictly prohibited, including vegetation. • Removal and disposal of identified invasive plant species in an ecologically sound manner.			
Health and Safety	General	• NEA is responsible for ensuring H&S of everyone on construction site including visitors and sub-contractor workers regardless they have been formally or informally employed. • Strictly implement SOP and all health and safety measures in annex. • Warning signs will be displayed around work sites to warn workers and members of the local community of potential risks. • Maintain warning / advisory signs in good and visible condition. • Emergency contact number and details for medical, fire, etc. are to be displayed at the site. • For all maintenance works undertake risk assessment and prepare H&S plan in accordance with EHS Guidelines, considering occupational and community H&S and including adherence emergency preparedness and response plan with communication systems and protocols to report an	• ADB SPS (2009) • IFC EHS Guidelines General • IFC EHS Guidelines: Electrical Power Transmission and Distribution (2007) • GoN laws and regulations (Chapter 2 of IEE)	NEA Throughout O&M phase	NEA PMU / PISC

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		emergency situation. Mitigation measures applicable to the construction stage are also applicable to O&M activities. • Enforce disciplinary system (e.g., immediate removal from site) for non-compliance with PPE requirements.			
	OHS	• Adequate supplies of potable drinking water meeting national standards should be provided to workers. • Sanitation and welfare facilities to be regularly cleaned and disinfected. • Handwashing facilities with clean running water supply and soap as well as hand sanitizers and closed bins for disposal of hygiene-related wastes to be provided on-site during works. • Display posters to promote handwashing and respiratory hygiene etc. • Arrange with nearest Health Center and/or Hospital for emergency cares of workers. • Maintain incident logbook and medical tests / health check-up of staff • Provide everyone who enters the substation with an OHS induction • Only allow suitably trained and qualified workers to be allowed to work on electrical equipment and at height, these workers must have training record of attending suitable training course on electrical safety and working at height and have a recent medical check-up to confirm they are fit for work. • Require other workers to observe the minimum approach distances.			

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		• Provide personal protective equipment (PPEs) for workers in accordance with national OHS regulations and GIIP • Keep vents/windows unblocked and replace defunct bulbs/lights immediately • Ensure all substation workers receive basic first aid and firefighting training with annual refreshers • Ensure that at least one staff at substation is fully trained as a first aider and fire marshal • During O&M works ensure qualified first aider and trained fire marshal is always available on-site with an appropriately equipped first aid kit and appropriate fire extinguisher and other firefighting equipment immediately available for use. • Maintain fully stocked, in-date first aid kit, keep first aid posters and emergency contact lists that are posted up to date • Maintain firefighting systems including in-date fire extinguishers and full sand buckets and keep fire safety posters up • Carry out regular inspections and periodic maintenance to ensure electrical standards are being upheld • Display clear emergency exits signs (in working order, if light signs, ensure they work) and keep exits clear of any blockages. Remove any trip hazards on the ground, e.g., materials, equipment, trash laying around. • Undertake regular pest control using integrated pest management approach • Maintain vegetation at the substation that poses a			

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		health and safety hazard • Cleaning of toilets on daily basis, use of disinfectant and floor cleaners; keep toilets/septic tank/soakaway maintained • Measure exposure levels to electromagnetic fields (EMF) and provide workers working in zones where EMF levels are above reference levels with personal EMF monitoring device to be attached onto their PPE. • Periodic spot monitoring using mobile phone app of noise levels and ambient EMF for substations at the boundary fence/near transformers to ensure they are below the occupational/community noise levels and ICNRP occupational/community EMF exposure levels • Maintain security and prevent entry by the local community and livestock by maintaining adequate boundary fencing or wall, always keeping control room doors and gates shut, and having security persons present 24x7 to prevent unauthorized public access and trespass. • NEA in conjunction with local municipalities, village heads, and the media with the support of CSOs to continue to organize health and safety campaigns on electrical safety community awareness raising activities in local communities and schools within 500 m of the substations			
	Fatalities	• In the event of any fatality occurring during the O&M phase at any work site, provide PMU with the details of the fatality within one day (24 hours) of the event occurring in a Fatality Report (for onward reporting to		NEA Throughout O&M phase	NEA PMU / PISC

Topic	Activity / Issue	Commitment	Applicable Project Standards / Guidelines	Implementation Responsibility (Budget Source and Timing)	Monitoring Responsibility
		ADB within 48 hours) and provide within 48 hours an incident report with corrective action detailing how reoccurrence will be prevented.			

Environmental Monitoring Plan (EMoP)

The EMoP sets out the minimum provisions for quantitative environmental monitoring and performance standards to be achieved.

Monitoring activities including laboratory analysis for air quality, noise, surface water and groundwater quality, and soil are to be carried out by accredited suitably qualified and experienced third-party monitoring experts. Quantitative monitoring activities may be modified during project implementation, depending on the EPC contractors' performance and analytical results obtained. If performance is worse than expected, corrective action will be identified, and environmental monitoring activities adjusted accordingly by NEA to help resolve any unsatisfactory performance.

In addition to quantitative monitoring there will also be supervision and monitoring of EMP implementation, the performance standard being all EMP measures are implemented in full at the appropriate time.

Table 4: General Environmental Monitoring Plan (EMoP)

Project Activity or Environment Impacts/ Risks	Monitoring Parameters	Method of Monitoring including Standards/ Guidelines	Frequency and Timing	Location	Performance Indicator	Implementation	Supervision (NEA PMU)
Pre-construction							
Statutory Clearances	Licenses / Permits and Insurances	Review of all applicable clearances, licenses, permits and insurances before the start of construction	One time prior to the start of construction	N/A	All relevant permits, licenses and insurances outlined in the Project IEE are obtained prior to the start of works.	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly reports with copies attached.	Review all clearances, licenses, permits and insurances and document compliance in EMR
Staffing	Contractors environmental, social, health and safety staff	Review of staff contracts, timesheets and payslips	Prior to the start of construction then periodically throughout construction	N/A	All staff outlined in the IEE are in place at the start of construction and are on site for the allotted periods specified in the EMP	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with evidence attached.	Review contracts, timesheets and payslips and document compliance in EMR
Training and Inductions	Training records	Review of all induction training records, including training materials, attendance sheets and photographs. Attendance at sample of sessions and randomised sample of people on tie to assess if they have received training and induction.	One time prior to the start of construction. Then periodically through construction to ensure new staff have received induction training and refreshers are being delivered.	N/A	All people on-site whether formally or informally employed have received the required training and induction.	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with evidence attached.	Review all training and induction records, attendance at sample of sessions, sample of people on site and document compliance in EMR
Community Awareness	Pre-construction and pre-operation awareness documents	Review documents prepared for community awareness activities, attendance sheets and photographs of meetings held to deliver them.	One time prior to the start of construction and again during commissioning	N/A	Awareness documents completed and distributed to adjacent villages within 500m	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress	Review awareness documents, attendance at sample of sessions held,

Project Activity or Environment Impacts/ Risks	Monitoring Parameters	Method of Monitoring including Standards/ Guidelines	Frequency and Timing	Location	Performance Indicator	Implementation	Supervision (NEA PMU)
		Randomized sample of residents to assess if they have received any awareness materials	prior to operation			reports with evidence attached.	conduct sample of residents and document compliance in EMR
Environmental management	Incident reporting system including GRM and environmental management provisions	Review of incident reporting system including GRM, inspection audit of environmental management provisions by environment safeguard staff	Prior to the start of construction then periodically throughout construction	All construction and operational areas and related facilities, labour camps and overnight accommodation areas etc.	System established and contract is fully compliance with EMP requirements, GON legislation and IFC EHS Guidelines	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with evidence attached including environment officer's checklists etc.	Review of contractor's system and audit, inspection audit by PISC environment expert and document compliance in EMR
Labor Camps and Overnight Accommodation, Sanitation and Welfare Facilities	GON legislation, ILO guidance on worker accommodation and IOM migrant workers accommodation checklist	Inspection audit of labor camps and overnight accommodation by labor staff.	Prior to the start of construction then periodically throughout construction	All labor camps and overnight accommodation areas	Labor camps and overnight accommodation are compliant with EMP requirements, GON legislation, ILO guidance on worker accommodation and IOM migrant workers accommodation checklist	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with their labor officer's inspection audit and other evidence attached.	Review of contractor's audit, inspection audit by PISC labor expert, and document compliance in EMR
Health and Safety	Health and Safety Risk Assessment, Incident Reporting System including labor GRM and H&S provisions	Review of risk assessment and incident reporting system including GRM, inspection audit of H&S provisions by H&S safeguard staff	Prior to the start of construction then periodically throughout construction	All construction and operational areas and related facilities, labour camps and overnight accommodation areas etc.	Risk assessment completed, system established, and contract is fully compliance with EMP requirements, GON legislation, IFC EHS Guidelines and ILO	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with evidence attached including H&S	Review of contractor's system and audit, inspection audit by PISC environment expert and document compliance in

Project Activity or Environment Impacts/ Risks	Monitoring Parameters	Method of Monitoring including Standards/ Guidelines	Frequency and Timing	Location	Performance Indicator	Implementation	Supervision (NEA PMU)
					Safety and Health in Construction	officer's checklists etc.	EMR
Drinking water supplies	GON drinking water standards	Drinking water tests from supplier Carry out visual inspection and randomized interviews with workers to identify any unrecorded grievances	One time for baseline establishment to ensure source of water suitable as drinking water	Sources of drinking water for construction/ operation of project for which supplier can provide copies of drinking water tests to confirm compliance.	GON drinking water parameters	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with records and test reports attached.	Check monitoring being undertaken, review records, conduct inspections and interviews with workers and document compliance in EMR
Construction including Site Establishment, Preparation and Clearance Works and Commissioning Activities							
Health and Safety – incidents	Records of health and safety incidents	Keep records of near miss, minor, lost time, and fatal health and safety incidents related to the project, compile records from construction sites into a database for tracking. Carry out randomized interviews with workers and the community to identify if any unrecorded incidents occurred.	Ongoing with Monthly Compilation of Records	All construction and operational areas and related facilities, labour camps and overnight accommodation areas etc. Offsite traffic incidents related to contractor's vehicles or the condition of access roads to site	Zero lost time incidents or fatalities (among workers and community) For 100% lost time incidents or fatalities immediate action taken to avoid repeat or escalation of situation All incidents including minor and near miss dealt with in accordance with EMP/CSEMP with lessons learnt for future 100% lost time and fatalities reported to NEA within 24	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with records and reports attached.	Check monitoring being undertaken, review records and reports, conduct interviews with workers and the community and document compliance in EMR

Project Activity or Environment Impacts/ Risks	Monitoring Parameters	Method of Monitoring including Standards/ Guidelines	Frequency and Timing	Location	Performance Indicator	Implementation	Supervision (NEA PMU)
					hours and ADB within 48 hours with incident report submitted within 48 hours with root cause analysis and corrective action taken.		
Water resources	Water volume used and source	Keep records of all water used (volume in m^3) and source. Carry out randomized interviews with the community to identify if any unrecorded grievances occurred.	Ongoing with Monthly Compilation of Records	All construction and operational areas and related facilities, labour camps and overnight accommodation areas etc.	Water use documented. No grievance received during construction or operation regarding conflict with other water users	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with records and evidence provided.	Check monitoring being undertaken, review records, conduct interviews with the community and document compliance in EMR
Soil (earthworks)	Volume of soil disturbed during construction	Keep records of earthworks involved, including total volume in m^3 of soil excavated and reused (any disposed of as spoil off site to licensed waste disposal facilities recorded as per waste generation) Carry out visual inspection and randomized interviews with community to identify if any unrecorded grievances occurred	Ongoing with Monthly Compilation of Records	Construction sites involving earthworks/cut and fill activities	Earthworks documented, and all excavated and cut and fill volumes accounted for, either reused on-site or disposed of off-site to licensed waste disposal facilities with no grievance received related to spoil disposal unresolved.	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with records and evidence provided.	Check monitoring being undertaken, review records, conduct Inspection and interviews with the community and document compliance in EMR
Hazardous materials– incidents	Pollution incidents	Records of pollution incidents (e.g., type of material spilled, amount in kg or $m^{3,}$ and action taken to clean up)	Ongoing with Monthly Compilation of Records	All construction and operational areas and related facilities, labour camps and overnight	Zero major incidents occurred. Minor incidents responded to in accordance with EMP/CSEMP with	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress	Check monitoring being undertaken, review records and reports, conduct

Project Activity or Environment Impacts/ Risks	Monitoring Parameters	Method of Monitoring including Standards/ Guidelines	Frequency and Timing	Location	Performance Indicator	Implementation	Supervision (NEA PMU)
		Carry out visual inspection and interviews with workers and the community to identify if any unrecorded incidents occurred		accommodation areas etc.	lessons learnt for future.	reports with records and reports attached.	Inspection and interviews with the workers and community and document compliance in EMR
Natural Resource Use (Construction Materials) and Waste Generation	Volume of construction materials used, and waste generated, and disposal route	Keep records of all types of materials used and wastes produced by type, volume/ weight. Document waste disposal through transfer notes including type, volume/ weight, transport provider, intermediaries if any and final treatment or disposal facility (with its license and capacity) Carry out visual inspection and randomized interviews with community to identify if any unrecorded grievances occurred	Ongoing with Monthly Compilation of Records	All construction and operational areas and related facilities, labour camps and overnight accommodation areas etc.	Transfer of 100% of construction wastes documented, and all wastes disposed of in an environmentally safe and sound manner in accordance with the EMP/CSEMP and IFC General EHS Guidelines with no grievance received related to waste disposal unresolved	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with records and other evidence provided.	Check monitoring being undertaken, review records, conduct Inspection and interviews with the community and document compliance in EMR
Wildlife	Animal casualties	Keep written record, supported by photographs, of any animal conflicts or casualties, including a cause of death if known Carry out visual inspection and randomized interviews with workers and community to identify if any unrecorded grievances occurred	Ongoing with Monthly Compilation of Records	Construction site, including temporary construction facilities. Offsite traffic incidents related to the contractor's vehicles or the condition of village roads used for access	Zero fatal animal casualties occurred For 100% incidents immediate action taken per wildlife encounter protocol and GON legislation and to avoid repeat or escalation of situation All incidents including minor and	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with records and reports attached.	Check monitoring being undertaken, review records and reports, conduct inspections and interviews with the community and document compliance in EMR

Project Activity or Environment Impacts/ Risks	Monitoring Parameters	Method of Monitoring including Standards/ Guidelines	Frequency and Timing	Location	Performance Indicator	Implementation	Supervision (NEA PMU)
					near miss dealt with in accordance with EMP/CSEMP with lessons learnt for future		
Employment	Records of all construction workers including subcontractor workers whether formally or informally employed and including any daily labor	Keep records of employment generated, age/gender/sex-disaggregated employment data, home locations, medical checks, if labor accommodation provided, and trainings and inductions received Carry out visual inspection and randomized interviews with workers to identify if any unrecorded grievances occurred	Ongoing with Monthly Compilation of Records	Construction site	Employment in accordance with EMP/CSEMP plus GON legislation; no grievance received related to employment of workers unresolved	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with records and other evidence provided.	Check monitoring being undertaken, review records, conduct Inspections and interviews with workers and document compliance in EMR
Drinking water supplies	GON drinking water standards	Drinking water tests from supplier Carry out visual inspection and randomized interviews with workers to identify any unrecorded grievances	One time for baseline establishment to ensure source of water suitable as drinking water	Sources of drinking water for construction for which supplier can provide copies of drinking water tests to confirm compliance.	GON drinking water parameters	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with records and test reports attached.	Check monitoring being undertaken, review records, conduct inspections and interviews with workers and document compliance in EMR
O&M							
Climate change emissions	SF6 used and leakage rates	Keep records of SF6 total volume used and leakage rates	Ongoing with Monthly Compilation of Records	Substations	EMP compliance: significantly less than 0.1% leakage rate	NEA O&M team to undertake monitoring and report to PMU in monthly and quarterly progress	Check monitoring being undertaken, review records, and document compliance in

Project Activity or Environment Impacts/ Risks	Monitoring Parameters	Method of Monitoring including Standards/ Guidelines	Frequency and Timing	Location	Performance Indicator	Implementation	Supervision (NEA PMU)
						reports with records attached	EMR
Health and Safety – incidents	Records of health and safety incidents	Keep records of near miss, minor, lost time, and fatal health and safety incidents, compile incident records into database for tracking Carry out randomized interviews with workers and the community to identify if any unrecorded incidents occurred.	Ongoing with Monthly Compilation of Records	Substations	Zero lost time incidents or fatalities (among workers and community) For 100% lost time incidents or fatalities immediate action taken to avoid repeat or escalation of situation All incidents including minor and near miss dealt with in accordance with EMP with lessons learnt for future 100% lost time and fatalities reported within NEA in 24 hours and ADB within 48 hours with incident report submitted within 48 hours with root cause analysis and corrective action taken.	NEA O&M team to undertake monitoring and report to PMU in monthly and quarterly progress reports with records and reports attached	Check monitoring being undertaken, review records and reports, conduct interviews with workers and the community and document compliance in EMR
Water resources	Water volume used and source	Keep records of all water used (volume in m^3) and source. Carry out randomized interviews with community to	Ongoing with Monthly Compilation of Records	Substations	Water use documented. No grievance received during construction or operation	NEA O&M team to undertake monitoring and report to PMU in monthly and	Check monitoring being undertaken, review records, conduct

Project Activity or Environment Impacts/ Risks	Monitoring Parameters	Method of Monitoring including Standards/ Guidelines	Frequency and Timing	Location	Performance Indicator	Implementation	Supervision (NEA PMU)
		identify if any unrecorded grievances occurred.			regarding conflict with other water users	quarterly progress reports with records provided.	interviews with the community and document compliance in EMR
Hazardous materials– incidents	Pollution incidents	Records of pollution incidents (e.g., type of material spilled, amount in kg or $m^{3,}$ and action taken to clean up) Carry out visual inspection and interviews with workers and the community to identify if any unrecorded incidents occurred	Ongoing with Monthly Compilation of Records	All construction and operational areas and related facilities, labour camps and overnight accommodation areas etc.	Zero major incidents occurred. Minor incidents responded to in accordance with EMP with lessons learnt for future.	NEA O&M team to undertake monitoring and report to PMU in monthly and quarterly progress reports with records and reports attached.	Check monitoring being undertaken, review records and reports, conduct Inspection and interviews with the workers and community and document compliance in EMR
Solid and Hazardous Materials Waste Generation	Solid and hazardous waste generated, and disposal route	Keep records of all types of wastes produced by type, volume/ weight. Document waste disposal through transfer notes including type, volume/ weight, transport provider, intermediaries if any and final treatment or disposal facility (with its license and capacity) Carry out visual inspection and randomized interviews with community to identify if any unrecorded grievances occurred	Ongoing with Monthly Compilation of Records	Substations	Transfer of 100% of O&M wastes documented, and all wastes disposed of in an environmentally safe and sound manner in accordance with the EMP and IFC General EHS Guidelines with no grievance received related to waste disposal unresolved	NEA O&M team to undertake monitoring and report to PMU in monthly and quarterly progress reports with records provided	Check monitoring being undertaken, review records, conduct Inspection and interviews with the community and document compliance in EMR
Drinking water supplies	GON drinking water standards	Drinking water tests from supplier Carry out visual inspection and	Ongoing with Monthly Compilation of Records	Sources of drinking water for operation for which supplier can provide copies	GON drinking water parameters	NEA O&M team to undertake monitoring and report to PMU in	Check monitoring being undertaken, review records,

Project Activity or Environment Impacts/ Risks	Monitoring Parameters	Method of Monitoring including Standards/ Guidelines	Frequency and Timing	Location	Performance Indicator	Implementation	Supervision (NEA PMU)
		randomized interviews with workers to identify any unrecorded grievances		of drinking water tests to confirm compliance.		monthly and quarterly progress reports with test reports attached	conduct inspections and interviews with workers and document compliance in EMR

Table 5: Quantitative and Instrumental Environmental Monitoring Plan (EMoP)

Project Activity or Environment Impacts/ Risks	Monitoring Parameters	Method of Monitoring including Standards/ Guidelines	Frequency and Timing	Location	Performance Indicator	Implementation	Supervision (NEA PMU)
Pre-construction							
Property and physical cultural resources	Pre-construction survey of property condition	Detailed photographic survey of physical cultural resources and property condition including structural engineering survey were properties at risk of damage from construction traffic levels	Once pre-construction	Private properties, buildings, drains, public utilities within 50m of substation or along village roads that will be used for offsite access	EMP compliance	Contractor to undertake monitoring and report to PMU before the commencement of construction works with copy of survey reports	Check monitoring being undertaken and document compliance in EMR
Vegetation/trees	Pre-clearance survey of trees to be cut	Detailed survey/ inventory of the number, location, size, and species of trees to be cut	Once pre-construction	Construction site, including temporary construction facilities	EMP compliance	Contractor's ecologist to undertake monitoring and report to PMU before the commencement of construction works with copy of survey reports	Check monitoring being undertaken and document compliance in EMR

Project Activity or Environment Impacts/ Risks	Monitoring Parameters	Method of Monitoring including Standards/ Guidelines	Frequency and Timing	Location	Performance Indicator	Implementation	Supervision (NEA PMU)
Vegetation/trees	Pre-clearance survey of habitat types, species present	Habitat/ vegetation survey with method to be agreed with PISC ecologist but including determination of MH or NH extent, extent x quality of habitat, invasive species, type dominance and extent, with incidental records of species presence	Once pre-construction	Construction site, including temporary construction facilities	EMP compliance	Contractor's ecologist to undertake monitoring and report to PMU before the commencement of construction works with copy of survey reports	Check monitoring being undertaken and document compliance in EMR
Air Quality	PM10, PM2.5, to be measured as 24hrs average over a fortnight along with meteorological data- temperature, humidity, wind speed, and wind direction.	Measurement professional, calibrated portable monitoring devices by accredited service provider (record 24-hour data over a fortnight)	One time for baseline establishment prior to the start of any activity on site (during dry season)	Site boundary and nearest receptor to dusty construction works where receptors <500m from site boundary – if no receptors in 500m no receptor monitoring is required.	Project standards as per IEE (national air quality standards complied with, no increase in baseline levels at receptors where WHO PM10 and PM2.5 levels already exceeded)	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with monitoring data provided including laboratory QA certification.	Check monitoring being undertaken and document compliance in EMR
Noise	LAeq 1hr day and night for representative 48hr period (ideally 24hr weekday + 24hr weekend and avoid holidays, festivities, strong wind, rain etc.)	Measurement professional, calibrated portable monitoring devices by accredited service provider	One time for baseline establishment prior to the start of any activity on site	Site boundary and nearest receptor to noisy construction works where receptors <500m from site boundary – if no receptors in 500m no receptor monitoring is required.	Project standards as per IEE (most stringent of GON and WHO guidelines on receptor not area basis for ambient noise) at site boundary and sensitive receptors (or less than 3dBA increase if ambient already exceeded)	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with monitoring data provided including laboratory QA certification.	Check monitoring being undertaken and document compliance in EMR

Project Activity or Environment Impacts/ Risks	Monitoring Parameters	Method of Monitoring including Standards/ Guidelines	Frequency and Timing	Location	Performance Indicator	Implementation	Supervision (NEA PMU)
Surface and Ground Water Quality	pH, EC, turbidity, color, TSS, DO, BOD5, COD, oil and grease, total and faecal coliform bacteria, total nitrogen, total phosphorus If used by local community as a source of drinking water to also test against GON drinking water standards (full suite of parameters)	Water sample is to be taken in a clean, non-contaminated, well-sealed container and tested within the next 48h by accredited laboratory	One time for baseline establishment prior to the start of any activity on site	Surface waterbody and groundwater wells within 500m of substation sites, at least one surface water sample from nearest surface water body and one groundwater sample from nearest groundwater well to be sampled – if no receptors in 500m no receptor monitoring is required.	GoN guidelines for surface water/drinking water for groundwater	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with monitoring data provided including laboratory QA certification.	Check monitoring being undertaken and document compliance in EMR
Soil Quality	pH, TPH, heavy metals, PCBs, PAHs, and any other contaminants indicated by contaminated land professional	Soil samples to be taken from surface and at depth in a clean, non-contaminated, well-sealed container and tested within the next 48h by accredited laboratory	One time for baseline establishment prior to the start of any activity on site	At locations of visible contamination in existing substation	International soil quality guidelines e.g., Australian	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with monitoring data provided including laboratory QA certification.	Check monitoring being undertaken and document compliance in EMR

Project Activity or Environment Impacts/ Risks	Monitoring Parameters	Method of Monitoring including Standards/ Guidelines	Frequency and Timing	Location	Performance Indicator	Implementation	Supervision (NEA PMU)
Hazardous materials - PCBs	Transformer oil for PCB content	Testing of transformer oil should follow UNEP Guidelines for PCB-testing	Once at the onset of the project, no additional impact as all equipment and oil procured by the project will be PCB-free.	All existing transformers at substations	PCB levels	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with monitoring data provided including laboratory QA certification.	Check monitoring being undertaken and document compliance in EMR
Drinking water supplies	GON drinking water standards	Water sample is to be taken in a clean, non-contaminated, well-sealed container and tested within the next 48h by accredited laboratory	One time for baseline establishment to ensure source of water suitable as drinking water	Sources of drinking water for construction/ operation of project for which supplier is unable to provide copies of drinking water tests to confirm compliance.	GoN drinking water parameters	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with monitoring data provided including laboratory QA certification.	Check monitoring being undertaken and document compliance in EMR
Construction including Site Establishment, Preparation and Clearance Works and Commissioning Activities							
Property and physical cultural resources	Post-construction survey of property condition	Detailed photographic survey of physical cultural resources and property condition including structural engineering survey were properties at risk of damage from village road upgrade works and construction traffic levels	Once on completion of construction	Private properties, buildings, drains, public utilities within 50m of substation and along village roads that will be used for offsite access	EMP compliance (no residual damage compared to baseline survey)	Contractor to undertake monitoring and report to PMU before the commencement of construction works with copy of survey reports	Check monitoring being undertaken and document compliance in EMR

Project Activity or Environment Impacts/ Risks	Monitoring Parameters	Method of Monitoring including Standards/ Guidelines	Frequency and Timing	Location	Performance Indicator	Implementation	Supervision (NEA PMU)
Vegetation/Trees	Post-construction survey of habitat types, species present	Habitat/ vegetation survey per pre-construction baseline including extent of cleared and uncleared area disaggregated to MH or NH, extent x quality of habitat that remains, invasive species, type dominance and extent, with incidental records of species presence	Once on completion of construction	Construction site, including temporary construction facilities	EMP compliance; satisfactory site restoration undertaken with NNL, no significant conversation or degradation of natural habitat compared to baseline situation, no invasive species introduced or now dominating habitat or with increased extent of compared to baseline situation	Contractor's ecologist to undertake monitoring and report to PMU before the commencement of construction works with copy of survey reports with monitoring data provided including laboratory QA certification	Check monitoring being undertaken and document compliance in EMR
Air Quality	PM10, PM2.5, CO, NOx, HC diesel generator emissions per GON requirements	Measurement professional, calibrated portable monitoring devices by accredited service provider (record 24-hour data over a fortnight)	Monitor once during commissioning of the operational diesel generator set	Diesel generator stack.	Project standards (GON emission standards for DG sets)	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with monitoring data provided including laboratory QA certification.	Check monitoring being undertaken and document compliance in EMR
Air Quality	PM10, PM2.5, to be measured as 24hrs average over a fortnight along with meteorological data- temperature, humidity, wind speed, and wind	Measurement professional, calibrated portable monitoring devices by accredited service provider (record 24-hour data over a fortnight)	Monitor at least once every quarter during active earthworks. As requested by PMU in event excessive dust or grievance	Site boundary and nearest receptor to dusty construction works with receptors <500m from site boundary, same locations as baseline – if no	Project standards as per IEE (national air quality standards complied with, no increase in baseline levels at receptors where WHO PM10 and PM2.5 levels	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with monitoring data provided including laboratory QA certification.	Check monitoring being undertaken and document compliance in EMR

Project Activity or Environment Impacts/ Risks	Monitoring Parameters	Method of Monitoring including Standards/ Guidelines	Frequency and Timing	Location	Performance Indicator	Implementation	Supervision (NEA PMU)
	direction.		received during construction.	receptors in 500m no receptor monitoring is required. Undertake additional locations at request NEA in event excessive dust experienced or grievance received	already exceeded)		
Noise	LAeq 1hr day and night for representative 48hr period (ideally 24hr weekday + 24hr weekend and avoid holidays, festivities, strong wind, rain etc.)	Measurement professional, calibrated portable monitoring devices by accredited service provider	Monitor at least once every month during active construction works. One time during commissioning. Then as requested by PMU in event excessive noise heard or grievance received during construction.	1m from noisy equipment within substation in respect of commissioning Site boundary and nearest receptor to noisy construction works with receptors <500m from site boundary, same locations as baseline – if no receptors in 500m no receptor monitoring is required. 1m from all diesel generator sets and other noise generating	Project standards as per IEE (most stringent of GON and WHO guidelines on receptor not area basis for ambient noise) at site boundary and sensitive receptors (or less than 3dBA increase if ambient already exceeded) GoN and IFC General EHS Guidelines for occupational noise exposure not exceeded at 1m from noisy equipment	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with monitoring data provided including laboratory QA certification.	Check monitoring being undertaken and document compliance in EMR

Project Activity or Environment Impacts/ Risks	Monitoring Parameters	Method of Monitoring including Standards/ Guidelines	Frequency and Timing	Location	Performance Indicator	Implementation	Supervision (NEA PMU)
				equipment. Undertake additional locations at request NEA in event excessive noise heard or grievance received			
Surface and Ground Water Quality	pH, EC, turbidity, color, TSS, DO, BOD5, COD, oil and grease, total and faecal coliform bacteria, total nitrogen, total phosphorus If used by local community as a source of drinking water to also test against GON drinking water standards (full suite of parameters)	Water sample is to be taken in a clean, non-contaminated, well-sealed container and tested within the next 48h by accredited laboratory	Monitor at least once every quarter during active construction involving earthworks, one time during commissioning (at substations) and then as requested by NEA in event of visible water pollution or grievance received during construction	Surface waterbody and groundwater wells within 500m of substation sites, same locations as baseline– if no receptors in 500m no receptor monitoring is required. Undertake additional locations at request NEA in event water pollution seen or grievance received	GON guidelines for surface water/drinking water for groundwater with an increase in baseline levels	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with monitoring data provided including laboratory QA certification.	Check monitoring being undertaken and document compliance in EMR
Influent and Effluent Water Quality	pH, EC, turbidity, color, TSS, DO, BOD5, COD, oil and grease, total and faecal coliform bacteria, total nitrogen,	Water sample is to be taken in a clean, non-contaminated, well-sealed container and tested within the next 48h by accredited laboratory	Monitor untreated source and treated water at least once every month and then as requested by	Sedimentation pond, septic tank or package sewage treatment works influent and	GON guidelines for surface water/drinking water for groundwater with an increase in baseline levels	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with monitoring data provided including	Check monitoring being undertaken and document compliance in EMR

Project Activity or Environment Impacts/ Risks	Monitoring Parameters	Method of Monitoring including Standards/ Guidelines	Frequency and Timing	Location	Performance Indicator	Implementation	Supervision (NEA PMU)
	total phosphorus		PMU in event of visible water pollution or grievance received during construction	effluent		laboratory QA certification.	
Drinking water supplies	GoN drinking water parameters	Water sample is to be taken in a clean, non-contaminated, well-sealed container and tested within the next 48h by accredited laboratory	Monitor untreated source and treated water at least once every month and then as requested by PMU in event of visible water pollution or grievance received during construction	Sources of drinking water for construction of project for which supplier is unable to provide copies of drinking water tests to confirm compliance.	GoN drinking water parameters	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports with monitoring data provided including laboratory QA certification.	Check monitoring being undertaken and document compliance in EMR
EMF	EMF exposure levels	EMF meter	One time during commissioning	Substation 1m from all EMF generating equipment and site boundary	ICNIRP public exposure limits for EMF complied with	EPC contractor to undertake monitoring and report to NEA in monthly and quarterly progress reports.	Check monitoring being undertaken and document compliance in EMR
O&M							
Air Quality	PM10, PM2.5, CO, NOx, HC diesel generator emissions per GON requirements	Measurement professional, calibrated portable monitoring devices by accredited service provider (record 24-hour data over a fortnight)	Monitor full-time during semi-annual testing of the operational diesel generator set As requested by PMU in event excessive emissions seen or grievance	Diesel generator stack.	Project standards (GON emission standards for DG sets)	NEA O&M team to undertake monitoring and report to PMU in monthly and quarterly progress reports with monitoring data provided including laboratory QA certification.	Check monitoring being undertaken and document compliance in EMR

Project Activity or Environment Impacts/ Risks	Monitoring Parameters	Method of Monitoring including Standards/ Guidelines	Frequency and Timing	Location	Performance Indicator	Implementation	Supervision (NEA PMU)
			received during operation of diesel generator.				
Influent and Effluent Water Quality	pH, EC, turbidity, color, TSS, DO, BOD5, COD, oil and grease, total and faecal coliform bacteria, total nitrogen, total phosphorus	Water sample is to be taken in a clean, non-contaminated, well-sealed container and tested within the next 48h by accredited laboratory	Monitor untreated source and treated water at least semi-annually and then as requested by PMU in event of visible water pollution or grievance received during O&M	Sedimentation pond, septic tank or package sewage treatment works influent and effluent	GON guidelines for surface water/drinking water for groundwater with an increase in baseline levels	NEA O&M team to undertake monitoring and report to PMU in monthly and quarterly progress reports with monitoring data provided including laboratory QA certification.	Check monitoring being undertaken and document compliance in EMR
Drinking water supplies	GoN drinking water parameters	Water sample is to be taken in a clean, non-contaminated, well-sealed container and tested within the next 48h by accredited laboratory	Monitor untreated source and treated water at least semi-annually and then as requested by PMU in event of visible water pollution or grievance received during O&M	Sources of drinking water for operation of project for which supplier is unable to provide copies of drinking water tests to confirm compliance.	GoN drinking water parameters	NEA O&M team to undertake monitoring and report to PMU monthly and quarterly progress reports with monitoring data provided including laboratory QA certification.	Check monitoring being undertaken and document compliance in EMR

Construction Specific EMP (CSEMP)

The CSEMP is the document that the EPC Contractor will prepare outlining how they intend to implement the project-level EMP and ensure that all the mitigation and monitoring is completed according to the implementation arrangements specified in the EMP and the IEE as a whole.

The CSEMP will describe the precise implementation details and the location of the required mitigation and monitoring activities, the persons at the contractor responsible for the mitigation and monitoring and other persons with roles or responsibilities related to EMP implementation, the schedule, budget, training and induction, recording keeping and reporting arrangements. The CSEMP and all its topic and site-specific subplans will be submitted to the PISC and NEA for approval at least 30 days before taking possession of any work site including for site establishment, preparation and clearance. Except for survey works related to the design process no access to the site will be allowed until the CSEMP is approved by the PISC and NEA project manager.

The CSEMP will include the following topic specific plans:

Table 6: CSEMP Topic Specific Plans

Plan	Approvals	
	NEA PMU	PISC
Construction Method Statement	Yes	Yes
Pollution Prevention Plan including Emergency Response Plan	Yes	Yes
Occupational Health and Safety Plan including Risk Assessment and Emergency Response Plan	Yes	Yes
Community Health and Safety Plan including Risk Assessment and Emergency Response Plan	Yes	Yes
Biodiversity Management: Invasive Species Control Procedures and Wildlife Encounter Protocol	Yes	Yes
Solid and Hazardous Waste Management Plan	Yes	Yes
Traffic Management Plan	Yes	Yes
Labour Management Plan	Yes	Yes
Code of Conduct	Yes	Yes
Chance Find Procedure	Yes	Yes
Communication Plan	Yes	Yes
Training and Induction Plan	Yes	Yes

The following site-specific plans will also be required, including:

Table 7: CSEMP Site Specific Plans

Plan	Approvals	
	NEA PMU	ENGINEER
Site Preparation including fill and levelling details, contaminated land remediation (existing) and site layout plan	Yes	Yes
Construction Camp, Labor Accommodation, Sanitation and Welfare Facility Management Plan(s) including layouts	Yes	Yes
Construction Workshops and Storage Area Management Plan(s) including layouts	Yes	Yes

Overarching Implementation Arrangements

The Project Management Unit (PMU) of NEA under the PMD will be responsible for ensuring correct implementation of the Environmental Management Plan (EMP) and approving the EPC Contractor's CSEMP to comply with ADB's safeguards requirements and environmental, health and safety (labor) national regulations.

Dedicated safeguards staff In PMD will be required to manage the below-mentioned tasks and environment, health and safety risks (and any social impacts) of the project. For this, the PMU will include a qualified and experienced environment safeguard officer and qualified [e.g., IOSH/NEBOSH certification] and experienced [12-15 years] health and safety safeguard officer of NEA. The officers may come from SSEMD but will be full-time on the project. The PMU will be assisted by environmental, health and safety specialists of the PISC in supervising the implementation of the EMP / CSEMP.

The cost for implementing mitigation and monitoring measures as outlined in this EMP will be included in the EPC contract.

If any change in design, unanticipated environmental or social impacts become apparent during project implementation, the PMU will be required to immediately inform ADB and (i) assess the significance of such unanticipated impacts; (ii) evaluate the options available to address them; and (iii) update the IEE and EMP taking appropriate corrective action where necessary before commencing or recommencing works.

The following sections provide the specific implementation requirements for all parties.

NEA Management and PMU

NEA PMD through their PMU is responsible for supervising the PISC, EPC Contractor and EMP implementation for overall compliance with ADB's SPS (2009) requirements and project environment-related legal covenants. NEA management is ultimately responsible to ensure EMP compliance.

Primary Responsibilities

The PMU's responsibilities include the following, but not limited to:

- Ensuring adherence to all applicable national environment, health, safety, and labor laws and regulations in force at the time.
- Ensuring adherence to ADB's Safeguard Policy Statement (2009) and the related IFC Environment, Health and Safety (EHS) general and power transmission and distribution guidelines (2007) as well as the ILO's Safety and Health in Construction guidelines and worker accommodation guidelines.
- Ensuring adequate management support, budget, staff, and other resources are allocated to satisfactorily implement, supervise, and monitor implementation of the EMP during all phases.
- Ensuring that all PMU/O&M staff support and attend all capacity development and training activities provided for them.

- Latest upon loan effectiveness appointing suitably qualified and experienced environment officer and health and safety officer under the PMU to support EMP implementation throughout all phases of the project component. The officers may come from SSEMD but will be full-time on the project.
- Locally disclosing the IEE and other environmental safeguards documents, including publication on NEA's website. Help with translation of the IEE into local languages or an explanation of its content will be extended free of charge to affected persons on request.
- Incorporating the EMP into the bidding and contract documents before issuing tenders and contract awards.
- Reviewing bids to ensure they are in accordance with the EMP requirements prior to contract award.
- Preparing a detailed training plan, providing training venues, and providing with support of PISC a suite of training activities for NEA staff and contractors in relation awareness raising on EMP implementation.
- Adopting a zero-tolerance approach to OHS and enforcing all NEA staff to comply with OHS requirements of the EMP including wearing of appropriate PPE on site to set a good example to the contractor and their workers.
- Implementing the CAP for existing substations before access is given to the contractor or, if responsibilities are delegated, supervising, and monitoring its implementation by the contractor.
- Implementing the EMP throughout all phases or, if responsibilities are delegated, supervising, and monitoring its implementation by the contractor.
- Reviewing and approving the contractor's detailed designs as well as CSEMP and EMP sub-plans to ensure they incorporate and are in accordance with the EMP requirements.
- Updating the IEE and the EMP as required in consultation with ADB prior to the approval of the contractor's detailed design. Obtaining ADB's review and clearance of the update prior to approval of the designs and the commencement of any work, including site establishment, preparation and vegetation clearance. Once cleared, ADB will disclose the updated IEE/EMP on its website and NEA will locally disclose It. All updates to the IEE/EMP are subject to ADB clearance before they become effective.
- Ensuring that necessary environment and forest clearances are obtained, and that compensation is paid to the forest department for cutting of trees before the commencement of related work.
- Ensuring the contractors secures all necessary permissions before the commencement of related work, maintain records with copies of all the clearances, permits, licenses, and insurances obtained.
- Ensuring the contractors provide adequate training to their subcontractors and all workers including daily EHS toolbox talks and emergency response drills; suggesting topics for the trainings based on site observations.
- Identifying areas for improvement, unsafe acts, and any non-compliances with the EMP by the contractor and/or NEA staff and instructing for corrective actions to be taken by them to bring implementation back on track.
- Thoroughly investigating all unanticipated impacts, near-misses, accidents, and chance finds; preparing a detailed incident report where applicable, identifying and instructing on corrective actions particularly to avoid any repetition of near-misses and accidents.
- Reporting to ADB any non-compliance or breaches of ADB safeguard requirements in a timely manner and take corrective actions promptly.
- Supervising, monitoring and reporting on EMP implementation for the project components including reporting on EMP implementation in quarterly progress reports and preparing semi-annual EMRs for submission to ADB up until the ADB project completion report, or for longer period if it is required by the ADB PCR. Submission to ADB for disclosure on their website, as well as for local disclosure.

- Undertaking with the support of PISC monthly EHS meetings including site walkover inspection to determine the status of EMP implementation by the contractors during construction as well as random "spot check" site visits to audit their EMP implementation. Minutes of monthly meetings and findings of site walkover inspections will be attached to the EMRs to be submitted to ADB.
- Preparing a community liaison plan to elaborate on ongoing consultation and information disclosure in relation to EMP implementation considering gender, vulnerable groups, and indigenous peoples; preparing consultation materials for distribution to affected communities, including conducting public awareness programs.
- Undertaking and documenting all ongoing consultation, details of consultations such as minutes of the meetings, photographs to be documented in the EMRs submitted to ADB.
- Establishing and operationalizing the GRM for affected persons (construction workers and local community members) in line with the IEE, including appointing GRM Focals and establishing a GRC, disseminating contacts, recording and promptly resolving grievances received. All ongoing grievance-related information will be documented in the EMRs submitted to ADB.
- Building up and sustaining institutional capacity in environmental management, health, safety and labor management.
- For operation and maintenance undertaking the environmental monitoring as set out in the EMoP documenting qualitative and quantitative monitoring results; for quantitative monitoring hire accredited, and quality assured, third-party laboratories.
- Once operational, any contractors hired for maintenance works or decommissioning will be supervised and monitored by NEA with roles and responsibilities the same as those of the contractors for construction
- Reporting any unanticipated impacts, major incidents (including fatalities) and chance finds to ADB within 48 hours of them occurring along with an Incident report with corrective action plan.
- Reporting to ADB any grievances submitted to the third formal stage of the GRM upon receipt.
- Developing and taking all requisite corrective action in case of any non-compliance with the EMP including repair of any property damages and financial compensation (insurance) for health and safety incidents.

Reporting

NEA will be responsible for the following documents and reports:

Table 8: NEA Reporting Responsibilities

Documents	Responsible Person	Destination of the documents	Submission timing		
			Design period	Construction period	Operation period
Bid and Contract Documents (addition of environmental requirements)	PMU ESO with support HSO	ADB	X		
Updated IEE /EMP	PMU ESO with support HSO	ADB	X (when IEE is finalized in response to substation detailed designs and layouts)	X (when any changes are made to IEE / EMP due to unanticipated impacts)	X (when any changes are made to IEE / EMP due to unanticipated impacts)
Training and Induction Plan	PMU ESO with support HSO	NEA / EPC Contractor	X (for design and construction)		X (for operation)
Community Liaison Plan	PMU ESO with support HSO	NEA / EPC Contractor	X		
Consultation and Grievance Redress Reporting (included in QPRs)	PMU ESO with support HSO	ADB		X (Quarterly)	X (Quarterly)
Incident Reports (included	PMU ESO	ADB		X (Quarterly)	X (Quarterly)

Documents	Responsible Person	Destination of the documents	Submission timing		
			Design period	Construction period	Operation period
in QPRs)	with support HSO				
Quarterly Progress Reports (QPR)	PMU ESO with support HSO	ADB	X (Quarterly)	X (Quarterly)	X (Quarterly)
Unanticipated impacts, major incident (including fatalities) and chance find reports	PMU ESO PMU HSO	ADB		X (48 hours)	X (48 hours)
Semi-annual environmental monitoring reports (EMR) including consultation, grievances and incidents	PMU ESO with support HSO	ADB	X (every 6 months)	X (every 6 months)	X (every 6 months until PCR issued or longer if recommended in PCR)

EMR

Following loan effectiveness, environmental monitoring reports (EMRs) will be submitted to ADB on a semi-annual basis by NEA up to the ADB project completion report with safeguards inputs also provided to quarterly progress reports. If recommended within the PCR, annual operational monitoring reporting will be continued until all issues have been closed out to the satisfaction of ADB. EMRs will be due for submission to ADB within 15 days of the month following period end, e.g., before mid-July and mid-January each year. The EMRs will describe project implementation progress, any scope or design changes, compliance against safeguard requirements that are covenanted in the legal agreements, progress with environment mitigation and offset implementation, quantitative monitoring results in accordance with the EMoP, and grievances received.

Draft EMRs submitted by NEA during project implementation will first be reviewed by ADB with comments on quality and acceptability provided and then, once resubmitted to ADB and cleared for disclosure, are to also be disclosed locally (in the same places as the IEE report was originally disclosed) by NEA and on the ADB website upon receipt. Any outstanding comments will be flagged to NEA for ongoing action.

EPC Contractors

Through the contract, NEA will delegate responsibility for implementing all relevant measures during design, pre-construction, and construction for the duration of their contract. The EPC Contractors will be required to comply with the EMP during the design, preconstruction, and construction phases, closely supervised and monitored by NEA. The EPC Contractor will be responsible for reporting environmental safeguards progress and performance at least monthly to NEA including record data required by the EMoP and providing necessary inputs to the quarterly progress reports and semi-annual EMRs for the duration of their contract. The requirement to undertake relevant mitigation and monitoring actions as set out in this EMP applies to the construction site as well as any temporary workers camps or overnight accommodation provided by them.

The EPC Contractor has the responsibility for EMP implementation under NEA. However, the EPC Contractor is required to ensure that the EMP requirements are cascaded down to all sub-contractors undertaking works, regardless they are formally or informally employed, and to be responsible for supervising and monitoring their sub-contractors in turn. Construction workers will need to abide, in their behavior and work, to directives issued by their employer with regards to environmental, health and safety management.

The EPC Contractor will be responsible for the preparation of their CSEMP. The CSEMP will need to be fully compliant with the project-level EMP and the IEE and will need to be prepared within 30 days of Contract award and approved 30 days prior to access to the site including for site establishment, preparation and clearance.

Specific Responsibilities

In addition to the above, the EPC Contractor will be responsible for:

- Implementing all measures and responsibilities allocated to the EPC Contractor under the EMP for the full duration of the contractor's involvement.
- Ensuring adherence to all applicable national and state environment, health, safety, and labor laws and regulations in force at the time.
- Ensuring adherence to ADB's Safeguard Policy Statement (2009) and the related IFC Environment, Health and Safety (EHS) general and power transmission and distribution guidelines (2007) as well as ILO's Safety and Health in Construction and worker accommodation guidelines.
- Ensuring the detailed design reflects the EMP requirements; seeking to ensure it has the same or no worse impact than the indicative designs which were assessed in the IEE.
- Supporting NEA to update (as required) the IEE in respect of the detailed design by providing sufficient details to inform a revised project description and any subsequent reassessment of impacts and risks.
- Undertaking and documenting a facilitated health and safety (H&S) risk assessment considering for all phases.
- Preparing a CSEMP and sub-plans as specified in the EMP for review and approval by NEA prior to the commencement of works including site establishment – see tables.
- Ensuring adequate budget, staff and other resources are allocated to comply with and implement the contractor's responsibilities under the EMP and to supervise and monitor the active construction site to protect the environment and ensure the health and safety of all workers and affected communities.
- Ensuring suitably qualified and experienced environment, health and safety safeguard officers, as per the EMP requirements have been appointed to undertake regular on-site supervision and monitoring activities before the commencement of works.
- Adopting a zero-tolerance approach to OHS on the project, enforce all workers to comply with the OHS requirements of the EMP including the wearing of appropriate PPE on the construction site.
- Obtaining all necessary permissions before the commencement of related work, share copies of all clearances, permits, licenses, and insurances obtained.
- Providing – in part with the support from NEA – and ensuring attendance at EHS trainings for formal and informal construction workers and other personnel as required.
- Ensuring that all construction workers including all formal and informal employees and subcontractors understand their responsibilities to implement the EMP and mitigate environmental impacts and risks associated with pre-construction and construction activities.
- Supporting NEA in undertaking ongoing consultation and implementing the site-level GRM; in particular, the contractor's GRM Focal shall thoroughly document details of complaints and make its best efforts to resolve the complaints at project site level; all this information is to be included in the contractor's monthly reports to NEA.
- Undertaking environmental monitoring as set out in the EMoP during pre-construction and construction and documenting qualitative and quantitative monitoring results; for quantitative monitoring the contractor is to hire accredited, and quality assured, third party laboratories.
- Submitting monthly environmental management reports to NEA (monthly EMP reports will be stand-alone but included as part of the contractors' monthly progress reports) relating to the work undertaken over the reporting period and documenting the environmental measures including monitoring activities that have been carried out, problems encountered, record data including near misses and accidents, grievances received, and follow-up actions that were taken (or will be taken) to correct the problems.
- Informing NEA immediately in case of any approved detailed design changes or unanticipated environmental impacts occurring during implementation, and as required, provide any information needed to NEA to enable them to promptly update the IEE/EMP for clearance by ADB before any changes are implemented.
- Informing NEA within 24 hours in case of chance find or accident on site and providing within 48 hours an incident report with corrective action detailing how reoccurrence will be prevented.
- Informing NEA immediately in case of any non-compliance and help them to prepare as necessary a corrective action plan for clearance by ADB, the contractor is required to implement all necessary corrective action requested by NEA to ensure the project remains in compliance with national and state regulatory requirements, ADB's SPS 2009, the project's loan covenants and EMP requirements.

EPC Contractor Reporting

The EPC Contractor will establish their own internal systems for monitoring and reporting their EMP implementation. The EPC Contractor will formally submit monthly summary environmental management reports per an agreed template to the PMU. Complete photographic records will be kept by the contractor covering all activities on site as well as key locations such as the construction site, receptors adjacent, workshops, stores, sanitation and welfare facilities, temporary worker camps or overnight accommodation etc. Photographs of key areas will be taken prior to construction activities beginning to provide the environmental baseline. Copies of all geo-referenced photographs will be submitted to the PMU along with the contractor's monthly report. Specifically, the EPC Contractor will be responsible for the following documents and reports:

Table 9: EPC Contractor Reporting Responsibilities

Documents	Responsible Person	Destination of the documents	Submission timing		
			Design period	Construction period	Operation period
Health and Safety Risk Assessment	HSS	PISC, PMU	X	X (updated prior to start of works and then at least annually updated)	
Detailed design for approval	ESM	PISC, PMU	X (Once, prior to the start of construction)		
CESMP for approval including all required subplans (see tables)		PISC, PMU	X (Once, prior to the start of construction)	X (updated through construction as needed)	
Environmental, health and safety checklists		PISC, PMU		X (every week, to be completed daily)	
Monthly environmental management reports including monitoring records and data per EMoP		PISC, PMU	X (every month)	X (every month)	

EPC Contractors Staff

To prepare and implement the CSEMP and to supervise and monitor the EMP/CSEMP implementation for the substation expansion components a team of specialists will be required as part of the contractor's team as illustrated in the following figure and described in detail below. If a contractor is awarded more than one contract package/lot then entirely separate EHS team is to be employed for each of them. There will also be a need for the contract to employ ad-hoc specialist Inputs to deliver specific EMP tasks that are assigned to them e.g., ecologist for checking of any trees to be cut, competent asbestos surveyor to confirm absence in the existing substations.

Figure 2: EPC Contractors Environmental, Social, Health and Safety Team

Environment, Health and Safety Supervisors

Environmental and Social Manager

During construction, the EPC Contractor must retain the expertise of an Environmental and Social Manager (ESM) to implement and continually update the CSEMP and to oversee and report on the operation of the EMP/CSEMP throughout the contract period. The ESM will be the EPC Contractors main focal point for all environmental, social, health and safety issues associated with the project components and will lead the other team members listed below. The ESM will be a suitably qualified and experienced full-time member of staff on the EPC Contractor's roster and should be on site at least five days per week.

The required qualifications of the ESM are as follows:

- Degree in environmental sciences, environmental management or related field.
- At least 10-12 years' experience in on-site environment, health and safety supervision and monitoring.
- Experience of at least five construction projects of a similar type, location, size and scale.
- Experience of construction projects receiving IFI funding whilst being conversant with national laws and regulations and IFI environment safeguard policies and requirements.

Specifically, in overseeing EMP implementation the ESM shall be responsible for:

- Responsible for ensuring ad-hoc specialist inputs (e.g., ecologist, competent asbestos surveyor) are employed to support detailed design and construction.
- Incorporate mitigation requirements written In the EMP In preparing the CEMP and its subplans.
- Translate mitigation requirements written in the CSEMP and its sub-plans into practical measures on the ground.
- Ensure that all staff are fully aware of the environmental sensitivities of the site and their responsibilities, as outlined in the management plans (e.g., via practical toolbox talks ahead of the construction).
- Retain records and take field notes and photographs to demonstrate compliance with the EMP/CSEMP.
- Organize regular consultations including formal monthly community meetings and informal weekly discussions with adjacent villages to keep them informed of progress e.g., construction schedule and changes in the schedule and to receive feedback from the community on any related environmental and social issues.

The ESM shall also manage all social and labor related issues. The contractor's ESM will act as their GRM focal to keep affected persons informed of works and be available to receive and deal with any grievances at the project site level. They will work with the labor specialist as GRM focal for labor.

In addition, the ESO will be responsible for the preparation of weekly environmental checklists and an environmental section of the EPC Contractor's monthly progress reports that shall be submitted to the PISC and PMU for review. The PISC shall provide a template of the checklist to the EPC Contractor.

The monthly reports, which will include the weekly environmental checklists, shall contain sections relating to:

- General progress of the contract and key construction works undertaken or milestones met.
- Records of and data from environmental monitoring.
- Environmental incidents, e.g., spills of liquids, fatalities, etc.
- Progress of any environmental initiatives, e.g., energy savings, recycling, etc.

- Conclusions and recommendations (corrective action plan).

The ESM shall provide daily toolbox training at the construction sites as well as monthly toolbox training with the labor officer on code of conduct, sanitation and welfare at the construction camp site/overnight accommodation. The ESO shall keep a record of all monthly training and toolbox training undertaken.

Health and Safety Specialist

The EPC Contractor shall also have a full-time suitably qualified and experienced Health and Safety Specialist (HSS) on the EPC Contractor's roster for the duration of their contract period, on site at least 5 days per week. If the contractor works more than five days per week, or more than one shift, during days or hours off, an alternate suitably qualified staff having NEBOSH/IOSH certification will be required to stand in. The HSS shall have at least 10-12 years of on-site experience supervising at least five projects of similar type, location, scale and size electrical infrastructure with relevant degree and NEBOSH/IOSH certification or similar qualification. They will need experience of construction projects receiving IFI funding whilst being conversant with national laws and regulations and IFI environment safeguard policies and requirements. The HSS shall report directly to the ESM.

The main responsibilities of the HSS will be:

- Provide H&S training, including daily toolbox training sessions at each active worksite.
- Provide inputs to the CSEMP and approve H&S risk assessments and plans for specific work activities.
- Conduct routine site inspections, weekly checklists, and issue internal stop notices, if necessary, for unsafe activities.
- Maintain H&S statistics log for near misses, as well as incidents.
- Provide H&S input to EPC Contractor progress and monitoring reports.

Pollution Control Specialist

The pollution control specialist will be a part time position to provide technical environment expertise to support detailed design and CSEMP preparation, particularly in respect of ensuring good international industry practice is incorporated into the design of oil bunds, storage areas, drainage, SF6 insulated equipment etc. They will have at least 10-12 years of pollution control management expertise including in design of oil bunds with a degree in environmental science or related field.

Labor Specialist

The EPC Contractor shall also have a part-time suitably qualified and experienced Labor Specialist on the EPC Contractor's roster for the duration of their contract period, present on each site at least once per month. They will have at least 5-6 years of labor management expertise including on construction sites with a degree in social science or related field. They will need experience of construction projects receiving IFI funding whilst being conversant with national laws and regulations and IFI environment safeguard policies and requirements. They will act as the GRM focal for workers at the construction site/construction camp site/overnight accommodation. They will be responsible for organizing regular consultations including formal and informal meetings and with the workers, conducting weekly checks of labor, sanitation and welfare facilities, audits of construction camp site/overnight accommodation, ensuring staff receive trainings for their role, establishing a system for and checking all workers have valid ID cards to access site, ensuring necessary labor paperwork, work permits and insurances are maintained, ensuring records of trainings, work permits, insurances, timesheets and pay slips are maintained and liaising with the HSS and site staff to ensure timely corrective actions where needed. The labor specialist will prepare the labor management plan and manage all labor related issues in coordination with the ESM and HSS. They will provide labor input to the EPC Contractor progress and monitoring reports.

Environment, Health and Safety Supervisors

The HSS will be supported at each site by full-time, dedicated, on-site Environment, Health and Safety Supervisors with at least one supervisor for each site, and each supervisor overseeing up to one subcontractor or 50 persons, in order to ensure the health and safety of all workers and local communities. They will also provide support to the ESM on environment. The supervisors will require

5-6 years of supervision experience, a relevant degree, and NEBOSH/IOSH certification or equivalent.

Management Systems

EPC Contractors will have a corporate EHS policy and environmental management certifications preferably such as ISO 14001 (or equivalent) and EHS certification such as OHSAS 18001 or equivalent.

Staff Costs

The following table provides a summary of the anticipated staff costs.

Table 10: EPC Contractor Environmental, Social, Health and Safety Staff Costs (BOQ)

#	Position	Estimated No. of Months	Month Cost ($)	Total Cost ($)
1	Environmental and Social Manager	12	1,000	12,000
2	Health and Safety Specialist	12	1,000	12,000
3	Pollution Control Specialist	1	800	800
4	Labor Specialist	3	500	1,500
5	EHS Supervisors x 2 (one per substation)	24	1,000	24,000

Control of Records

The list of records that must be available by the EPC Contractor for review must include:

- Definitive IEE and EMP (as disclosed on the ADB website)
- Legal register (of applicable national and state legislation)
- Environment, health and safety (labor) permits and licenses
- Contractor's certifications and insurances
- Tree felling permits, vehicle emission test certificates etc.
- Training plan and training records (including inductions)
- Community liaison plan, community awareness documentation and records of all consultations undertaken
- Records of emergency preparedness and response drills
- Document review and approval records
- Contractor's CSEMP and sub-plans and copies of approval records
- Completed site checklists and photographic records
- Copies of correspondence related to environmental, health and safety issues
- Corrective and preventive action request records
- H&S Risk Assessment
- Incident record and incident reports
- GRM register
- Work program and schedule
- List of equipment and maintenance log
- Route/program of construction material transportation
- Records of maintenance and cleaning schedules for sediment and oil/grease traps
- Records of quantity of discharged wastewater and concentration of pollutants
- Waste disposal records and waste transfer notes including waste disposal sites and instructions for waste transportation
- Log of material inventories and consumption
- Chance find records (if any)
- Staff contracts, timesheets and pay slips
- Construction camp site/overnight accommodation reports

- Water Quality sampling results
- Air Quality and Noise test results
- EMF measurement results
- Property surveys
- Habitat surveys
- Tree inventory

These records shall be kept on-site by the EPC Contractors ESM and available for inspection at any time.

Project Implementation and Supervision Consultant (PISC)

The PISC will support NEA in ensuring the correct implementation of the Project's EMP, and all related documents.

Pre-Construction Responsibilities

The PISC shall be responsible for the following:

- Guide NEA on the implementation of the EMP during the pre-construction.
- Support NEA in preparing a detailed training plan.
- Support delivery of safeguard training and capacity building activities and provide on-the-job guidance to NEA safeguards staff and the EPC Contractors on ensuring compliance with the EMP requirements.
- Provide guidance to the contractors on how the Project EMP Is to be implemented including (a) the requirements for each mitigation and monitoring measure, and (b) the implementation schedule for each measure considering that no activity will be approved to commence unless the related mitigation and monitoring is set.
- Support NEA in reviewing the EPC Contractor's outline and detailed designs and method statements for compliance with the EMP to ensure these documents incorporate and are in accordance with (a) the environmental and social requirements of the construction contracts and as reflected in the Project EMP, and (b) the conditions of environmental approvals of the Government, where required.
- Support NEA in reviewing the EPC Contractors' CSEMP and all topic specific (such as waste) and site-specific plans; recommend modifications to these documents to be compliant with: (a) the environmental and social requirements of the construction contracts and as reflected in the Project EMP, and (b) the conditions of environmental approvals of the Government, where required.
- Support NEA to ensure that their contractors secure all necessary permissions before the commencement of related works, and maintain records with copies of all clearances, permits, licenses, and insurances obtained.
- Support NEA in ensuring the contractor provides adequate EHS training to their subcontractors and all workers including communication of emergency plans, daily EHS tool box talks and emergency mock response drills; topics for trainings to be provided based on-site observations.
- Guide PMU safeguard team on the environmental and social aspects of the project with an emphasis on supervision, monitoring and reporting requirements.
- Develop formal systems and templates for NEA staff and EPC Contractor safeguard staff to supervise, monitor and report on day-to-day implementation all aspects of EMP implementation, including the immediate reporting of non-compliances, unanticipated impacts, accidents, chance finds, grievances etc.
- Develop the compliance monitoring system to be used during the construction period for monitoring the contractors' performance relative to environmental requirements, including the preparation of: (a) monitoring and corrective action forms and checklists, (b) inspection procedures, and (c) documentation procedures.

- Conduct orientation sessions with the EPC Contractor on the compliance monitoring system to be used, notification of non-compliance, and the process of requiring contractors to implement corrective measures when necessary.
- Support NEA in preparing a community liaison plan.
- Assist the NEA with establishing and operating the grievance redress mechanism, including creating a grievance tracker chart which is to be updated on a weekly basis.
- Support NEA in updating the IEE/EMP as required in consultation with ADB prior to approval of the detailed designs to reflect any national environment clearance conditions and any changes from the project description assessed by the IEE.
- Support NEA to undertake ongoing meaningful consultation with affected communities to keep them informed of progress and with local disclosure of the findings of the IEE report and EMRs etc.
- Support NEA in reporting on EMP implementation within the quarterly progress reports and preparing EMRs for submission to ADB.

Construction and O&M Responsibilities

The PISC shall be responsible for the following:

- Guide NEA on the implementation of the EMP during the construction, operation and maintenance.
- Following the formal systems and templates developed for supervision and monitoring support NEA safeguards staff to undertake day-to-day supervision to ensure that contractors adhere to all the provisions in the EMP as well as their CSEMPs and sub-plans as approved by NEA.
- Keep daily records and photo logs of site observations to inform preparation of the semi-annual EMRs.
- Support monthly EHS meetings including site walkover inspection to determine the status of EMP implementation by the contractor during construction as well as random “spot check” site visits to audit their EMP implementation.
- Report any unanticipated impacts, grievances, unsafe acts, or EMP violations to NEA, identifying areas for improvement, and assisting them in implementing solutions and remedial measures.
- Support NEA in reporting on EMP implementation within the quarterly progress reports and preparing semi-annual EMRs for submission to ADB.
- Support NEA with updating of the IEE/EMP as necessary if any unanticipated impacts (including project scope or design changes) occur during implementation
- Support NEA to undertake ongoing meaningful consultation with affected communities to keep them informed of progress and with local disclosure of the findings of the IEE report and EMRs etc.
- Support operationalization of the GRM and assist NEA in resolving grievances received.
- Develop standard operating procedures reflecting good international industry practice for pollution control and health and safety management at substations for NEA to follow during O&M.

Upon Completion of Contracts

The PISC shall prepare a report on each project component and the contractor's environmental and social compliance performance, including lessons learned that may help NEA in their environmental monitoring of future projects at the end of construction. The reports will be an input to the overall project completion report. PISC will continue to support NEA with O&M until the end of their contract.

Reporting

Table 11: PISC Reporting Responsibilities

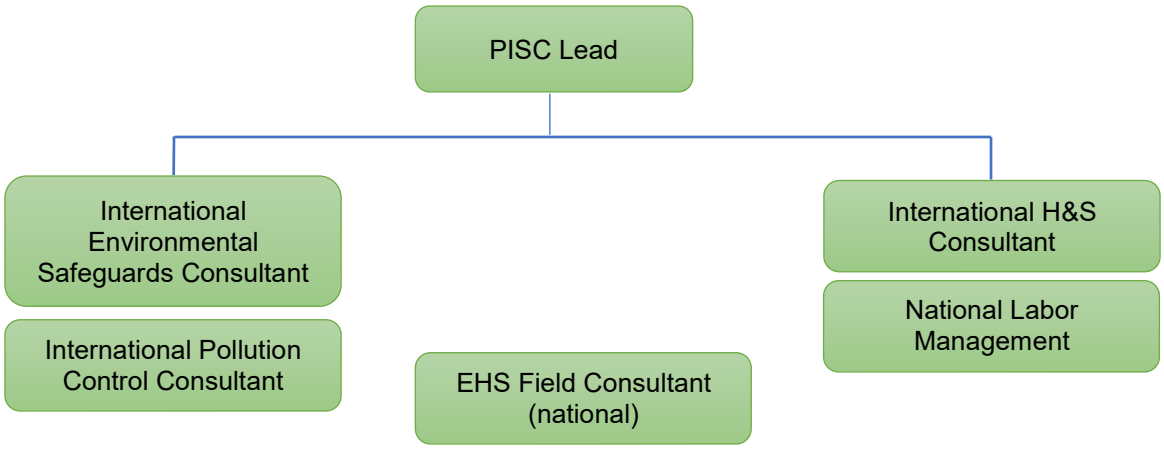
Documents	Responsible Person	Destination of the documents	Submission timing		
			Design period	Construction period	Operation period
Compliance reports	ESC with inputs from HSC, PCC,	PMU, ADB	X (every month)	X (every month)	X (every month)

Documents	Responsible Person	Destination of the documents	Submission timing		
			Design period	Construction period	Operation period
	LMC				
Completion reports	ESC with inputs from HSC, PCC, LMC	PMU, ADB		X (at completion of construction phase contract)	

PISC Staff

The PISC shall have the following staff on their roster for the existing substations. They will also be able to call upon external experts to support these more generalist consultants with resolving any site-specific issues and to deliver the capacity building trainings with respect to ecology, asbestos, PCBs management, SF_6 etc.

Figure 3: PISC Environmental, Social, Health and Safety Team



Environmental Safeguards Consultant (international)

The ESC will work closely with the NEA safeguards staff and EPC Contractor's ESM and work on general environment focused tasks associated with EMP implementation such as conducting environmental trainings and briefings to provide environmental awareness on ADB and government environmental safeguards policies, requirements and international good industry practices; ensuring baseline monitoring and reporting of EPC Contractor's compliance with environmental mitigation and monitoring measures during the design, pre-construction and construction phase and NEA's compliance with mitigation and monitoring measures during the O&M phase.

The ESC will (i) develop the compliance monitoring system with inputs from other experts, (ii) review all documents and reports regarding the integration of environment aspects including EPC Contractor's CSEMP and subplans, (iii) supervise the EPC Contractor's compliance to the EMP/CSEMP alongside the NEA safeguards staff, and (iv) prepare monthly compliance and the completion reports.

The ESC will be professionally qualified with a master's degree in environmental science, environmental management or equivalent. They will have 20 years' experience in conducting environmental impact assessments and management of infrastructure projects, and minimum 12-15 years of international experience in supervision, monitoring and implementation of EMPs and preparing environmental monitoring reports, including for substation and transmission line projects and IFI lenders.

Health and Safety Consultant (international)

The HSC will be a professionally qualified specialist with at least 20 years of experience in health and safety with IOSH/NEBOSH certification or equivalent and a minimum of 12-15 years of international experience of major civil works construction supervision including in countries with mature H&S

systems, undertaking works in steep and remote terrains, and for IFI lenders. Experience of transmission/distribution projects and in facilitating health and safety risk assessment workshops, trainings and developing good practice guidance is essential. The consultant will provide trainings and be responsible for ensuring that all aspects of the project comply with the health and safety provisions of the project's civil works contracts, EMP/CSEMP, and with relevant national laws and regulations. They will develop standard operating procedures reflecting good international industry practice for health and safety management at substations for NEA.

Pollution Control Consultant (international)

The PCC will be a professionally qualified specialist with a master's degree in environmental science, environmental management or equivalent and at least 12-15 years of international experience with pollution control measures for oil, fuel and chemicals management including the design of oil bunds and storage areas. Experience in providing trainings and developing good practice guidance is essential. The consultant will provide trainings and be responsible for ensuring that all aspects of the project comply with the pollution control provisions of the project's civil works contracts, EMP/CSEMP, and with relevant national laws and regulations. They will develop standard operating procedures reflecting good international industry practice for pollution control at substations for NEA.

Labor Management Consultant (national)

The LMC will be a professionally qualified specialist with a master's degree in social science or equivalent and at least 12-15 years of experience in labor management internationally and in South Asia, ideally Nepal, with exposure to the core labor standards, good international industry practice, from ILO and IFI lender projects. The consultant will provide trainings and be responsible for ensuring all aspects of the project comply with labor provisions of the project's civil works contracts, EMP/CSEMP, and with relevant national laws and regulations.

EHS Field Consultant (national)

The EHS field consultant will be a professionally qualified specialist with at least 12-15 years of experience in environment, health and safety management in Nepal with exposure to good international industry practice and IFI lender projects. The consultant will support the trainings and undertake monthly site visits to each active site including construction camps/overnight accommodation to ensure all aspects of the project comply with the EHS provisions of the project's civil works contracts, EMP/CSEMP, and with relevant national laws and regulations.

Staff Costs

The following table provides a summary of the anticipated staff costs.

Table 12: PISC Environmental, Social, Health and Safety Staff Costs

#	Position	Estimated No. of Months	Month Cost ($)	Total Cost ($)
1	Environmental Safeguards	2	15,000	30,000
2	Health and Safety	2	15,000	30,000
3	Pollution Control	1	15,000	15,000
4	Labor Management	2	15,000	30,000
5	EHS Field Consultant	3	2,000	6,000

EMP/CSEMP Review and Update

The contents of the EMP/CSEMP will be reviewed and updated periodically to evaluate the environmental controls and procedures therein to make sure they are still applicable to the activities being carried out and effective. Reviews will be undertaken by the EPC Contractor and PISC as follows:

- The full EMP/CSEMP will be reviewed in detail on an annual basis;
- Relevant parts of the EMP/CSEMP will be reviewed following a reportable or major incident e.g., fatality;
- Relevant parts of the EMP/CSEMP will be reviewed in case of any issues/grievances or failure of mitigation to reduce impacts occurs; and
- Relevant parts of the EMP/CSEMP will be reviewed following the receipt of an updated site specific or topic specific plan.

The review will include analysis of the monitoring data, monitoring reports, incident reports, complaints/grievances, and feedback from stakeholders. Any update to the project-level EMP requires ADB review and clearance, whilst any update to the CSEMP requires NEA and PISC review and clearance.

Corrective Actions

If any performance standards are breached or any of the safeguard requirements that are covenanted in the loan agreements are found not to be satisfactorily complied with by NEA and their contractors, an appropriate, time bound, budgeted, corrective action plan (CAP) will be developed and implemented as agreed upon with ADB to rectify unsatisfactory performance or safeguard noncompliance. NEA and/or PISC will also issue corrective action requests to the contractor during their day-to-day supervision and monitoring of EMP implementation as required.

Meetings and Site Visits

PMU will convene monthly EHS meetings to be attended by the contractor's management and environment safeguard team to discuss progress; initially progress will be discussed in relation to design actions and as the project progresses will move onto pre-construction and contraction actions. During the monthly EHS meetings areas for improvement, unsafe acts, and any non-compliances, time-bound corrective actions and responsibilities to address them will be discussed, agreed, and documented. NEA safeguard staff and/or PISC will be given delegated authority to instruct the contractor to take corrective action at any time in relation to EMP implementation, alternatively on instruction from safeguard staff or consultants who do not hold delegated authority those holding it must immediately act on their instruction.

For any ADB supervision missions to ongoing construction works contractors will provide all ADB staff with a site health and safety induction before allowing them to enter the site and adequate PPE in accordance with Table 2.7.1 of the IFC EHS General Guidelines - Occupational Health and Safety Section and ILO Safety and Health in Construction.

Capacity Development

To build the capacity of NEA and the EPC Contractors for implementation of the EMP and other safeguard requirements, a training program will be delivered. The training program will be implemented as per training modules provided in the following table, training needs will be further determined and elaborated in a training plan. Training modules can be changed during construction phase based on requirements of the contractors. The basic objective of giving training to the different stakeholder is to enhance their capabilities for implementation of the EMP and EMoP during construction and operation.

Delivery of the training program is part of the project cost that includes institutional strengthening, capacity building and training whilst the contractor will factor in their attendance within the contract amount.

It is recommended that the training be given:

- Upon the award of contracts to the contractor
- Before the start of construction work at each site including site establishment, preparation and clearance
- Refresher during construction
- Before demobilization of contractor and commencement of O&M

Table 13: Training Requirements

Training Session	Required Attendees/Recipients	Delivery Mode/Duration	Training Conducted by	Budget Source
Introduction to ADB's Safeguard Policy Statement (2009), IFC EHS Guidelines, ILO safety and health in construction, GON requirements, and Project EMP including EMOP	PMU, EPC Contractors' Management and Environment Safeguards Teams	Lecture session, presentation, and discussion. In Person/ 1 day	Safeguard Unit of PMU / PMC EMC & HSC	PMC Budget
Corrective action plan implementation for existing SS	SS staff of NEA PMU, PMU, EPC Contractors' Management, Design Teams and Environment Safeguards Teams	Lecture session, presentation, and discussion. Online/ 0.5 day	Safeguard Unit of PMU / PMC EMC, HSC and PCC	PMC Budget
H&S at substations, awareness raising	SS staff of NEA PMU, PMU, EPC Contractors' Management, Design Teams and Environment Safeguards Teams	Lecture session, presentation, and discussion. Online/ 0.5 day	Safeguard Unit of PMU / PMC HSC	PMC Budget
Oil management at substations, awareness raising	SS staff of NEA PMU, PMU, EPC Contractors' Management, Design Teams and Environment Safeguards Teams	Lecture session, presentation, and discussion. Online/ 0.5 day	Safeguard Unit of PMU / PMC EMC & PCC	PMC Budget
SF6 and its management at substations, awareness raising	SS staff of NEA PMU, PMU, EPC Contractors' Management, Design Teams and Environment Safeguards Teams	Lecture session, presentation, and discussion. Online/ 0.5 day	Safeguard Unit of PMU / PMC EMC & PCC	PMC Budget
EMP implementation for outline and detailed design	PMU EPC Contractors' Design Teams and Environment Safeguards Teams	Lecture session, presentation, and discussion. In Person/ 1 day	Safeguard Unit of PMU / PMC EMC, HSC and PCC	PMC Budget
Facilitated H&S workshop (design stage)	PMU, Contractors Management, Construction, and Environment Safeguards Staff	Facilitated workshop In Person/ 1 day	PMC HSC	PMC Budget
GRM operation (initial run at start of project, and then on handover to operational staff)	All GRM levels- GRM Focal Points, GRC, PMU, Contractors Management, Environment Safeguards Team, GRM Focal Points of Contractors, Local Government Representatives etc.	Lecture session, presentation, and discussion. In Person/ 1 day	Safeguard Unit of PMU / PMC EMC	PMC Budget
EMP implementation for pre-construction and construction, including workshop on CSEMP preparation	PMU, Contractors' Construction Teams and Environment Safeguards Teams	Lecture session, presentation, and discussion. In Person/ 1 day	Safeguard Unit of PMU / PMC EMC, HSC and LMC	PMC Budget
Facilitated H&S workshop (construction stage)	PMU, Contractors Management, Construction, and Environment Safeguards Staff	Facilitated workshop In Person/ 1 day	PMC HSC	PMC Budget
Environmental quality monitoring requirements; site supervision and monitoring including use of detailed monitoring framework (checklists) and preparing period	PMU, Contractors Management and Environment Safeguards Teams	Lecture session, presentation, and discussion. In Person/ 2 days	Safeguard Unit of PMU / PMC EMC, HSC and LSC	PMC Budget

Training Session	Required Attendees/Recipients	Delivery Mode/Duration	Training Conducted by	Budget Source
Environmental Monitoring Reports				
Site restoration	PMU, Contractors Management, Construction, and Environment Safeguards Staff	Lecture session, presentation, and discussion. Online/ 0.5 day	Safeguard Unit of PMU / PMC EMC	PMC Budget
EMP in O&M including workshop on standard operating procedures for SS	PMU, NEA O&M Team	Lecture session, presentation, and discussion. In Person/ 1 day	Safeguard Unit of PMU / PMC EMC, HSC and PCC	PMC Budget

EMP Implementation Schedule

The definitive version of the ADB disclosed EMP will be incorporated into the contract document. Strictly no contracts will be awarded before the final EMP has been incorporated into the contract documentation. Further, no site establishment or construction activity is to take place before NEA has received and approved the contractor's CSEMP including all sub-plans. Tentative implementation schedule of the project is listed in the following table; if timelines are extended that any inputs will need to be pro-rata. The contractors will submit a more detailed implementation schedule for the detailed design, pre-construction, and construction once the contract is awarded.

Table 14: Key EMP Milestones in Implementation Schedule

S. No	Description	Indicative Time Frame
1	Project Implementation	
A	Bidding Documents	Q4 2024
B	Procurement	Q1 2025 [6 months]
C	Construction commencement	Q2 2025
D	Construction Completion	Q1 2026 [12 months]
E	Defects Liability Period	Q1 2027 [12 months]
2	Pre-Construction and Construction Phase	
A	Implementation of mitigation measures and conduct environmental monitoring for which NEA is responsible	Immediate implementation, noting EMP requirements must be reflected in contract for which bidding documents may be issued prior to ADB project approval
B	Establishment of GRM	Immediate implementation, latest within one month of loan effectiveness or before the start of works on site if sooner
C	Appointment of NEA PMU safeguards team	Latest within one month of loan effectiveness for the PMU safeguard support, before start of works on site if sooner.
D	Appointment of PISC	PISC must be appointed latest within three months of loan effectiveness and prior to the approval of detailed design, CSEMP approval, site establishment, site preparation, etc.
E	Implementation of mitigation measures and conduct environmental monitoring for which contractor is responsible	Upon award of the contract
F	Updating the IEE/EMP to reflect outline and detailed design and obtaining ADB clearance of update	Prior to approval of the outline and detailed design (as needed)
G	Submission and approval of the Contractor's Specific Environmental Management Plan (CSEMP)	One month before the start of works including any site establishment, site preparation, and earthworks
H	Monthly EMR for Project's Monthly Progress Report	5th day after effective month (covering the month prior)
I	Semi-Annual EMR during pre-construction and construction for submission to ADB	15th day of January or July following loan effectiveness
J	Restoration of construction sites	Before demobilization of contractor
3	Operation Phase	

S. No	Description	Indicative Time Frame
A	Implementation of mitigation measures and monitoring activities for operational period	Upon commissioning and handover
B	Semi-Annual EMR during operation for submission to ADB	15th day of January or July following loan effectiveness up until the PCR is issued

Budget

Costs will be associated with implementation of the mitigation plan, EMoP and capacity development. Necessary budgetary provisions must be planned and allocated by NEA for implementing the environmental measures as part of the EMP. The main EMP budget items have been identified for implementing the environmental management and monitoring and capacity development activities required, and an indicative budget allocated for each. The budget will be refined during project implementation but enables preparedness for financial requirements.

For contract related costs these are only an estimate based on an estimate of the construction and installation cost, since the contracts are subject to competitive bidding it will be for the contractor/consultants to reflect in their BOQ and ensure adequate budget is provided in their bids for the EMP implementation. The construction EMoP will be part of the Contractor's contract, whereas the operational EMoP will be the responsibility of NEA O&M team. Operational cost is an annual cost, it will be incurred annually for each year the substations are in operation.

Table 15: Indicative Implementation Budget

Item	Quantity	Estimated Rate ($)	Estimated Total Amount ($)	Budget Source
Pre-Construction and Construction				
NEA Safeguard Staff and Incidentals				
Environment Safeguard Officer [SSEMD]	1 x 30 PM	800	24,000	NEA Counterpart
Health and Safety Officer [SSEMD]	1 x 30 PM	800	24,000	NEA Counterpart
Training Session Expenses	11 days	500	5,500	NEA Counterpart
Expenses for consultation, GRM etc.	30 months	100	3,600	NEA Counterpart
PMC Safeguard Specialists				
Environmental Safeguards	1 x 2 PM	15,000	30,000	PMC Contract
Health and Safety	1 x 2 PM	15,000	30,000	PMC Contract
Pollution Control	1 x 1 PM	15,000	15,000	PMC Contract
Labor Management	1 x 2 PM	15,000	30,000	PMC Contract
EHS Field Consultant	1 x 3 PM	2,000	6,000	PMC Contract
Contractor's Environment Safeguards Team				
Environmental and Social Manager	1 x 12 PM	1,000	12,000	Construction Contract
Health and Safety Specialist	1 x 12 PM	1,000	12,000	Construction Contract
Pollution Control Specialist	1 x 1 PM	800	800	Construction Contract
Labor Specialist	1 x 3 PM	500	1,500	Construction Contract
EHS Supervisors x 2 (one per substation)	2 x 12 PM	1,000	24,000	Construction Contract
Other Costs				
Impementation of CAP at existing SS	Lump sum	10,000	20,000	NEA Counterpart (unless delegated to contractor)

Item	Quantity	Estimated Rate ($)	Estimated Total Amount ($)	Budget Source
Contractor's EMP implementation cost (including PPE provision) – estimated at 0.5% of costs	Lump Sum Based on 15m costs	75,000	75,000	Construction Contract
Pre-construction/construction/commissioning environmental quality monitoring (see table)	Lump Sum	n/a	18,038	Construction Contract
Total Budget	**-**	**-**	**331,438**	-
Contingency @ 10%	**-**	**-**	**33,144**	-
Operation				
Environment Safeguard Officer [SSEMD]	1 x 12 PM	800	24,000 9,600	NEA Counterpart
Health and Safety Officer [SSEMD]	1 x 12 PM	800	24,000 9,600	NEA Counterpart
Training Session Expenses	1 day	500	500	NEA Counterpart
Expenses for consultation, GRM etc.	12 months	100	1,200	NEA Counterpart
Operation environmental quality monitoring (see table)	Lump Sum	n/a	1,060	NEA Counterpart
Total Budget	**-**	**-**	**21,962**	**-**
Contingency @ 10%	-	-	**2,196**	-

Table 16: Environmental Quality Monitoring Budget Per Substation

Parameters per Monitoring Plan	Sites	Rate in USD	Quantity/ location	Frequency	Total in $
Pre-Construction					
Property surveys	Access Road	1000	2	1	2000
Tree and habitat surveys	Substations	1000	2	1	2000
Noise		36	2	1	72
Air quality		157	2	1	314
Surface water quality		54	2	1	108
Ground water quality		54	2	1	108
Soil quality		354	2	1	708
PCB		500	2	1	1000
Drinking water source for potability		54	2	1	108
Construction					
Noise	Substations	36	2	12	864
Air quality		157	2	4	1,256
Surface water quality		54	2	4	432
Ground water quality		54	2	4	432
Influent and effluent		54	2	12	1,296
Drinking water source for potability		54	2	12	1,296
Commissioning					
Property surveys	Access Road	1000	2	1	2000
Tree and habitat surveys	Substations	1000	2	1	2000
Air quality (DG)		157	2	1	314
Noise		36	2	1	250
EMF		500	2	1	1000
Drinking water source for potability		54	2	1	108
		Total Monitoring Budget for Contractor Cost			**18,038**
O&M (Annual)					

Air quality (DG Set)	Substations	157	2	2	628
Influent and effluent (Septic Tank)	Substations	54	2	2	216
Drinking water source for potability	Substations	54	2	2	216
		Total Monitoring Budget for NEA Cost			**1,060**

Appendix A – Corrective Action Plan

S. No	Issue	Corrective Action	By whom	By when	Budget (source)
0	General lack of knowledge on EHS issues	Short term: • Provide all SS managers with EHS awareness training so they can understand and implement the corrective action that is required at each SS • Records of all EHS permits applicable to the SS to be made available at the site Long term: • Develop and adopt corporate wide EHS policy and manuals/procedures (SOP) for SS operation • SOP developed for SS to include guidelines for pollution prevention including management or handling procedures for oil spills, spillage, runoff from leaks off equipment, and waste management, including for hazardous waste management • SOP developed for SS to include guidelines for H&S management including emergency preparedness :Ensure copy of EHS policy and SOP available at all SS Provide SS managers/workers on training with respect implementation of the SOP • Provide specific training (refer IEE EMP Chapter for details) to all SS managers/workers on EHS issues.	NEA PMU to implement	Short term actions upon loan effectiveness and before any project works commence Long term actions before operation of the project substations	NEA operational budget, may be supported by PISC international environment expert.
1a	General housekeeping and waste management, handling and storage of hazardous material needs improvement (corporate level)	• Develop and cascade to the SS for implementation a standardized housekeeping and waste management system/procedure in accordance with national laws and regulations and the EHS Guidelines on Hazardous Materials Management and Waste Management. • System/procedure to include avoiding or minimizing the generation waste materials, as far as practicable. Where waste generation cannot be avoided but has been minimized, the preference should be recovery and reuse. Where waste cannot be recovered or reused, reputable, legitimate, licensed contractors must be appointed to treat, destroy, and dispose of it in an environmentally sound manner. • Develop as part of system/procedure a checklist for SS managers on correct storage and disposal of transformer oils, other fuel, oil, and chemicals, old transformer oil drums, scrap metals, electronic wastes, municipal solid wastes, and wastewater etc.	NEA PMU to implement	Before any project works commence	NEA operational budget, may be supported by PISC international environment expert.

S. No	Issue	Corrective Action	By whom	By when	Budget (source)
		• Provide training to all SS managers on implementation of the housekeeping and waste management system/procedure and use of the checklist (document training and attendance by SS managers). Training on Oil Spill Reporting, Recovery and Clean up.			
1b	General housekeeping and waste management, handling and storage of hazardous material needs improvement (substation level)	In short-term: • Identify and demark in the SS compound an appropriate area for waste storage yard and for storage of oil barrels, fuel etc. • Implement housekeeping and waste management system/procedure to include the (i) segregation of all solid and hazardous waste generated; and (ii) environmentally sound storage of all solid and hazardous materials and waste in dedicated, labelled areas within the premises of substations over impermeable layer. • Provide training to both SS staff on implementation of the housekeeping, waste management system/procedure, and oil spill reporting, recovery and clean up (document training and attendance by SS managers). • Construct a dedicated, covered, bunded impermeable area to 110% for storage of barrels of transformer oil, other fuel, oils, and chemicals to prevent leakage into the ground	NEA SS Managers to implement, for audit by NEA PMU	Short-term actions before any project works utilizing substation commence	SS operational budget.
2	Boundary wall safety and drainage	• Survey of the potential undercutting or damage to the boundary wall by percolating water and drains/streams from outside the boundary wall at the New Butwal SS. • Ensure adequate retention mechanism to prevent collapse of the wall in New Butwal SS. • Timely monitoring and clearing of drainage system to ensure the percolation of water from the northern wall of the Kushma SS does not inundate the switchyard. • Cautionary timely trimming of the *Ficus religiosa* tree at the northern boundary wall observed to overgrow into the Kushma SS switchyard taking into account the religious value attached to local people (suggest to already plant a replacement at an agreed with concerned stakeholders).	NEA SS Managers to implement, for audit by NEA PMU	Before any project works commence	SS operational budget.
3a	First aid kits and PPE, training in use of PPE and health and safety and emergency procedures in event of illness,	• Source first aid kits and PPE for distribution to SS Managers -- PPE (footwear, masks, protective clothing, ear mufflers, pollution masks and goggles in appropriate areas) to be provided to the staff, in accordance with the Summary of	NEA PMU to implement	Before any project works commence	NEA operational budget, may be supported by PISC international environment

S. No	Issue	Corrective Action	By whom	By when	Budget (source)
	accident, fire, or natural hazard to be provided (corporate level)	Recommended Personal Protective Equipment According to Hazard, provided in IFC. 2007. General EHS Guidelines: Occupational Health and Safety. • Periodic checks of first aid kits and PPE at substations should be carried out, recorded and information on the same should be monitored. • Develop as part of health and safety system/procedure a checklist for SS managers on correct content of first aid kit, PPE to be provided at SS, need for renewal if out of date etc. • Develop as part of health and safety system/procedure an incentive/disciplinary system to ensure use of PPE by workers at SS, such as use of written warnings etc. • Provide training to all SS managers on use of the checklist and incentive/disciplinary system, as well as on (i) proper use of PPEs - the importance of safety needs to be stressed to effect behavioral/attitudinal change, (ii) general health and safety aspects, and (iii) emergency procedures in event of accident, fire or natural hazard to be given on a train-the-trainer basis (document training and attendance by SS managers) • Provide emergency medical contacts, location and transportation means. • Provide training to all SS managers on the development and implementation of emergency preparedness and response plans for (i) environmental incident, (ii) health and safety incident in accordance with the General EHS Guidelines			expert.

S. No	Issue	Corrective Action	By whom	By when	Budget (source)
3b	First aid kits and PPE, training in use of PPE, health and safety and emergency procedures in event of illness or accident to be provided (substation level)	• Ensure appropriately equipped first aid kits available at first aid stations in each working area and building to be easily accessible; need to also include list of equipment and its use by dates as well as poster of the first aid procedures and emergency contact details/local hospital at the site. • Ensure appropriate PPE is available at the substation and is actively used by staff by implementing the incentive/disciplinary system. • Provide training to all SS staff (including housekeeping staff) on (i) proper use of PPEs the importance of safety needs to be stressed to effect behavioral/attitudinal change, (ii) general health and safety aspects, and (iii) emergency procedures in event of accident (document training and attendance by SS managers) • Ensure that a first aider is always provided on-site; this can be a member of staff trained in emergency procedures to follow in event of accident. • Ensure biological control of snakes within the SS premises and basic trainings with posters on immediate actions of first aid in case of snake bites and poisonous stings.	NEA SS Managers to implement, for audit by NEA PMU	Before any project works utilizing substation commence	SS operational budget.
3c	Emergency response systems need to be improved, training and protocol in emergency procedures in event of fire or natural hazard to be provided (substation level)	• Develop and implement emergency preparedness and response plans for (i) environmental incident, (ii) health and safety incident in accordance with the General EHS Guidelines to include details of emergency equipment on site, NEA designated Team, nearest doctors, hospital, fire station, monthly testing of fire alarms, emergency preparedness and response training plan, and quarterly emergency fire/earthquake/flood simulation drills with records. • Provide training to all SS staff (including housekeeping staff) on emergency procedures in event of fire or natural hazard, including undertaking emergency fire/earthquake/flood simulation drills (document training and attendance by SS managers) • Ensure adequate supply of water for the hydrant system since the New Butwal SS and Kushma SS are reliant on municipal supply of water. • Ensure that a fire marshal is provided on-site at all times; this can be a member of staff trained in	NEA SS Managers to implement, for audit by NEA PMU	Before any project works utilizing substation commence	SS operational budget.

S. No	Issue	Corrective Action	By whom	By when	Budget (source)
		emergency procedures to follow in event of fire.			
4	Health and safety risk reduction measures	Short-term: - • Install warning signs (in written and graphic form using ISO electrocution symbols) on substation boundary fence and on high risk electrical equipment within the site • Measure EMF levels at the substation to confirm that international good practice reference levels for workers/adjacent residents per IFC EHS Guidelines not exceeded using necessary standard equipment or means • If reference levels exceeded provide workers with personal monitor so they can measure and manage their EMF exposure. • Provide earplugs and dust masks for workers in areas close to the crushing plant at New Butwal SS. Long term: - • If EMF exposure risk identified because of measurements, install shield to prevent workers being exposed	NEA SS Managers to implement, for audit by NEA PMU	Short-term actions before any project works utilizing substation commence; long-term actions by project completion	SS operational budget.
5	SS staff safety and security, and welfare facilities for SS Staff	• Preventing gaps in boundary walls to ensure safety and security. • Drains sloping to ensure no stagnation of water. • Guard rooms drains in New Butwal SS having water stagnation issue to be resolved • Guard room in Kushma SS to repair tiles. • Clogged septic tanks to be repaired and cleared and also ensure timely clearing.	NEA SS Managers to implement, for audit by NEA PMU	Before any project works utilizing substation commence	SS operational budget.
6	Biodiversity (bird electrocution risk)	• For both New Butwal and Kushma substations for former which is already located in Important Bird Area and the latter next to community forest, assess the electrocution risk to birds from any lower voltage wires and/or jumpers at existing incoming and outgoing connections, as well as high voltage connections and where risk is deemed to be high retrofit with “bird sensitive” design measures. • Fencing designs for safety to and from wildlife. Stronger, higher walls with spikes, to prevent small mammals such as monkeys and also unauthorized person’s intrusion.	NEA SS Managers to implement, for audit by NEA PMU	By project completion.	SS operational budget.

ENVIRONMENT

The national laws and regulations and IFC EHS guidelines should be followed along with the following environmental guidance:

Pollution Prevention

Air Pollution (Dust)

- Use of modern equipment, exclude over-aged or worn-out equipment or vehicles from the construction site
- Trucks importing loose raw materials or removing spoil must be covered with tarpaulin to reduce dust generation
- Position any stationary emission sources (e.g., water pumps, diesel generators, compressors, etc.) as far as practical from the nearest properties
- Impose speed limits on construction vehicles on off- and on-site access roads to minimize exhaust and dust emissions especially where access roads run adjacent to properties
- Prohibit engine idling
- Stockpiles of spoil and other dust generating materials to be kept to a minimum necessary to undertake works for the day and covered with tarpaulin
- Minimize double handling and drop loads
- Cover exposed soil with materials like gravel to minimize re-suspension of dust
- Sprinkle earthworks, off- and on-site access roads that are not blacktopped, and material stockpiles with water during the construction period to avoid dust being dispersed by wind and mitigate dust related issues due to frequent movement of construction vehicles as necessary i.e., 2-3 times per day but more often if needed during excavations, dry and windy conditions that enable dust to be easily mobilized and the dust to be visible.
- Regularly clean dust from the off-site access roads during and immediately after construction work is completed.
- Strictly prohibit the burning of wastes generated by project-related activities.
- Ensure workers working near or having long exposure to vehicle exhausts and earthworks are provided with clean N95 dust masks to avoid inhalation or particulate matter and other pollutants.
- Periodic medical respiratory checks to be performed on workers exposed to high dust levels.

Noise and Vibration

- Use of modern equipment, exclude over-aged or worn-out equipment or vehicles from the construction site
- Select construction techniques and low noise generating equipment e.g., less than 55 dBA sound pressure level at 1m, and stage noisy works to limit their duration to minimize noise and vibration
- Fit all equipment and vehicles used in construction with exhaust silencers where the manufacturer's design allows this
- Position any stationary emission sources (e.g., water pumps, diesel generators, compressors, etc.) as far as practical from the nearest properties
- Prohibit engine idling
- Prohibit use of horn by construction vehicles
- Impose speed limits on construction vehicles on off- and on-site access roads to minimize noise emissions especially where access roads run adjacent to properties
- Provide appropriate PPE (acoustic ear plugs or earphones capable of reducing noise levels to 80 dB(A) for hearing protection) to any workers subjected to noise levels of 80 dBA for more than 8 hours per day and ensure they wear it e.g., if piling etc.
- No unprotected ear should be exposed to a peak sound pressure level (instantaneous) of more than 140 dB(C) or average maximum sound levels of 110 dB(A).
- Periodic medical hearing checks to be performed on workers exposed to high noise levels of 80 dBA for more than 8 hours per day.

Soil and Water Pollution

- Avoid storage of all fuel, oil, and chemicals in areas located within 100m of surface water and groundwater springs, etc. to avoid direct contamination or contamination through run off

- Drums, containers or tanks of fuel, oil, or chemicals to be labelled and kept in a designated, labelled storage area under lock and key when not in use
- Establish dedicated fuel, oil, and chemicals stores (drums/containers/tanks) on impermeable bunded area of 110% volume to avoid spills and leaks contaminating soil and affecting water quality
- Secondary containment design to also consider means to prevent contact between incompatible materials in the event of a release.
- Place all drums or containers of fuel, oil, or chemicals on drip trays it not sited on impermeable surface with 110% bunded capacity.
- Place all equipment that containing fuel or oil on drip trays it not sited on impermeable surface with 110% bunded capacity.
- Undertake refilling or refuelling only on areas of hard protected soil, preferably bunded, at least 100m from surface water with all drainage directed through oil interceptors.
- Provide drip trays/catch basins or other overflow/drip containment measures at connection points or possible overflow locations during refilling or refuelling
- Use of dripless hose connections for vehicle tanks and fixed connections with storage tanks
- Use dedicated fittings, pipes, and hoses on containers or tanks and regularly inspect their condition
- Use of refilling or refuelling equipment that is compatible and suitable for the characteristics of the materials being transferred and designed to ensure safe transfer
- Overfills of drums, containers, and tanks to be prevented as they are among the most common causes of leaks and spills resulting in soil and water contamination, this can be achieved by:
  - Checklist of measures to follow during filling operations
  - Provision of automatic fill shutoff valves to prevent overfilling
  - Installation of gauges on containers or tanks to measure volume inside
  - Use of pipe connections with automatic overfill protection (float valve)
  - Pumping less volume than available capacity by ordering less material than its available capacity
- Provision of overfill or over pressure vents that allow controlled release to a capture point
- Maintain procedures to prevent hazardous materials from being stored in incorrect containers or tanks
- Provide spill response kit with sufficient absorbent materials (e.g., sorbents, dry sand, sandbags) on-site for immediately soaking up any fuel, oil, or chemical leaks/spills that do accidentally occur
- Undertake construction during the dry season to minimize exposed areas subject to erosion by surface water runoff and to avoid flood risk, leading to accidents and/or water contamination.
- Deep excavations to be limited to dry season to prevent the need to pump out and dispose of sediment laden water.
- Works over or near watercourses will adopt protection measures to guard against loss of soil that would result in the turbidity of water.
- Implement measures to prevent landslides to avoid contamination of rivers by soil.
- Minimize soil erosion and surface water runoff by reducing the extent of earthworks, revegetating earthworks on completion, and covering stores of sand and spoil with tarpaulin
- Ensure surface water runoff from the construction site shall not discharge directly to surface water but shall be discharged through sedimentation basin and oil interceptor.
- Provision of oil-water separator on all drainage systems
- If water from excavations is pumped it must be disposed of via a sedimentation basin, it must not be disposed of directly to surface water.
- Do not allow washing of equipment or vehicles in surface water and ensure all washing water is discharged to sedimentation basin and oil interceptor instead of directly to surface water.
- Provision of designated hard standing areas for equipment servicing, refueling and wash down located at least 100m from surface water bodies, groundwater springs, with drainage directed through oil and grease interceptors before discharge into a settling pond
- Cement will be stored in enclosed storage facilities and not exposed to the elements.
- Do not undertake any concrete mixing within 100m of surface water
- Strict prohibition on open defecation and urination by construction workers
- No use of pit latrines
- Toilets and washing facilities to be connected to septic tank (with soak pit)
- No untreated wastewater is to be discharged direct to surface water or the ground
- Spent engine oil from the equipment will be collected and sent for recycling and re-use.

Materials and Waste Management

- Import all materials from existing licensed sources and keep records of all materials used, and sources.
- Storage yards will be fenced using a solid fence to catch windblown material.
- Minimize waste generation, restrict use of plastics and polyethene and use recyclable/biodegradable materials during construction to the extent possible
- Use durable, long-lasting materials that will not need to be replaced as often, thereby reducing the amount of construction waste generated over time.
- Purchase perishable construction materials e.g., paints incrementally to reduce spoilage of unused materials.
- Use building materials that have minimal packaging to avoid generation of excessive packaging waste
- Use construction materials containing recycled content when possible and in accordance with technical standards
- Prior to the start of works the contractor will ensure the waste management system is established at the construction sites and workers camps.
- Separate waste containers (drums, bins, skips or bags) will be provided for different types of waste; prevent the commingling or contact between incompatible wastes and allow for inspection between containers to monitor leaks or spills
- Sensitize workers on good housekeeping and the environmentally sound storage and disposal of construction and wastes, and importantly not to leave garbage lying around.
- Collect and segregate construction wastes including scrap metal, oil, and solid waste; ensure all workers are familiar with this segregation and arrange garbage bins to collect these wastes so they are not thrown on the floor
- Clearly identifying (label) and demarcating the waste storage area(s) on a site plan
- Store all the wastes produced in an environmentally sound manner in designated, labelled area with separate waste containers (drums, bins, skips or bags) for each distinct type of waste.
- Store solid waste in enclosed bins to contain leachate and avoid vermin.
- Store hazardous waste so as to prevent accidental releases to air, soil, and water resources in closed containers away from direct sunlight and rain
- Limiting access to hazardous waste storage areas to workers who have received proper training
- Secondary containment systems to be constructed using materials appropriate for the wastes being contained
- Provide adequate ventilation where volatile wastes are stored
- Conducting periodic inspections of waste storage areas and documenting the findings
- Encourage recovery of recyclable wastes that could be reused or sold to licensed recyclers, rather than disposing of it.
- Prohibit use of waste (e.g., empty cement bags and containers, plastic, wooden planks) for backfilling – only inert spoil may be used for backfilling to avoid need for off-site disposal (any excess inert spoil is to be disposed of at suitably licensed waste facilities).
- Prohibit burning of construction wastes.
- Prohibit dumping of construction wastes on-site, into streams, in agricultural fields etc.
- Provide weekly toolbox talk to remind of the importance of waste disposal, prohibition of disposal on the road, in drains etc., prohibition on burning of wastes, and open defecation and urination.
- Develop a procedure/system to penalize through escalating fines or similar any construction workers who breach these requirements.
- Document all wastes removed off site (including excavated soil, solid and hazardous waste) using transfer notes, to be taken by licensed waste contractors who should reuse/recycle or dispose of the waste to suitably licensed and engineered waste management facilities according to type
- Excavated spoil that cannot be reused to a licensed disposal site as suitable for accepting inert wastes ensuring no solid or hazardous wastes are comingled with the inert excavated spoil
- Collect solid waste and dispose of it to suitably engineered and licensed sanitary waste facilities
- Ensure any hazardous waste such as oily rags or old drums disposed of in suitably licensed hazardous waste facilities
- Waste containers designated for off-site shipment to be secured and labelled with the contents and associated hazards, be properly loaded on the transport vehicles before leaving the site, and be accompanied by a shipping paper, that describes the load and its associated hazards

Emergency Preparedness and Response Planning

1. For spills and leaks an emergency preparedness and response plan tailored to the hazards associated with the project, should include:

- SOP for the management of containment structures, specifically the removal of any accumulated fluid, such as rainfall, to ensure that the intent of the system is not accidentally or willfully defeated
- Implementation of inspection programs to ensure containment structures are physically intact and being well managed
- Identification of locations of hazardous materials and associated activities on an emergency plan
- Documentation of availability of specific personal protective equipment and training needed to respond to an emergency
- Documentation of availability of spill response equipment sufficient to handle at least initial stages of a spill and a list of external resources for equipment and personnel, if necessary, to supplement internal resources
- Description of response activities in the event of a leak, spill, release, or other emergency including internal and external notification procedures, specific responsibilities of individuals, decision process for assessing severity of the incident and determining appropriate action, first aid and emergency medical treatment, evacuation routes, post-event activities such as clean-up and disposal, incident investigation, worker re-entry, and replenishment of used PPE and spill response equipment
- Inspecting, testing, and maintaining the emergency response equipment
- Training of workers on release prevention, including drills specific to hazardous materials stored on site

Soil Erosion and Runoff Management

2. Bunding is an engineering soil conservation measure used for creating obstruction to the surface water runoff for controlling soil erosion. By bunding, an area is divided into smaller parts; thereby the effective slope length is reduced. The reduction of the slope length causes a reduction of the soil erosion as the surface runoff water is retained in the bund. Bunds are simple earthen embankments of varying lengths and heights, constructed across the slope. Graded bunds are adopted in case of high or medium annual rainfall (>600 mm) and relatively less permeable soil areas and in cases such as a construction site where the water ponded behind the bund is to be removed.

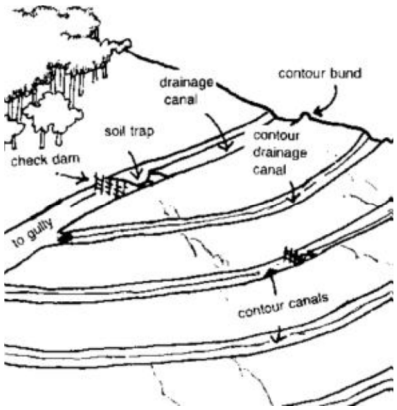


Figure 1: Bund illustration in hilly area

3. Construction of three-stage sedimentation ponds/tanks with an inlet, mid, and outlet section is required to allow sediment to settle out of surface water runoff before release of water. Silt fences can be used to channel surface water runoff to the sedimentation pond/tank. The working volume of the sedimentation pond/tank must be sufficient to allow for a minimum hydraulic retention time of at least 120 minutes under the peak surface water runoff conditions. If runoff rates exceed the capacity of a sedimentation pond/tank, one or more additional sedimentation ponds/tanks will be needed in parallel to accommodate the higher flow rates. Maximum sediment accumulation in the sedimentation pond/tank must be 25% or less.

Figure 2: Sedimentation Pond/Tank Illustrations

Source: Minnesota Strom Water Manual, https://www.eng.auburn.edu/research/centers/hrc-temp/news/erosion-control.html, https://cals.ncsu.edu/crop-and-soil-sciences/extension/training-programs/workshops/erosion-and-sediment-control/

HEALTH AND SAFETY

The national laws and regulations, IFC EHS guidelines, ILO safety and health in construction should be followed along with the following safety guidelines:

a. Preventive and protective measures should be introduced according to the following order of priority:

- Eliminating the hazard by removing the activity from the work process.
- Controlling the hazard at its source through use of engineering controls.
- Minimizing the hazard through design of safe work systems and administrative or institutional control measures.
- Providing appropriate personal protective equipment (PPE) in conjunction with training, use, and maintenance of the PPE.

b. OHS Training

- Training should generally be provided to management, supervisors, workers, and occasional visitors to areas of risks and hazards.
- Provisions should be made to provide OHS orientation training to all new employees to ensure they are apprised of the basic site rules of work at / on the site and of personal protection and preventing injury to fellow employees.
- Training should consist of basic hazard awareness, site- specific hazards, safe work practices, and emergency procedures for fire, evacuation, and natural disaster, as appropriate.
- Any site-specific hazard or color coding in use should be thoroughly reviewed as part of orientation training.

c. Basic OHS Training

- A basic occupational training program and specialty courses should be provided, as needed, to ensure that workers are oriented to the specific hazards of individual work assignments.
- Workers with rescue and first-aid duties should receive dedicated training so as not to inadvertently aggravate exposures and health hazards to themselves or their co- workers.

Training would include the risks of becoming infected with blood–borne pathogens through contact with bodily fluids and tissue.

- Through appropriate contract specifications and monitoring, the contractor should ensure that service providers, as well as contracted and subcontracted labor, are trained adequately before assignments begin.

d. Tool Box Talks:

- Tool Box Talk meetings to be conducted every day before starting of the work. Work Plan for the day along with hazards/risks involved in the activities and safe working practices for the same are to be discussed with the workers, these can be conducted by contractor‘s supervisory staff as well.
- Record of the Tool Box Talk meeting to be generated and signature of all the workers/supervisor are to be taken on the meeting sheet. This activity will gradually enhance the safety awareness and will also help in operating in a planned manner.

e. Labeling

- All vessels that may contain substances that are hazardous as a result of chemical or toxicological properties, or temperature or pressure, should be labeled as to the contents and hazard, or appropriately color coded.

f. Noise

- No employee should be exposed to a noise level greater than 85 dB(A) for a duration of more than 8 hours per day without hearing protection. In addition, no unprotected ear should be exposed to a peak sound pressure level (instantaneous) of more than 140 dB(C).
- The use of hearing protection should be enforced actively when the equivalent sound level over 8 hours reaches 85 dB(A), the peak sound levels reach 140 dB(C), or the average maximum sound level reaches 110dB(A). Hearing protective devices provided should be capable of reducing sound levels at the ear to at least 85 dB(A).
- Although hearing protection is preferred for any period of noise exposure in excess of 85 dB(A), an equivalent level of protection can be obtained, but less easily managed, by limiting the duration of noise exposure. For every 3 dB(A) increase in sound levels, the ‘allowed’ exposure period or duration should be reduced by 50 percent.
- Prior to the issuance of hearing protective devices as the final control mechanism, use of acoustic insulating materials, isolation of the noise source, and other engineering controls should be investigated and implemented, where feasible

g. Electricity

- Marking all energized electrical devices and lines with warning signs
- Checking all electrical cords, cables, and hand power tools for frayed or exposed cords and following manufacturer recommendations for maximum permitted operating voltage of the portable hand tools
- Double insulating/grounding all electrical equipment used in environments that are, or may become, wet; using equipment with ground fault interrupter (GFI) protected circuits
- Appropriate labelling of service rooms housing high voltage equipment (‘electrical hazard’) and where entry is controlled or prohibited
- Conducting detailed identification and marking of all buried electrical wiring prior to any excavation work

h. Training and licensing industrial vehicle operators in the safe operation of specialized vehicles such as forklifts, including safe loading/unloading, load limits

- Ensuring drivers undergo medical surveillance
- Ensuring moving equipment with restricted rear visibility is outfitted with audible back-up alarms

- Establishing rights-of-way, site speed limits, vehicle inspection requirements, operating rules and procedures, and control of traffic patterns or direction
- Restricting the circulation of delivery and private vehicles to defined routes and areas, giving preference to 'one-way' circulation, where appropriate

i. Fall prevention and protection measures should be implemented whenever a worker is exposed to the hazard of falling more than two meters. Fall prevention may include:

- Installation of guardrails with mid-rails and toe boards at the edge of any fall hazard area
- Proper use of ladders and scaffolds by trained employees
- Use of fall prevention devices, including safety belt and lanyard travel limiting devices to prevent access to fall hazard area, or fall protection devices such as full body harnesses used in conjunction with shock absorbing lanyards or self- retracting inertial fall arrest devices attached to fixed anchor point or horizontal lifelines
- Appropriate training in use, serviceability, and integrity of the necessary PPE
- Inclusion of rescue and/or recovery plans, and equipment to respond to workers after an arrested fall

j. Fires and or explosions resulting from ignition of flammable materials or gases can lead to loss of property as well as possible injury or fatalities to project workers. Prevention and control strategies include:

- Storing flammables away from ignition sources and oxidizing materials.
- Defining and labeling fire hazards areas to warn of special rules (e.g. prohibition in use of smoking materials, cellular phones, or other potential spark generating equipment);
- Providing specific worker training in handling of flammable materials, and in fire prevention or suppression

k. Personnel Protective Equipment

- Risks to the health and safety of workers can be prevented by provision of Personal Protective Equipment (PPEs) to all workers. Personal protective equipment like safety gloves, helmet, mufflers etc. will be provided during the construction period and during the maintenance work. This will be included in the BOQ list. Depending on the nature of work and the risks involved, contractors must provide without any cost to the workers, the following protective equipment. The list of protective equipment is given in Table 1.
- Helmet shall be provided to all workers, or visitors visiting the site, for protection of the head against impact or penetration of falling or flying objects.
- All PPE must be of good quality with mark of quality standard certification.
- Safety belt shall be provided to workers working at heights for bridge construction, etc.
- Safety boots shall be provided to all workers for protection of feet from impact or penetration of falling objects on feet.
- Ear protecting/ earmuffs/plugs shall be provided to all workers in high noise zones.
- Eye and face protection equipment shall be provided to all welders to protect against sparks.
- Respiratory protection devices shall be provided to all workers during occurrence of fumes, dusts, or toxic gas/vapor.
- The supervisor must ensure that appropriate personal protective equipment is available to workers; properly worn when required and properly cleaned, inspected, maintained and stored.
- A worker shall be responsible for using the items of personal protective equipment provided by the employer;
- A worker who is required to use personal protective equipment must-
    - Use the equipment in accordance with training and instruction.
    - Inspect the equipment before use.
    - Refrain from wearing protective equipment outside of the work area which if done so would constitute a hazard; and
    - Report any equipment malfunction to the supervisor or employer.
- A worker who is assigned responsibility for cleaning, maintaining or storing personal protective equipment must do so in accordance with training and instruction provided.
- An emergency procedures manual will be kept.

- First aid facilities will be made available on-site and doctors called in from nearby village/towns when necessary. Minimum contents of the first aid box is given in Table 2.

Table 1 - Personnel Protection Equipment (PPE) for safety of different body parts

No.	Body Part to be Protected	PPE
1	Head	Safety helmet, hard hat, Crash helmets
2	Eye	Eye protectors, eye protectors for radiations, shield and helmet, zero power goggles
3	Ear	Earplug, earmuffs
4	Noise-Mouth	Du respirator, gas mask, self-contained breathing apparatus, dust masks
5	Hand	Standard work gloves, cutting gloves, leather work gloves, heat protective gloves, anti-vibration gloves
6	Foot	Industrial safety boots, chemical-proof boots
7	Body	Standard work clothing, chemical-proof clothing, heat protective clothing, leather apron
8	Others	Safety belts, personal protective equipment for radiation protection, back support belts
9	Communicable diseases	Sanitizer, masks etc.

Table 2 - Contents of first-aid box

Sr. No.	Description	Quantity
1	First aid leaflet	1 copy
2	Sterilized finger dressing	10 nos.
3	Sterilized hand or foot dressing	10 nos.
4	Sterilized body or large dressing	6 nos.
5	Sterilized burns dressing - small	4 nos.
6	Sterilized burns dressing - large	2 nos.
7	Sterilized burns dressing – extra large	6 nos.
8	Sterilized cotton wool (25 gms)	2 tubes
9	Cetavolon	2 tubes
10	Eye pads	6 nos.
11	Adhesive plaster	1 spool
12	Assorted roller bandage	6 nos.
13	Triangular bandages	6 nos.
14	Safety pins	6 nos.
15	Scissors, ordinary, 12.7cms, both sides sharp	1 pair
16	Antiseptic liquid, 150 ml, or equivalent	2 nos.
17	Cotton wool for padding, 100 gms	2 packets
18	Eye Ointment of sulphacetamide preparation	1 tube
19	Loose woven gauze (28”x8”), compressed pack	1 packet
20	Aspirin, 300 mg (10 tablets)	5 strips
21	Note Pad, with a pencil in a plastic cover	1 no.
22	Adhesive dressing strips	10 strips
23	Field dressing of modified army pattern	3 nos.
24	Record cards in a plastic cover	1 set
25	Torch, medium size	1 no.
26	Eye wash	1 no.
27	Wooden splints, small	1 set
28	Wooden splints, big	1 set
29	Disinfectant, Spirt, 100ml	1 bottle

l. Proper demarcation & barricading

Safety barricading to be done around the working area from day one to safeguard against trespassing. —people at work board must be placed to indicate work under progress in the vicinity. Barricading to be kept in place till the work is over, even if it takes few days to complete. No excavated pits / loose soil areas should be kept open without barricading around the area. Also, all storage area of materials near the working area must be demarcated and barricaded properly.

m. Use of cranes

- Cranes with 20% factor of safety (i.e. cranes with a lifting capacity higher than the weight to be lifted) are to be used.
- The crane should be operated by a licensed operator only.

- Operational fitness of the crane has to be checked before hiring the crane.
- The lifting hooks must have a safety lock in place to avoid slipping of the clings.
- The lifting capacity of the slings to be checked before starting of the work. The slings with 20% factor of safety in mechanical strength must be used for lifting.

n. Working near the existing power lines:

- No work to be taken up without proper shutdown while working in the existing power line or while working in the proximity of any existing power line.
- Work to be started only after the line (all the phases) is properly/securely earthed from both the ends and line clearance/work permit is issued by the concerned authority in writing with start and end time specifically mentioned.
- All the earthing points to be personally verified by senior engineer of contractor as EHS supervisor. Also secure against re-connection.
- No shutdown to be arranged over phone communication. Personal check is to be made for every shutdown and line clearance.
- The work under shutdown should be executed under direct supervision of a qualified supervisor/engineer of NEA and the owner (if not NEA line). The work group should not be left alone to execute the work.

o. Material handling & work process:

- Poles and accessories to be stored in proper demarcated area and should be away from the routes/places of public use.
- Ensure adequate ingress & egress around the work area.
- While lifting or shifting the equipment nobody should stay boarded.
- Correct tools and plant must be used for fixing and assembling to avoid accidents in the process. All the work must be supervised by senior engineer of contractor as EHS supervisor who can guide the team in every activity.
- While lifting heavy items with multiple sections, proper support slings (along the length) are to be provided from the point of lifting sling to the bottom of the item to avoid fall of sections due to malfunction of the slip joints.
- No persons under the influence of alcohol neither be allowed to enter the work location nor should help in the work from outside by any means.

p. Records and documentation

Reports prepared by the contractor shall include information on the place, date and time of the incident, name of persons involved, cause of incident, witnesses present and their statements. Based on such reports, the management can jointly identify any unsafe conditions, acts or procedures and recommend for the contractor to undertake certain mitigative actions to change any unsafe or harmful conditions.

q. Accidents and Diseases monitoring: the contractor should establish procedures and systems for reporting and recording:

- Occupational accidents and diseases
- Dangerous occurrences and incidents

These systems should enable workers to report immediately to their immediate supervisor any situation they believe presents a danger to life or health. The systems and the employer should further enable and encourage workers to report to management all:

  - Occupational injuries and near misses
  - Suspected cases of occupational disease
  - Dangerous occurrences and incidents

All reported occupational accidents, occupational diseases, dangerous occurrences, and incidents together with near misses should be investigated with the assistance of a person knowledgeable/competent in occupational safety. The investigation should: Establish what happened;

Determine the cause of what happened, identify measures necessary to prevent a recurrence, Distinction is made between fatal and non-fatal injuries. These two main categories are divided into three sub-categories according to time of death or duration of the incapacity to work.

OHS Plan will include:

1. Safety Training Program – to provide general and specialized training courses for all workers on the site and at all levels of supervision and management. General courses will consist of (i) an initial Safety Induction which all workers will be required to attend prior to being allowed to work on site, all visitors and project workers who have not attended the safety induction course must be always accompanied by inducted workers when within the working area. and (ii) periodic safety training refreshers covering similar topics to induction, conducted not less than once every six months. All subcontractor workers will be required to participate in relevant training courses appropriate to the nature, scale, and duration of the subcontract. Since they have heightened risk only trained workers must undertake certain activities e.g., working at height, working in confined spaces, working with electricity etc. Workers must have attended such training before they are involved in relevant works and the contractor must either offer an internal training course or organize for attendance on an external specialist training course. Workers must have a training record of attending a suitable training course. Untrained workers will not be permitted to work at height, enter confined spaces, work with live electricity etc.

2. Medical Check-Up/Health Surveillance – of workers fitness, eyesight, hearing, respiratory health, and communicable and noncommunicable diseases before work commences; and then repeated every six months by the contractor during construction. Only workers who have passed their fitness test and have the requisite medical clearance must undertake certain activities e.g., working with electricity etc.

3. Safety Meetings – will be conducted monthly during construction phase by APDCL. During construction the meetings will require attendance by the safety representatives of all contractors and subcontractors on-site. The minutes of all safety meetings including actions agreed will be taken and sent to APDCL within seven days of the meeting.

4. Safety Inspections – the contractor will regularly inspect, test, and maintain all safety equipment, scaffolds, guardrails, working platforms, hoists and other lifting equipment, ladders and other means of access, lighting and signage, firefighting equipment, first aid kit, stock take and condition of PPE etc. Signs will be graphic and in the languages of workers, kept clear of obstructions and legible to read. Lighting will meet illumination guidelines for the working area as per IFC EHS Guidelines on OHS. Equipment, which is damaged, dirty, incorrectly positioned or not in working order will be immediately repaired, or replaced, by the contractor.

5. Site Audit - during construction the contractor's H&S officer and APDCL will undertake monthly audits of compliance with the health and safety plan.

6. Personal Protective Equipment (PPE) as a last resort where risks cannot be avoided – workers will be provided (before they start work) with appropriate PPE at no cost to the workers. PPE provided to workers (regardless formal and informal, directly contracted or subcontracted) in accordance with GoN legislation and Table 2.7.1. Summary of Recommended Personal Protective Equipment according to Hazard in IFC EHS Guidelines on OHS including safety shoes, helmets, goggles, earmuffs, and face masks and ensure that this is always worn by them with a strict disciplinary system (no work condition if not compliant) being enforced for any non-compliance.

7. Work Zone Noise Levels: during construction protective measures need to be provided and as per the WB-IFC EHS Guidelines on OHS, Table 2.3.1. sets the level at 85 dB (A) for 8 hours exposure this being more stringent than the GoN requirements will be adopted, as well as 140 dB(C) peak/instantaneous noise exposure for workers working near the high noise generating machinery. High noise work areas must be adequately signposted. In these high noise work areas PPE in the form of sound reducing earmuffs/ear plugs to the workers are to be provided. In the first instance, however, reduction in noise levels to the lowest practical level must be achieved by adoption of suitable preventive measures, such as, use of enclosures with suitable absorption material, etc. Workers operating in the high noise work areas will be given auditory tests as part of health surveillance.

8. EMF levels at the construction site to be kept within international good practice levels as per ICNRP (reference and peak values) for the occupational exposure.

9. Electricity: IFC EHS Guideline on Electric Power Transmission and Distribution requirements for working with electricity will be observed with only licensed electricians that meet the requirements set out in them allowed to work on live electricity with strict adherence to safety standards including those listed in said guidelines. Live lines will be deactivated and properly grounded before work is performed on, or in proximity, to the lines and this will be checked and certified in writing by the contractor's Health and Safety Officer in advance. While working at heights personal safety measures such as harnesses, tool bags, ropes etc. will need to be provided.

10. Emergency Preparedness and Response Sub-Plan including communication systems and protocols to report an emergency e.g., health emergency, work-related accident including electrocution, traffic accident, accident involving the community, natural hazard including flooding, fire, virus outbreak etc. It will need to be developed in consultation with local emergency services with adequate fire and first aid first-responders will need to be based on the construction site to facilitate immediate response. Provide readily available first aid for workers as well as an ambulance for more serious cases. Make arrangements for a doctor on call and nearest Health Center and/or Hospital for emergency cares of workers. Regular drills will be required involving all workers to prepare for an incident.

11. International good practice measures provided in the IFC EHS Guidelines: https://www.ifc.org/en/insights-reports/2000/general-environmental-health-and-safety-guidelines and ILO Safety and Health in Construction (2022): https://www.ilo.org/resource/other/safety-and-health-construction-revised-edition

Appendix C – Labour Accommodation Requirements

Temporary Worker Accommodation

In addition to GON requirements for temporary overnight labor accommodation follow ILO Safety and Health in Construction and worker accommodation guidelines and the below points to comply with the core labor standards etc.

Day camps with temporary structures to provide protection against the weather conditions for rest and eating of food will be required at site as a rest area but these are not to be used for sleeping overnight. Adequate quantity of safe drinking water and container for their safe storage shall be provided at day camps; at least 4 liters of water per person per day to be provided for consumption during the working day at each site. If no existing toilets within 100m that can be used, temporary sanitation facilities for men and women workers shall be provided where the wastewater generated is enclosed in a container to be later taken offsite for wastewater treatment and disposal. Food provided to day camps should be cooked off site; if it is to be reheated at site fire-safety measures must be adopted with LPG cylinders or kerosene purchased from authorized vendors. After completion of the construction work the temporary structures shall be removed and the land will be restored to its earlier condition.

1.1 General living facilities

Location

- Appropriate siting to avoid flooding or other natural hazards
- Location within a reasonable distance from the worksite to be unaffected by the worksite's noise, emissions or dust but avoiding undue amount of time travelling to work
- Safe and free transport to the worksite where remotely located
- Built with structurally sound materials, kept in good repair, clean and free from rubbish and other refuse
- After completion of the construction work the temporary structures shall be removed and the land will be restored to its earlier condition.

Drainage

- Adequate drainage, no waterlogging

Heating, air conditioning, ventilation and light

- Adequate heating, air conditioning and ventilation where appropriate
- Adequate natural light and artificial light, including emergency lighting

Water

- Easy access to an adequate supply of free, safe and potable water
- Constructed and covered storage tanks to prevent water from pollution or contamination
- Regular monitoring of drinking water quality

Wastewater and solid waste

- Adequate discharge of wastewater, sewage, food and any other waste materials
- Disposal of sewage and other wastewater shall be made connected to an existing sewerage system or made through a septic tank-soak pit arrangement
- Separate enclosed (lidded) bins with proper markings in terms of recyclable or non-recyclable waste shall be provided in the labor camps and kitchen premises in sufficient numbers for collection of garbage.
- Specific containers for rubbish collection in adequate number and being regularly emptied
- Pest extermination, vector control and disinfection throughout the living facilities

1.2 Rooms/dormitories facilities

- Kept in good condition, aired and cleaned at regular intervals
- Built with easily cleanable flooring materials
- Adequate furniture (such as table, chair, mirror, bedside light) for every worker
- Lockable doors and windows with mosquito screens when necessary
- Living space and space for privacy
- Adequate living space (see also International standards for spacing at migrant workers' accommodation)
- Adequate headroom, providing full and free movement, of not less than 203 cm
- Inside dimensions of a sleeping space of at least 198 cm by 80 cm
- Minimized number of workers sharing the same room/dormitory (recommended 2–8 worker)
- Mobile partitions or curtains to ensure privacy
- Gender-segregated accommodations, except in family accommodation
- Separate sleeping rooms for shifts to ensure no workers working during the day share a room with workers on night shifts
- Bed arrangements and storage facilities
- A separate bed for each worker
- Minimum space of 1 m between beds
- Minimized use of double deck bunks and no use of triple deck bunks
- Enough clear space between the lower and upper bunk of the bed where double deck bunks are in use (recommended 0.7–1.1 m)
- Reasonably comfortable bedding materials (mattress, pillow, cover and clean bed linen) for each worker
- Bedding and bedframe materials designed to deter vermin
- Individual, lockable storage facilities for each worker to secure their belongings

1.3 Sanitary facilities

- Sanitary and toilet facilities provided for men and women including private bathing area, showers, or baths in overnight accommodation.
- Separate housekeeping staff shall be engaged for regular cleaning of the accommodation.
- Frequent cleaning and kept in good condition
- Located within the same buildings with rooms/dormitories
- Constructed from easily cleanable materials
- Shower/bathroom flooring made of anti-slip hard washable materials
- Adequate privacy, including ceiling to floor partitions and lockable doors
- Adequate number of sanitary facilities (a minimum of one toilet, one wash basin and one tub or shower for every six persons)
- Convenient and easily accessible location
- Compliance with minimum standards of health and hygiene
- Separate sanitary facilities for men and women, except in family accommodation
- Suitable light and good ventilation to open air, independently of any other part of the accommodation
- Adequately stocked soap and hygienic paper
- Adequate supply of hot and cold fresh running water (at least 80-100 liters per capita per day)

1.4 Canteen, cooking and laundry facilities

- If workers cook their own meals, kitchen space is provided separately from the sleeping areas.
- No labor shall be allowed to collect fuel wood/NTFP or purchase fuel wood/NTFP from unauthorized vendors.
- LPG cylinders or kerosene purchased from authorized vendors shall be provided.
- Being built with adequate and easy to clean materials
- Being kept in clean and sanitary condition
- Common dining rooms, canteens or mess rooms, and kitchen space located away from sleeping areas
- Enough space in the canteen (1–1.5 m2 per worker)
- Adequately furnished canteen (tables, benches, individual drinking cups and plates)

- Adequate facilities to maintain adequate personal hygiene (enough washbasins, clean water, materials for hygienic drying)
- Places for food preparation adequately ventilated and equipped to protect against contamination between and during food preparation
- Kitchen floor, ceiling and wall surfaces adjacent to or above food preparation and cooking areas built in non-absorbent, durable, non-toxic, easily cleanable materials
- Wall surfaces adjacent to cooking areas made of fire-resistant materials; food preparation tables equipped with a smooth, durable, non-corrosive, non-toxic, washable surface
- Adequate facilities for cleaning, disinfecting and storage of cooking utensils and equipment
- Adequate sealable containers to deposit food waste and other refuse; refuse frequently removed from the kitchen to avoid accumulation
- Implementation of the WHO “5 keys to safer food” or equivalent process in relation to food safety
- Provided food containing appropriate nutritional value and considering migrant workers' religious/cultural backgrounds
- Adequate facilities for washing and drying clothes, appropriately situated and furnished laundry facilities
- Collection of waste water from washing areas and kitchens further disposed through existing sewerage connection or septic tank with soak away

Medical facilities

- Adequate number and stock of first aid kits
- Adequate number of staff/workers trained to provide first aid
- Residents are provided guidance on alcohol, drug and HIV/AIDS and other health risks
- On site medical facilities/services (where possible and depending on the medical infrastructure existing in the community)
- Separate facilities for sick workers to prevent the spread of transmissible diseases among occupants
- Appropriate and reasonable accommodations in connection with pregnancy, childbirth and nursing

1.6 Leisure, social and telecommunication facilities

- Basic collective social/rest spaces and adequate recreational areas where not otherwise available in the community
- Dedicated places for religious observance
- Reasonable access to internet facilities, telephone or other modes of communications free of charge or at affordable/public prices

2.1 Management and staff

- An appointed person with adequate background, competency and experience to manage the accommodations or monitor third-party service providers
- Clear contractual management responsibilities and monitoring and reporting requirements where third-party service providers are being used
- Adequate staff to implement the accommodation standards (cleaning, cooking, security, general maintenance)
- Basic health and safety training for staff, including training in nutrition and food handling for those in charge of the kitchen
- Frequent inspection and maintenance of premises and records kept

2.2 Fees and costs for accommodation and related services

- Accommodation free of charge where migrant workers are not free to look for their own accommodations

- Fair and transparent renting arrangements, not costing migrant workers more than a small proportion of income (when costs are charged)
- Adequate information to migrant workers about all payments made
- Clearly specifying renting arrangements and regulations in migrant workers' employment contracts
- Food and other services provided at the facilities for free or reasonably priced (this means not above the local market price)
- No in-kind payments for accommodation and related services

2.3 Health and safety

- Adequate health and safety management plans including electrical, mechanical, structural and food safety
- Available emergency plans on health and fire safety and other specific occurrences (earthquakes, floods, tornadoes, pandemic)
- Regular training in safety and health rules and procedures for all occupants
- Posting of safety notices and operational instructions in language migrant workers understand or visual form
- Adequate number of staff/workers trained in providing first aid
- Easy access to medical facilities and medical staff, including women doctors/nurses where appropriate Guidance on alcohol, drug and HIV/AIDS and other health risks-related activities provided to migrant workers
- Access to adequate contraception measures and mosquito nets (where relevant)

Fire safety

- Specific and adequate fire safety plan and measures
- Training of fire wardens
- Installing, periodic testing and maintenance of fire equipment (alarms, extinguishers, etc.)
- Training for migrant workers in fire procedures and periodic drills (in a language they understand)
- Bedding not containing flammable materials
- Radiators and other heating apparatus properly placed to avoid risk of fire, and shielded where necessary to prevent discomfort to occupants
- Emergency evacuation plans are displayed at strategic areas in language understood by workers
- Clearly marked emergency exits
- Adequate means of escape provided and properly maintained

2.4 Security

- Security at worker's accommodation shall be ensured.
- A security plan including clear measures to protect migrant workers against theft and attack and clear provisions on the use of force
- The backgrounds of security staff checked for previous crimes or abuses
- Clear instructions for security staff not to harass, intimidate, discipline, discriminate against migrant workers or restrict the freedom of movement
- Adequate training for security staff in dealing with violence and harassment and the use of force (including gender-based violence and sexual harassment)
- Body searches only performed in exceptional circumstances by specifically trained security staff; pat down searches on women workers only performed by women security staff

2.5 Migrant workers' rights, rules and regulations on migrant workers' accommodation

- Migrant workers' 24/7 access to the accommodation; security measures reasonable and not unduly restricting migrant workers' freedom of movement
- Adequate transport system to the surrounding communities
- Withholding migrant workers' documentation papers prohibited; migrant workers entitled to keep their documents in their own lockers
- Trade union representatives' access to migrant workers in the accommodation site
- Visitor access allowed in accordance with company rules for privacy or safety
- Migrant workers' religious, cultural and social backgrounds respected
- Adequate information to migrant workers about their rights and obligations (a copy of the accommodations' internal rules, procedures and sanction mechanism in a language or through a media they understand)
- Non-discriminatory, fair and reasonable house regulations
- Effective grievance mechanisms for migrant workers to articulate their grievances
- Display of contact information of consular services, company personnel and civil society organizations at the facilities

Permanent Worker Accommodation

In addition to GON requirements for permanent labor accommodation follow ILO worker accommodation guidelines and the below additional points to comply with the core labor standards etc.

Integrity of Structures

- Surfaces, structures and installations should be easy to clean and maintain, and not allow for accumulation of hazardous compounds.
- Buildings should be structurally safe, provide appropriate protection against the climate, and have acceptable light and noise conditions.
- Fire resistant, noise-absorbing materials should, to the extent feasible, be used for cladding on ceilings and walls.
- Floors should be level, even, and non-skid.

Severe Weather

- Structures should be designed and constructed to withstand the expected elements for the region and have an area designated for safe refuge, if appropriate.

Exit

- Passages to emergency exits should be unobstructed at all times.
- Exits should be clearly marked to be visible in total darkness. The number and capacity of emergency exits should be sufficient for safe and orderly evacuation of the greatest number of people present at any time, and there should be a minimum of two exits from any work area.
- Facilities also should be designed and built taking into account the needs of disabled persons.

Fire Precautions

- Equipping facilities with fire detectors, alarm systems, and fire-fighting equipment. The equipment should be maintained in good working order and be readily accessible. It should be adequate for the dimensions and use of the premises, equipment installed, physical and chemical properties of substances present, and the maximum number of people present.
- Provision of manual firefighting equipment that is easily accessible and simple to use
- Fire and emergency alarm systems that are both audible and visible

Lavatories and Showers

- Adequate lavatory facilities (toilets and washing areas) should be provided for the number of people expected to work/live in the facility and allowances made for segregated facilities, or for indicating whether the toilet facility is "In Use" or "Vacant". Toilet facilities should also be provided with adequate supplies of hot and cold running water, soap, and hand drying devices.

Potable Water Supply

- Adequate supplies of potable drinking water should be provided from a fountain with an upward jet or with a sanitary means of collecting the water for the purposes of drinking
- Water supplied to areas of food preparation or for the purpose of personal hygiene (washing or bathing) should meet drinking water quality standards

Lighting

- Workplaces should, to the degree feasible, receive natural light and be supplemented with sufficient artificial illumination to promote workers' safety and health, and enable safe equipment operation. Supplemental 'task lighting' may be required where specific visual acuity requirements should be met.
- Emergency lighting of adequate intensity should be installed and automatically activated upon failure of the principal artificial light source to ensure safe shut-down, evacuation, etc.

Safe Access

- Passageways for pedestrians and vehicles within and outside buildings should be segregated and provide for easy, safe, and appropriate access
- Equipment and installations requiring servicing, inspection, and/or cleaning should have unobstructed, unrestricted, and ready access
- Hand, knee and foot railings should be installed on stairs, fixed ladders, platforms, permanent and interim floor openings, loading bays, ramps, etc.
- Openings should be sealed by gates or removable chains
- Covers should, if feasible, be installed to protect against falling items
- Measures to prevent unauthorized access to dangerous areas should be in place

First Aid

- Ensure that qualified first-aid can be provided at all times.
- Appropriately equipped first-aid stations should be easily accessible throughout the place of work
- Eye-wash stations and/or emergency showers should be provided close to all workstations where immediate flushing with water is the recommended first-aid response
- Where the scale of work or the type of activity being carried out requires, dedicated and appropriately equipped first-aid room(s) should be provided. First aid stations and rooms should be equipped with gloves, gowns, and masks for protection against direct contact with blood and other body fluids
- Remote sites should have written emergency procedures in place for dealing with cases of trauma or serious illness up to the point at which patient care can be transferred to an appropriate medical facility.

Air Supply

- Sufficient fresh air should be supplied for indoor and confined work spaces. Factors to be considered in ventilation design include physical activity, substances in use, and process-related emissions.
- Air distribution systems should be designed so as not to expose workers to draughts
- Mechanical ventilation systems should be maintained in good working order. Point-source exhaust systems required for maintaining a safe ambient environment should have local indicators of correct functioning.
- Re-circulation of contaminated air is not acceptable. Air inlet filters should be kept clean and free of dust and microorganisms.
- Heating, ventilation and air conditioning (HVAC) and industrial evaporative cooling systems should be equipped, maintained and operated so as to prevent growth and spreading of disease agents (e.g. Legionella pneumophilia) or breeding of vectors (e.g. mosquitoes and flies) of public health concern.

Temperature

- The temperature in work, rest room and other welfare facilities should, during service hours, be maintained at a level appropriate for the purpose of the facility.

OHS Training

- Provisions should be made to provide OHS orientation training to all new employees to ensure they are apprised of the basic site rules of work at / on the site and of personal protection and preventing injury to fellow employees.

- Training should consist of basic hazard awareness, site- specific hazards, safe work practices, and emergency procedures for fire, evacuation, and natural disaster, as appropriate. Any site-specific hazard or color coding in use should be thoroughly reviewed as part of orientation training.

Permanent Accommodation

- A separate bed for each worker
- Adequate headroom, providing full and free movement, of not less than 203 cm
- The minimum inside dimensions of a sleeping space should be at least 198 cm by 80 cm
- Beds should not be arranged in tiers of more than two
- Bedding materials should be reasonably comfortable
- Bedding and bedframe materials should be designed to deter vermin
- Separate accommodation of the sexes
- Adequate natural light during the day- time and adequate artificial light
- A reading lamp for each bed
- Adequate ventilation to ensure sufficient movement of air in all conditions of weather and climate
- heating where appropriate
- Adequate supply of safe potable water
- Adequate sanitary facilities (see below)
- Adequate drainage
- Adequate furniture for each worker to secure his or her belongings, such as a ventilated clothes locker which can be locked by the occupant to ensure privacy
- Common dining rooms, canteens or mess rooms, located away from the sleeping areas
- Appropriately situated and furnished laundry facilities
- Reasonable access to telephone or other modes of communications, with any charges for the use of these services being reasonable in amount
- Rest and recreation rooms and health facilities, where not otherwise available in the community
- In workers' sleeping rooms the floor area should not be less than 7.5 square metres in rooms accommodating two persons; 11.5 square metres in rooms accommodating three persons; or 14.5 square metres in rooms accommodating four persons. If a room accommodates more than four persons, the floor area should be at least 3.6 square metres per person. Rooms should indicate the permitted number of occupants.
- As far as practicable, sleeping rooms should be arranged so that shifts are separated and that no workers working during the day share a room with workers on night shifts.

Sanitation Facilities

- Adequate sanitary facilities should include a minimum of one toilet, one wash basin and one tub or shower for every six persons. They should be provided at a convenient location which prevents nuisances.
- Sanitary facilities provided should meet minimum standards of health and hygiene. They should also provide reasonable standards of comfort, including hot and cold fresh running water.
- There should be separate sanitary facilities provided for men and for women.
- Sanitary facilities should have ventilation to the open air, independently of any other part of the accommodation.
- Soap and hygienic paper should be adequately stocked.
- Measures should be taken to prevent the spread of diseases. Separate facilities should be provided for sick workers to prevent the spread of transmissible diseases among the occupants.
- Fire safety measures should be taken, including installing and maintaining fire equipment (alarms, extinguishers, etc.).
- Workers should be trained in fire procedures.
- Bedding should not contain flammable materials.
- Radiators and other heating apparatus should be placed so as to avoid risk of fire, and shielded where necessary to prevent discomfort to occupants.

Inspection of premises

- Premises should be inspected frequently to ensure that the accommodation is clean, decently habitable and maintained in a good state of repair. The results of each such inspection should be recorded and be available for review.

Vacating the premises upon termination of employment

- When a worker's contract of employment is terminated, the worker should be entitled to a reasonable period of time to vacate the premises, in accordance with national law and custom.

Water Conservation

- Regularly maintain plumbing, and identify and repair leaks
- Shut off water to unused areas
- Install self-closing taps, automatic shut-off valves, spray nozzles, pressure reducing valves, and water conserving fixtures (e.g. low flow shower heads, faucets, toilets, urinals; and spring loaded or censored faucets)
- Operate dishwashers and laundries on full loads, and only when needed
- Install water-saving equipment in lavatories, such as low- flow toilets

Appendix D – Project Standards

Table 1: Ambient Air Quality Standards

Parameter	Averaging Period	Nepal's Ambient Air Quality Standard (µg/m^3)	WHO Air Quality Guidelines (µg/m^3)	
			2005[a]	2021[b]
TSP	Annual	-	-	-
	24-hour	**230**	-	-
PM_{10}	Annual	-	20	**15**
	24-hour	120	50	**45**
PM_{25}	1-year	-	10	**5**
	24-hour	40	25	**15**
SO_2	Annual	50	-	-
	24-hour	70	20	40
NO_2	1-year	40	40	**10**
	24-hour	80	-	**25**
CO	8-hour	**10,000**	-	-
Pb	1-year	**0.5**	-	-
Benzene	1-year	**20**	-	-

*National Ambient Air Quality Standards for Nepal, 2012. This also sets out the test methods to be used within Nepal. 24 hourly values shall be met 95% of the time in a year. 18 days per calendar year the standard may be exceeded but not on two consecutive days

[a] Source: Environmental, Health and Safety General Guidelines, 2007. International Finance Corporation, World Bank Group.

[b] Source: World Health Organization 2021

[c] Most stringent levels are shown in bold and will be applicable to the project. If less stringent levels or measures are appropriate in view of specific project circumstances, the implementing agency will provide full and detailed justification for any proposed alternatives that are consistent with the requirements presented in ADB SPS in the IEE.

Source: Environment Statistics of Nepal 2011, Government of Nepal, National Planning Commission Secretariat, Central Bureau of Statistics, Kathmandu, Nepal.

Table 2: Operational Diesel Generator Emission Standards[4]

Category (KW)	CO	HC+NOx	PM
KW<8	8	7.5	0.8
8≤KW<	6.6	7.5	0.8
19≤KW<	5.50	7.50	0.60
37≤KW<	5.00	4.70	0.40
75≤KW<	5.00	4.00	0.30
130≤KW<	3.5	4	0.2

[4] Source: Emission Standard for Diesel Generator 2069

Table 3: Imported Diesel Generator Emission Standards

Category (kW)	CO	HC+NOx	PM
kW<8	8	7.5	0.8
8<19	6.6	7.5	0.8
19<37	5.5	7.5	0.6
37<75	5	4.7	0.4
75<130	5	4	0.3
130<560	3.5	4	0.2

Table 4: Light and Over 2.5 Ton Commercial Vehicle Emission Standards

Limit Values, Grams per Kilometer			
Type of Vehicle	Mass of CO	Mass of HC	Mass of NOx
L CV (RM=<1305 Kg)	2.3	0.2	0.15
L CV (1305>RM< or =1760 Kg)	4.17	0.25	0.18
L CV (RM > 1760 Kg)	5.22	0.29	0.21

Table 5: Noise Level Standards

Receptor/ Source	**National Noise Standard Guidelines, 2012** (dB)		**WHO Guidelines Value For Noise Levels Measured Out of Doors**[a] (One Hour LA_q in dBA)	
	Day	**Night**	**07:00 – 22:00**	**22:00 – 07:00**
Industrial area	75	**70**	**70**	70
Commercial area	**65**	**55**		
Rural residential area	**45**	**40**	**55**	**45**
Urban residential area	55	50		
Mixed residential area	63	55		
Quiet area	**50**	**40**	-	-
Water Pump		65		-
Diesel generator		90		-

[a] Guidelines for Community Noise, WHO, 1999.

[b] National standards are area based but WHO guidelines apply to the receptor. Most stringent levels are shown in bold and will be applicable to the project. Noise levels will be monitored at the receptor based on the most stringent level applicable e.g., a residential property in a commercial area will apply the WHO residential level whilst a residential property in a rural area will apply the GoN level. If less stringent levels or measures are appropriate in view of specific project circumstances, the implementing agency will provide full and detailed justification for any proposed alternatives that are consistent with the requirements presented in ADB SPS in the IEE. If the applicable noise levels are already exceeded by background the maximum increase in background level at the receptor is 3dBA.

Source: Environmental, Health and Safety General Guidelines, 2007. International Finance Corporation, World Bank Group.

Control room noise should follow best practice guidelines as set out in the IFC EHS guidelines on OHS where the average noise level within the control room shall not exceed 40-50dBA during the length of the 8-hour working day.

Table 6: Applicable Drinking Water Quality Standards

Group	National Drinking Water Quality Standards, 2022			Remarks
	Parameter	Unit	Max. Concentration Limits	
Compulsory Parameters				
Physical Parameters	Turbidity	NTU	5	NHBGV
	pH		6.5 – 8.5	NHBGV
	Color	TCU	5	NHBGV
	Taste and Odor		Should not be offensive	NHBGV
	Electrical Conductivity	µS/cm	1500	NHBGV
Chemical Parameters	Iron	mg/l	0.3 (3)	NHBGV
	Manganese	mg/l	0.2	NHBGV
	Arsenic	mg/l	0.05	NHBGV
	Fluoride	mg/l	0.5-1.5 (min-max)	HBGV
	Ammonia	mg/l	1.5	NHBGV
	Chloride	mg/l	250	NHBGV
	Sulphate	mg/l	250	NHBGV
	Nitrate	mg/l	50	NHBGV
	Copper	mg/l	1	NHBGV
	Zinc	mg/l	3	NHBGV
	Aluminnium	mg/l	0.2	NHBGV
	Total Hardness	mg/l	500	NHBGV
	Residual Chlorine	mg/l	0.1 - 0.5	HBGV (for system with chlorination only)
Microbial Parameter	E-coli	CFU/100ml	0	HBGV
Further testing based on risk and relevance				
Physical Parameter	Total Dissolved Solids	mg/l	1,000	NHBGV
Chemical Parameter	Calcium	mg/l	200	NHBGV
	Lead	mg/l	0.01	HBGV
	Cadmium	mg/l	0.003	HBGV
	Chromium	mg/l	0.05	HBGV
	Cyanide	mg/l	0.07	HBGV
	Mercury	mg/l	0.001	HBGV
	Nitrites	mg/l	3	HBGV
Microbial Parameter	Total Coliform	CFU/100ml	0 (95% samples)	HBGV

HBGV = Health-Based Guideline Value; NHBGV = Non-Health-Based Guideline Value
Source: Ministry of Water Supply, Nepal. Nepal Gazette published on 2079/3/22 BS (July 6, 2022)

Table 7: Generic Standard: Tolerance Limit for Industrial (Wastewater) Effluents Discharged into Inland Surface Waters and Public Sewers

#	Parameters	Industrial waste into Inland Surface Waters	Wastewater into inland Surface Waters from CWTP*	Industrial Effluents into Public Sewers*	IFC EHS Guideline Indicative Values
1	TSS, mg/l	30-200	50	600	50
2	Particle size of TSS	Shall pass 850-micron Sieve	Shall pass 850-micron Sieve		-
3	pH Value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	6.0-9.0
4	Temperature °C[1]	<40	<40	45	-
5	TDS, mg/L, max			2100	-
6	Color and Odor				-
7	BOD for 5 days at 20-degree C, mg/L Max	30-100	50	400	30
8	Oils and grease, mg/L, Max, Max	10	10	50	-
9	Phenolic compounds, mg/	m1	1	10	-

#	Parameters	Industrial waste into Inland Surface Waters	Wastewater into inland Surface Waters from CWTP*	Industrial Effluents into Public Sewers*	IFC EHS Guideline Indicative Values
10	Cyanides (as CN), mg/L, Max	0.2	0.2	2	-
11	Sulfides (as S), mg/L, Max	2	2	2	-
	Sulphates (SO_4), mg/L, Max			500	-
12	Radioactive materials: a. Alpha emitters, c/ml, Max	10^{-7}	10^{-7}		-
	b. Beta emitters, c/ml, Max	10^{-8}	10^{-8}		-
13	Insecticides	Absent	Absent	Absent	-
14	Total residual chlorine, mg/L	1	1	1000 as chlorides	-
15	Fluorides (as F), mg/L, Max	2	2	10	-
16	Arsenic (as AS), mg/L, Max	0.2	0.2	1	-
17	Cadmium (as, Cd), mg/L, Max	2	2	2	-
18	Hexavalent chromium (as Cr), mg/L, Max	0.1	0.1	2	-
19	Copper (as Cu), mg/L, Max	3	3	3	-
20	Lead (as Pb), mg/L, Max	0.1	0.1	0.1	-
21	Mercury (as Hg), mg/L, Max	0.01	0.01	0.01	-
22	Nickel (as Ni), mg/L, Max	3	3	3	-
23	Selenium (as Se), mg/L, Max	0.05	0.05	0.05	-
24	Zinc (as Zn), mg/L, Max	5	5	5	-
25	Sodium, %, max				-
26	Ammoniacal nitrogen, mg/L, Max	50	50	50	-
27	COD, mg/L, Max	250	250	1000	125
28	Silver, mg/L, Max	0.1	0.1	0.1	-
29	Mineral Oils, mg/L, Max			10	10 (oil and grease)
30	Inhibition of nitrification test at 200ml/l			<50%	-
31	Total Nitrogen mg/l	-	-	-	10
32	Total Phosphorus mg/l	-	-	-	2
33	Total Coliform Bacteria MPN / 100 ml	-	-	-	400

Source: MOE, 2010 and IFC EHS Guidelines.

Notes: CWTP= Combined Wastewater Treatment Plant; Under enforcement since BS 2058/1/17 (30 April 2001); *Under enforcement since BS 2060/3/9 (23 June 2003); [1] Shall not exceed 40°C in any section within 15 m downstream from the effluent outlet.

Table 8: Surface Water Quality (Aquatic Ecosystems)

	Parameter name	Target Water Quality Range	Chronic Effect Value	Acute Effect Value
1.	Aluminium (mg/l)	At pH <6.5: 5	10	100
		At pH >6.5:10	20	150
2.	Ammonia (µg/L)	< 7	< 15	< 100
3.	Arsenic (µg/L)	< 10	< 20	< 130
4.	Atrazine (µg/L)	< 10	< 19	< 100
5.	Cadmium			
	Soft water (60 mg/l CaCO3)	< 0.15	0.3	3
	Medium water (60 – 119 mg/l)	< 0.25	0.5	6
	Hard water (120 – 180 mg/l)	< 0.35	0.7	10
	Very Hard (> 180 mg/l)	< 0.40	0.8	13
6.	Chlorine (Residual) µg/L	< 0.2	0.35	5
7.	Chromium (VI) µg/L	7	10	200
8.	Chromium (III) µg/L	< 12	24	340
9.	Copper µg/L			
	Soft water (60 mg/l CaCO3)	< 0.3	0.53	1.6
	Medium water (60 – 119 mg/l)	< 0.8	1.5	4.6
	Hard water (120 – 180 mg/l)	< 1.2	2.4	7.5
	Very Hard (> 180 mg/l)	< 1.40	2.8	12
10.	Cyanide µg/L	1	4	110
11.	Dissolved Oxygen (% saturation)	80 – 120	> 60	> 40
12.	Endosulphan (µg/L)	< 0.01	0.02	0.2
13.	Fluoride (µg/L)	< 750	1500	2540
14.	Iron	The iron concentration should not be allowed to vary by more than 10% of the background dissolved iron concentration for a particular site or case, at a specific time.		
15.	Lead µg/L			
	Soft water (60 mg/l CaCO3)	< 0.2	0.5	4
	Medium water (60 – 119 mg/l)	< 0.5	1.0	7
	Hard water (120 – 180 mg/l)	< 1.0	2.0	13
	Very Hard (> 180 mg/l)	< 1.2	2.4	16
16.	Manganese (µg/l)	< 180	370	1300
17.	Mercury (µg/l)	< 0.04	0.08	1.7
18.	Nitrogen (inorganic)	Inorganic nitrogen concentrations should not be changed by more than 15% from that of the water body under local unimpacted conditions at any time of the year; The trophic status of the water body should not increase above its present level, though a decrease in trophic status is permissible; The amplitude and frequency of natural cycles in inorganic nitrogen concentrations should not be changed.		
19.	pH			
	All aquatic ecosystems	pH values should not be allowed to vary from the range of the background pH values for a specific site and time of day, by > 0.5 of a pH unit, orby > 5%, and should be assessed by whichever estimate is more conservative.		
20.	Phenols (µg/l)	<30	60	500
21.	Phosphorus (inorganic)	All surface waters Inorganic phosphorus concentrations should not be changed by > 15 % from that of the water body under local, unimpacted conditions at any time of the year; The trophic status of the water body should not increase above its		

	Parameter name	Target Water Quality Range	Chronic Effect Value	Acute Effect Value
		present level, though a decrease in trophic status is permissible (see Effects); The amplitude and frequency of natural cycles in inorganic phosphorus concentrations should not be changed.		
22.	Selenium (µg/l)	< 2	5	30
23.	Temperature (All aquatic ecosystems)	Water temperature should not be allowed to vary from the background average daily water temperature considered to be normal for that specific site and time of day, by > 2°C, or by > 10%, whichever estimate is the more conservative.		
24.	Total Dissolved Solids (All inland waters)	-TDS concentrations should not be changed by > 15% from the normal cycles of the water body under un impacted conditions at any time of the year; -The amplitude and frequency of natural cycles in TDS concentrations should not be changed.		
25.	Total Suspended Solids (All inland waters)	Any increase in TSS concentrations must be limited to < 10% of the background TSS concentrations at a specific site and time.		
26.	Zinc (µg/l)	< 2	3.6	36

Source: Department of Irrigation, Ground Water Project (Nepal Gazette (Number 10, 16 June 2008)

Table 9: Guideline Values for Vibration Velocity to be Used When Evaluating the Effects of Short-term and Long-term Vibration on Structures

Group	Type of structure	Guideline Values for Velocity (mm/s)				
		Short-term				Long-term
		At foundation			Uppermost Floor	Uppermost Floor
		Less than 10 Hz	10 Hz to 50 Hz	50 to 100 Hz	All frequencies	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40	10
2	Residential dwellings and buildings of similar design and/or use	5 (105 dB)	5 to 15	15 to 20	15	5 (105 dB)
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (e.g. buildings that are under a preservation order)	3 (100.5 dB)	2 to 8	8 to 10	8	2.5 (99.0 dB)

Source: DIN 4150-3, Structural Vibration, Part 3: Effect of vibration on structures

Table 10: ICNIRP Limit Values Concerning Electric and Magnetic Fields (50 Hz) for the Public and at Working Places

Source	Electric Field Strength [kV/m]	Magnetic Flux Density [µT]
Occupational exposure	10	500
General public exposure	5	100

Source: ICNIRP. Guidelines for limiting exposure to electromagnetic fields (up to 300 GHz). 2020

Table 11: Minimum Lighting Levels for Workplace Safety

Location / Activity	Light Intensity
Emergency light	10 lux
Outdoor non working areas	20 lux
Simple orientation and temporary visits (machine storage, garage, warehouse)	50 lux
Workspace with occasional visual tasks only (corridors, stairways, lobby, elevator, auditorium, etc.)	100 lux
Medium precision work (simple assembly, rough machine works, welding, packing, etc.)	200 lux
Precision work (reading, moderately difficult assembly, sorting, checking, medium bench and machine works, etc.), offices.	500 lux
High precision work (difficult assembly, sewing, color inspection, fine sorting etc.)	1,000 – 3,000 lux

TABLE OF CONTENTS

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. However, in case of conflict between the requirements specified in this Chapter and requirements specified under other Chapters, the requirements specified under respective Chapters shall prevail.

2.0 GENERAL REQUIREMENT

2.1 The bidders shall submit the technical requirements, data and information as per the technical data sheets provided in the bid documents.

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 recognized that the Contractor may have standardized 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 Purchaser. Unless brought out clearly, the Bidder shall be deemed to conform to this specification scrupulously. All deviations from the specification shall be clearly brought out in the respective schedule of deviations. Any discrepancy between the specification and the catalogues or the bid, if not clearly brought out in the specific requisite schedule, will not be considered as valid deviation.

2.3 Wherever a material or article is specified or defined by the name of a particular brand, Manufacturer or Vendor, the specific name mentioned shall be understood as establishing type, function and quality and not as limiting competition.

2.4 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/CIGRE/IEEE/NEMA 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 Purchaser's approval.

4.0 SERVICES TO BE PERFORMED BY THE EQUIPMENT BEING FURNISHED

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

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

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

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

4.5 The equipment shall also comply with the following:

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

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

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

4.6.1 System Parameter

220kV System

SL No	Description of parameters	220 kV System
1.	System operating voltage	220kV
2.	Maximum operating voltage of the system(rms)	245kV
3.	Rated frequency	50Hz
4.	No. of phase	3
5.		
i)	Full wave impulse withstand voltage (1.2/50 microsec.)	1050 kV_p
ii)	Switching impulse withstand voltage (250/2500 micro sec.) dry and wet	-
iii)	One-minute power frequency dry withstand voltage (rms)	-
iv)	One-minute power frequency dry and wet withstand voltage (rms)	460kV
6.	Corona extinction voltage	156kV
7.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 156kV rms for 220kV system	1000 micro-volt
8.	Minimum creepage distance (25mm/kV)	6125 mm
9.		
i.	Phase to phase	2100 mm
ii.	Phase to earth	2100 mm
iii)	Sectional clearances	5000 mm
10.	Rated short circuit current for 1 sec. duration	40kA
11.	System neutral earthing	Effectively earthed

132kV & 33kVSystem

SL No	Description of parameters	132 kV System	33 kV System
1.	System operating voltage	132kV	33kV
2.	Maximum operating voltage of the system(rms)	145kV	36kV
3.	Rated frequency	50Hz	50Hz
4.	No. of phase	3	3
5.	Rated Insulation levels		
i)	Full wave impulse withstand voltage (1.2/50 microsec.)	650 kV_p	170 kV_p
ii)	One-minute power frequency dry and wet withstand voltage (rms)	275kV	70kV
6.	Corona extinction voltage	105kV	-
7.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 92KV rms for 132KV system	500 micro-volt	-
8.	Minimum creepage distance (25mm/kV)	3625 mm	900 mm
9.	Min. Clearances		
i.	Phase to phase	1300 mm	320 mm
ii.	Phase to earth	1300 mm	320 mm
iii)	Sectional clearances	4000 mm	3000 mm
10.	Rated short circuit current	31.5 kA for 1 Sec	25 kA for 3 Sec
11.	System neutral earthing	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:

220kV System

S.N.	Parameters	**220 kV**
(a)	Max. System voltage Um(kV)	2456
(b)	Impulse withstand voltage (dry & wet) (kV_p)	± 1050
(c)	Power frequency withstand voltage (dry and wet) (kV rms)	460
(d)	Total creepage distance (min) (mm)	6125

132kV & 33kV System

S.N.	Parameters	**132 kV**	**33kV**
(a)	Max. System voltage Um(kV)	145	36

(b)	Impulse withstand voltage (dry & wet) (kVp)	± 650	± 170
(c)	Power frequency withstand voltage (dry and wet) (kV rms)	275	75
(d)	Total creepage distance (min) (mm)	3625	900

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.

4.6.3.1

(A) 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	- 0.5g horizontal -	
Rating of Auxiliary Contacts	10 A at 220/110 V 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	- 0.5g horizontal -	
Partial discharge for: -		
- Surge arrester at 1.05 COV	- Not exceeding 50 pc. -	
- for CT/CVT	- Not exceeding 10 pc. –	

(C) **For 33 kV Vacuum Circuit Breaker and Isolator**:

Rated voltage kV (rms)	36
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 micro sec.)	
- between line terminals and ground	±170 kV_p
- between terminals with circuit breaker open	±170 kV_p
- between terminals with isolator open	±170 kV_p
2) One-minute power frequency dry and wet withstand voltage	

-	between line terminals and ground	70kV(rms)
-	between terminals with circuit breaker open	70kV(rms)
-	between terminals with Isolator open	70kV(rms)

Minimum creepage distance:

Phase to ground (mm)	900
Between CB Terminals (mm)	900
System neutral earthing	Effectively earthed
Seismic acceleration	0.5 g
Rating of Auxiliary Contacts	10 A at 250 V DC
Breaking capacity of Auxiliary Contacts	2 A DC with circuit time constant of not less than 20ms

Auxiliary Switch shall also comply with other clauses of Chapter-GTR.

(D) FOR 33kV CT/VT/SA

Rated voltage kV (rms)	36
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	±170 kV_p
-	for arrester housing	±170 kV_p

2) One-minute power frequency dry and wet withstand voltage

-	between line terminals and ground	70kV rms
-	for arrester housing	70kV rms

Minimum creepage distance:

Phase to ground (mm)	900
Between Terminals (mm)	900
System neutral earthing	- Effectively earthed -
Seismic acceleration	0.5 g
Cantilever strength of bushing	350 kg (minimum)

(E) Technical Parameters of Bushings/Hollow Column Insulators/support insulators for 33kV:

(a)	Rated Voltage (kV)	36
(b)	Impulse withstand voltage (Dry & Wet) (kV_p)	±170

(c)	Power frequency withstand voltage (dry and wet) (kV rms)	75
(d)	Total creepage distance (mm)	900

(e) Pollution Class-III Heavy (as per IEC 71) and as specified in Section-2 for all class of equipment.

The requirement of alternate long & short sheds stated in model technical specification shall not be applicable in case of 33 kV.

5.0 ENGINEERING DATA AND DRAWINGS

5.1 The list of drawings/documents which are to be submitted to the Purchaser shall be discussed and finalised by the Purchaser 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 Purchaser. 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 Purchaser, 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 Purchaser 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 Purchaser 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 Purchaser 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 Purchaser. Approval of Contractor's drawing or work by the Purchaser 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 Purchaser 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 Purchaser 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 Purchaser 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 Purchaser 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 Purchaser 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 Purchaser.

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

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.

6.1.7 All oil, grease and other consumables used in the Works/ Equipment shall be purchased in Nepal unless the Contractor has any special requirement for the specific application of a type of oil or grease not available in Nepal. In such is the case he shall declare in the proposal, where such oil or grease is available. He shall help Purchaser in establishing

equivalent Nepal make and Nepal Contractor. The same shall be applicable to other consumables too.

6.1.8 A cast iron or welded steel base plate shall be provided for all rotating equipment which are to be installed on a concrete base unless otherwise agreed to by the Purchaser. Each base plate shall support the unit and its drive assembly, shall be of design with pads for anchoring the units, shall have a raised up all around and shall have threaded in air connections, if so required.

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 equipment 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 Purchaser. 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 PLCC 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 Purchaser or the Contractor may propose changes in the specification of the equipment or quality thereof and if the Purchaser & 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 Purchaser. 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 Purchaser (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 Purchaser'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 organization 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 authorizing release of manufactured product to the Purchaser.

(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 Purchaser or his duly authorized 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 purchaser'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. Purchaser reserves the right to witness any or all the tests. The Contractor shall intimate the Purchaser the detailed program about the tests atleast three (3) weeks in advance in case of domestic supplies & six (6) weeks in advance in case of foreign supplies.

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 or reputed consultant.

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

However, in case of instrument transformers, the following type tests should have been conducted within 5 (five) 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 (for instrument transformers) as mentioned above are conducted earlier than 5 (five) years prior to the originally Scheduled date of bid opening, the contractor shall repeat these test(s) at no extra cost to the purchaser.

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 Purchaser.

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

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

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 labor, materials, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Purchaser /Inspector or his authorized representative to carry out effectively such tests of the equipment in accordance with the Contract and shall give facilities to the Purchaser /Inspector or to his authorized representative to accomplish testing.

9.8 The inspection by Purchaser 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 Purchaser 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 complies with the specification.

9.10 The Purchaser 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 Purchaser.

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 Purchaser 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 Purchaser 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 Purchaser, the Contractor shall also submit packing details/associated drawing for any equipment/material under his scope of supply, to facilitate the Purchaser 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. Purchaser takes no responsibility of the availability of the wagons.

11.2 All coated surfaces shall be protected against abrasion, impact, discoloration 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 discolored 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 Indian Standards.

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

12.2.6 Galvanized material must be transported properly to ensure that galvanized 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 IS-6005/Equivalent International standard “Code of practice for phosphating iron and sheet”. 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 Purchaser’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 Purchaser 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 energization 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 Purchaser. 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 Purchaser immediately of any damage, shortage, discrepancy etc. for the purpose of Purchaser's information only. The Contractor shall submit to the Purchaser 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 Purchaser 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 Purchaser, as well as protection of the same against theft, element of nature, corrosion, damages etc.

13.8 Where material / equipment is unloaded by Purchaser before the Contractor arrives at site or even when he is at site, Purchaser 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 Purchaser. 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	± 10	50 ± 2.5%	3/4 Wire	Solidly Earthed.

230V	± 10	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 5.9 meter from plinth level for 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:

A	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	Electro galvanized for sizes Plain, washers below M12, for thers hot dip galvanized.
	ii) Spring washers for item ‘a’ to ‘c’	Electro-galvanized 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 galvanized. 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 A AC plug and socket shall be provided in the cabinet with ON-OFF switch for connection of hand lamps. Plug and socket shall be of industrial grade.

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

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

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

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

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

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

i) Check for wiring

ii) Visual and dimension check

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

19.0 Void.

20.0 TERMINAL BLOCKS AND WIRING

20.1 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.

20.2 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.

20.3 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.

20.4 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.

20.5 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.

20.6 The terminal blocks shall be of extensible design.

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

20.8 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.

20.9 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.

20.10 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.

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

20.12 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.

20.13 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.

20.14 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.

21.3 Switches and Fuses:

21.3.1 Each panel shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with miniature circuit breaker / switch/ fuse 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.

21.3.2 All fuses shall be of HRC cartridge type conforming to IS: 9228/ Equivalent 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.

22.0 Bushings, Hollow Column Insulators, Support Insulators:

22.1 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.

22.2 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.

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

22.4 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.

22.5 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.

22.6 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.

22.7 All iron parts shall be hot dip galvanized 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.

22.8 Tests

In bushing, hollow column insulators and support insulators shall conform to type tests and shall be subjected to routine tests in accordance with IS: 2099 & IS: 2544 & IS: 5621/ Equivalent International Standard.

23.0 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.

23.1 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 IS: 4691/ Equivalent 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.

23.2 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.

23.3 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 electro-dynamic 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 IS:325/ Equivalent 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 at least 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 20% and open for speeds above 20% of the rated speed. The speed switch shall be capable of withstanding 120% of the rated speed in either direction of rotation.

23.4 Running Requirements:

a) The maximum permissible temperature rises over the ambient temperature of 50^{o} C shall be within the limits specified in IS: 325/ Equivalent 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 IS: 4729/ Equivalent 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.

23.5 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 Purchaser without any extra cost to the Purchaser. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates and shall furnish the list of instruments to the Purchaser for approval.

(a) Insulation resistance.

(b) Phase sequence and proper direction of rotation.

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

24.0 TECHNICAL REQUIREMENT OF EQUIPMENTS

24.1 1.1 KV Grade Power & Control Cables

24.1.1 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.

24.1.2 Applicable for PVC Power Cable

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

24.1.3 Applicable for XLPE Power Cables

The Manufacturer, whose XLPE Power cables are offered, should have designed, manufactured, tested and supplied in a single contract at least 25 km 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.

24.2 LT Switchgear

24.2.1 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 (i.e. Molded Case Circuit Breakers) modules of the type offered which should be in successful operation as on originally Scheduled date of bid opening.

24.2.2 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.

24.3 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 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

LIST OF SPECIFICATIONS

GENERAL STANDARDS AND CODES

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 Hexafluoride
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 & Control gear 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	-	Techniques 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

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 control gear - Part 100: Alternating current circuit-breakers
IEC-62271-101	-	High-voltage switchgear and control gear - 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 control gear - Part 110: Inductive load switching
IEC-62271-109	-	High-voltage switchgear and control gear - 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-C37.20	-	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 control gear - 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
PLCC and line traps		
IEC-60353	-	Line traps for A.C. power systems.
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 meter
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(Central Office)	-	Three phase induction motors
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	-	Characteristics 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 pin type.
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 porcelain 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 colors 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 Automatic 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 embroilment of Hot Galvanized structural steel products and procedure for detaching embroilment
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 flanges and 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 pipe threads
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.

ANNEXURE - B

Sl No.	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	GTP and drawings for Bus-Post Insulator
9	Tension/suspension string insulator and Hardware Assembly GTP and drawing
10	Soil Investigation Report (if applicable)
11	**Circuit Breakers (220kV,132kV, 33 kV- As applicable)** - GA drawing, GTP, Type test Reports
12	**CTs & CVTs (220kV,132 kV, 33kV- As applicable)** - GA drawing, GTP, Type test Reports
13	**Surge Arrestors (216kV,120kV, 30kV- As applicable)** - GA drawing, GTP, Type test Reports
14	**Isolators (220kV,132kV, 33 kV- As applicable)** - GA drawing, GTP, Type test Reports
15	**Control, Relay Panels and Substation Automation system** - GTP, technical literature, type test reports
16	**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)** 220/132/11 kV Tower, structure & foundation design/drawings. **d)** 220/132/11kV Equipment support structure & foundation design/drawing

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. For identical construction, the existing drawings will be provided as far as possible.

SECTION 03

POWER TRANSFORMER

Table of Content

1.0 General

1.1 This specification covers design, engineering, manufacture, testing at manufacturer's works, delivery at site including all materials, accessories, spares, unloading, handling, proper storage at site, erection, testing and commissioning of the equipment specified.

1.2 Transportation

1.2.1 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.

1.2.2 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.

1.2.3 The Contractor shall dispatch the transformer filled with oil or in an atmosphere of nitrogen or dry air. In the former case the contractor shall take care of the weight limitation on transport and handling facility at site. In the latter case, necessary arrangement shall be ensured by the contractor to take care of pressure drop of nitrogen or dry air during transit and storage till completion of oil filling during erection. A gas pressure testing valve with necessary pressure gauge and adaptor valve shall be provided.

1.2.4 Transformer shall also be fitted with at least one Electronic impact recorder (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 before dispatch and must continue till the unit is installed on its foundation. The data of electronic impact recorder(s) shall be down loaded at site and a soft copy of it shall be handed over to Engineer-in-charge. Further, within three weeks the contractor shall communicate the interpretation of the data. In the unlikely event of impact recorder output not available at site, the equipment shall be thoroughly internally inspected by the manufacturer's representative before erection at site to ensure healthiness of the equipment. Contractor shall mount Vehicle tracking system (GPRS/ GPS/ GSM based) to track the exact position of the vehicle on which the equipment is being loaded for transportation in order to ensure traceability and safety during transportation.

2.0 Performance

2.1 The transformers shall be used for bi-directional flow of rated power.

2.2 Transformers shall be capable of operating under natural cooled condition up to the full/Specified load. Transformers shall be fitted with coolers, capable of dissipating total losses at continuous maximum rating.

2.3 The transformers shall be capable of being operated, without danger, on any tapping at the rated MVA with voltage variation of $\pm$ 10% corresponding to the voltage of the tapping.

2.4 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 per cent continuous over voltage condition it does not exceed 1.9 Tesla at any tap position.

2.5 DGA of oil shall be periodically monitored by the Employer and the interpretation of DGA results will be as per IEC - 60599.

2.6 Radio Interference and Noise Level

2.6.1 The transformers shall be designed with particular attention to the suppression of maximum harmonic voltage, especially the third and fifth so as to minimize interference with communication circuit.

2.6.2 The noise level of transformer, when energized at normal voltage and frequency with cooler equipments in operation shall not exceed, when measured under standard conditions, the values specified at relevant clause.

2.7 The transformers shall be capable of being loaded in accordance with IEC-60076-7. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.

2.8 The transformer and all its accessories including CTs etc. shall be designed to withstand without injury, 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 3 secs. The short circuit level of the HV & LV System to which the subject transformers will be connected is 40 kA for 1 sec (sym, rms, 3 phase fault) on 220kV, 31.5 kA (sym., rms,3 phase fault on 132 kV) & 25kA (sym., rms, 3 phase faults on 33kV).

2.9 Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any winding.

2.10 Transformers shall withstand, without injurious heating, combined voltage and frequency fluctuations which produce the following over fluxing conditions:

110% for continuous operation
125% for 1 - minute
140% for 5 – seconds

2.11 Dynamic Short Circuit Test requirement

i) For 220 kV Class Transformer:

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on rating of 220 kV voltage class transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report/ Certificate along with bid as specified on Volume I, Section 3, EQC clause 2.6. In case bidder has not successfully tested 220 kV voltage class transformer for Dynamic Short Circuit Test, their bid shall be considered technically non-responsive. Further design review of offered 220 kV class transformers shall be carried out based on design of short circuit tested 220 kV voltage class transformer.

ii) For 132 kV Class Transformer:

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on rating of 132 kV voltage class transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report / Certificate along with bid as stipulated in Volume I, Section 3, EQC clause 2.6. In case bidder has not successfully tested 132 kV voltage class transformer for Dynamic Short Circuit Test, their bid shall be considered technically non-responsive. Further design review of offered 132 kV voltage class transformers shall be carried out based on design of short circuit tested 132 kV voltage class transformer.

iii) For 33 kV Class Transformer:

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on rating of 33 kV voltage class transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report / Certificate along with bid as stipulated in Volume I, Section 3, EQC clause 2.6. In case bidder has not successfully tested 33 kV voltage class transformer for Dynamic Short Circuit Test, their bid shall be considered technically non-responsive. Further design review of offered 33 kV voltage class transformers shall be carried out based on design of short circuit tested 33 kV voltage class transformer.

2.12 Design Review

The transformers 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 and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc so that the transformer provides long life with least maintenance.

Design reviews shall be conducted by Owner or an appointed Consultant at different stages of the procurement process for transformer, however the entire responsibility of design shall be with the manufacturer.

Owner may visit to the manufacturers works to inspect design, manufacturing and test facilities.

The design review will commence after placement of award with 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 scope of this specification.

The design review shall be conducted generally following the “Guidelines for conducting design reviews for transformers 100 MVA and 132 kV and above” prepared by Cigre SC 12 Working Group 12.22.

The manufacturer shall provide all necessary information and calculations during design review 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.

The manufacturer will be required to demonstrate the use of adequate safety margin for thermal, mechanical, dielectric and vibration etc. design to take into the account the uncertainties of his design and manufacturing processes.

The scope of such a design review shall at least include the following:

1.	Core and magnetic design
2.	Winding and tapping design
3.	Short-circuit withstand capability
4.	Thermal design including review of localized potentially hot area.
5.	Cooling design
6.	Overload capability
7.	Eddy current losses
8.	Seismic design, as applicable
9.	Insulation co-ordination
10.	Tank and accessories
10.1	Bushings and barrier design
10.2	Tap changers
10.3	Protective devices
10.4	Radiators
10.5	Oil and oil preservation system
11.	Corrosion protection
12.	Electrical and physical Interfaces with substation
13.	Earthing
14.	Processing and assembly
15.	Testing capabilities
16.	Inspection and test plan
17.	Transport and storage
18.	Sensitivity of design to specified parameters
19.	Acoustic Noise
20.	Spares, inter-changeability and standardization

21.	Maintainability

3.0 Construction Details

The features and construction details of each power transformer shall be in accordance with the requirement stated hereunder.

3.1 Tank and Tank Accessories

3.1.1 Tank

3.1.1.1 Tank shall preferably be of welded construction and fabricated from tested quality low carbon steel of adequate thickness.

3.1.1.2 All seams and those joints not required to be opened at site shall be factory welded, and wherever possible they shall be double welded. After completion 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.

3.1.1.3 Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.

3.1.1.4 The transformer shall have conventional type tank. In case the joint is welded it 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 of the joint.

3.1.1.5 Each tank shall be provided with:

(a) Lifting lugs suitable for lifting the equipment complete with oil.

(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. Each jacking pad shall be designed to support with an adequate factor of safety for at least half of the total mass of the transformer 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.

3.1.1.6 The tank shall be designed in such a way that it can be mounted on the rollers.

3.1.1.7 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 injury when using plates or rails.

3.1.1.8 Paint system and procedures

The painting details for transformer main tank, pipes, conservator tank, radiator, control cabinet/ marshalling box / oil storage tank etc. shall be as given below. The paint should not fade during drying process. The paint should be able to withstand temperature up to 120 deg. C. The detailed painting procedure shall also be submitted along with the bid which shall be finalized before award of the contract.

	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thick-ness (DFT)	Colour shade
Main tank, pipes, conservator tank, oil	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-	Epoxy high build Micaceous iron oxide	Aliphatic polyurethane (PU) (Minimum	Minimum 155μm	RAL 7035

storage tank etc. (external surfaces)		40μm)	(HB MIO) (75μm)	50μm)		
Main tank, pipes (above 80 NB), conservator tank, oil storage tank etc. (Internal surfaces)	Shot Blast cleaning Sa 2 ½*	Hot oil resistant, non-corrosive varnish or paint or epoxy	--	--	Minimum 30μm	Glossy white for paint
Radiator (external surfaces) **	Chemical / Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40μm)	Epoxy base Zinc primer (30-40μm)	PU paint (Minimum 50μm)	Minimum 100μm	Matching shade of tank/ different shade aesthetically matching to tank
Radiator and pipes up to 80 NB (Internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish	--	--	--	--
Control cabinet / marshalling box/RTCC	Seven tank process as per IEC	Zinc chromate primer (two coats)	--	EPOXY paint with PU top coat	Minimum 80μm	RAL 7035 shade for exterior and interior

Note: * Indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.
** **Radiator hot dip galvanized may also acceptable**.

3.1.2 **Tank Cover**

3.1.2.1 The tank cover shall be designed to prevent retention of rain 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.

3.1.2.2 At least one adequately sized inspection openings shall be provided in the transformers 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.

3.1.2.3 The tank covers shall be fitted with pockets at the position of maximum oil temperature at maximum continuous rating for bulbs of oil and winding temperature indicators. It shall be possible to remove these bulbs without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.

3.1.2.4 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.

3.1.2.5 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. Groove provided to accommodate round nitrile rubber cord for rectangular openings shall be milled.

3.1.2.6 Tank hotspot

The maximum temperature on any metal part shall not exceed 130 deg. Celsius.

3.1.2.7 Currents flowing in tank cover and bushing turrets

To allow for the effect of possible induced and capacitive surge current, good electrical connection shall be maintained between the tank and turrets.

3.1.2.8 The transformer shall be provided with pipe flange of suitable diameter with bolted blanking plate, gasket and shall be fitted at the highest point of the transformer tank for maintaining vacuum in the tank.

3.1.3 **Axles and Wheels**

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

3.1.3.2 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.

3.1.3.3 The rail track gauge shall be 1676 mm.

3.1.4 **Foundation and Anti Earthquake Clamping Device**

To prevent transformer movement during earthquake, suitable clamping devices shall be provided for fixing the transformer to the foundation.

3.1.5 **Conservator & Oil Preservation System**

Main conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture, and shall be fitted with magnetic oil level gauge with low oil level potential free contacts.

3.1.5.2 OLTC shall have conventional type conservator with prismatic oil level gauge.

3.1.5.3 **Conservator tank and pipe work**

3.1.5.3.1 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 100degC. The capacity of the conservator tank shall be such that the transformer shall be able to carry the specified overload without overflowing of oil. The Calculation shall be submitted during design review.

3.1.5.3.2 The conservator shall be fitted with integral 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 wherever applicable.

3.1.5.3.3 Conservator shall be positioned so as not to obstruct any electrical connection to transformer. Pipe work shall neither obstruct the removal of tap changers for maintenance or the opening of inspection or manhole covers.

3.1.5.3.4 Pipe work connections shall be of adequate size for their duty and as short and direct as possible. Only radiused elbows shall be used.

3.1.5.3.5 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.

3.1.5.3.6 This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degree.

3.1.5.4 **Oil Preservation Equipment**

The requirements of air cell type oil sealing system are given below.

3.1.5.4.1 Contact of the oil with atmosphere is prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth.

3.1.5.4.2 The temperature of oil is likely to rise up to 100 deg. C during operation. As such air cell used shall be suitable for operating continuously at 100 deg C.

3.1.5.4.3 Air cell of conservator shall be able to withstand the vacuum during installation /maintenance periods. Otherwise provision shall be kept to isolate the conservator from the main tank when the latter is under vacuum by providing a vacuum sealing valve or other suitable means in the pipe connecting main tank with the conservator. 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, the recommended replacement intervals and the supplier.

3.1.5.4.4 The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator.

3.1.5.5 **Dehydrating Filter Breather**

Conservator shall be fitted with a dehydrating filter breather. It shall be so designed that:

a) Passage of air is through silica gel.
b) Silica gel is isolated from atmosphere by an oil seal.
c) Moisture absorption indicated by a change in colour of the tinted crystals can be easily observed from a distance.
d) Breather is mounted not more than 1200 mm above rail top level.
e) To minimize the ingress of moisture two breathers (of identical size) shall be connected in series for main tank conservator and two breathers (of identical size) shall be connected in series for OLTC tank conservator.

3.1.5.6 Pressure Relief Device

Adequate number of pressure relief devices shall be provided at suitable locations. These shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage to equipment. The device shall operate at a static pressure less than the hydraulic test pressure of the transformer tank. It shall be mounted directly on the tank. One set of electrically insulated contacts shall be provided for alarm/tripping. Discharge of pressure relief device shall be properly taken through pipes and directed away from the transformer/other equipment and this shall be prevented from spraying on the tank. Following routine tests shall be conducted on PRD

a. Air pressure test
b. Liquid pressure test
c. Leakage test
d. Contact test
e. Dielectric test.

3.1.5.7 **Buchholz Relay**

A double float/reed type Buchholz relay shall be provided. Any gas evolved in the transformer shall collect in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper/stainless steel tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling with the transformer in service. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure. Buchholz relay shall be type tested as per international standards. Buchholz relay and its terminal box shall conform to IP 55 degree of protection.

3.1.5.8 **Temperature Indicators**

3.1.5.8.1 **Oil Temperature Indicator (OTI)**

All transformers shall be provided with a 150 mm (approx.) dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent ungrounded alarm and trip contacts, maximum reading pointer and resetting device shall be provided in the OTI. A temperature sensing element suitably located in a pocket on top oil shall be furnished. 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. The setting of alarm and tripping contacts shall be adjustable at site.

In addition to the above, the following equipment shall be provided for remote indication of oil temperature:

a) Signal transmitter

Signal transmitter shall have additional facility to transmit signal for recording oil temperature at Employer's data acquisition system, for which duplex platinum RTD with nominal resistance of 100 ohms at zero degree centigrade shall be supplied. The RTD shall be three wire ungrounded system. The calibration shall be as per SAMA (USA) standard or equivalent. The RTD may be placed in the pocket containing temperature sensing element and image coil for OTI system which will be used for both remote OTI and DAS. Necessary equipment for sending the signal to remote OTI and DAS shall be provided. In lieu, separate RTD for each of the functions shall be provided.

b) Remote oil temperature indicator

It shall be suitable for flush mounting on Employer's/RTCC panel. This shall not be repeater dial of local OTI and will operate by signal transmitter.

Any special cable required for shielding purpose, for connection between cooler control cabinet and remote OTI control circuit, shall be in the scope of Contractor. Only one ROTI with a four-point selector switch shall be provided.

3.1.5.8.2 **Winding Temperature Indicator (WTI)**

A device for measuring the hot spot temperature of each winding shall be provided (HV and LV). It shall comprise the following:

i) Temperature sensing element.

ii) Image coil.

iii) Auxiliary CTs, if required to match the image coil, shall be furnished and mounted in the cooler control cabinet.

iv) 150 mm (approx.) dia. local indicating instrument with maximum reading pointer and two adjustable electrically independent, ungrounded contacts; besides that, required for control of cooling equipment if any, one for high winding temperature alarm and one for trip. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C.

v) Calibration device.

vi) Accuracy of WTI shall be ± 3.0 deg C or better.
The setting of alarm and tripping contacts shall be adjustable at site and typical values are as given below which will be reviewed during detailed engineering based on manufacturer's recommendation.

Alarm – 110degC
Trip - 120degC

vii) In addition to the above, the following equipment shall be provided for remote indication of winding temperature for each of the winding:

a) Signal transmitter for each winding

Signal transmitter shall have additional facility to transmit signal for recording winding temperature at Employer's data acquisition system, for which duplex platinum RTD with nominal resistance of 100 ohms at zero degree centigrade shall be supplied. The RTD shall be three wire ungrounded system. The calibration shall be as per SAMA (USA) standard or equivalent. The RTD may be placed in the pocket containing temperature sensing element and image coil for WTI system which will be used for both remote WTI and DAS. Necessary equipment for sending the signal to remote WTI and DAS shall be provided. In lieu, separate RTD for each of the functions shall be provided.

b) Remote winding temperature indicator

It shall be suitable for flush mounting on Employer's panel. This shall not be repeater dial of local WTI and will operate by signal transmitter.

Any special cable required for shielding purpose, for connection between cooler control cabinet and remote WTI control circuit, shall be in the scope of Contractor. Only one RWTI with a selector switch shall be provided for all the windings (HV and LV).

3.1.9 **Earthing Terminals**

3.1.9.1 Two (2) earthing pads (each complete with two (2) nos. holes, M10 bolts, plain and spring washers) suitable for connection to 75 x 6 mm galvanised steel grounding flat shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

3.1.9.2 Two earthing terminals suitable for connection to 75 x 6 mm galvanised steel flat shall also be provided on cooler, marshalling box and any other equipment mounted separately.

3.2 **Core**

3.2.1 The core shall be constructed from prime quality, non-ageing, cold rolled, super grain oriented, and silicon steel laminations.

3.2.2 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. 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 most extreme operating condition. Adequate temperature margin shall be provided to maintain longer life expectancy for this material.

3.2.3 The insulation of core to bolts and core to clamp plates shall be able to withstand a voltage of 2 KV (rms) for 1 minute.

3.2.4 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.

3.2.5 All steel sections used for supporting the core shall be thoroughly sand blasted after cutting, drilling and welding.

3.2.6 Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.

3.2.7 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.

3.2.8 Adequate lifting lugs will be provided to enable the core and windings to be lifted.

3.2.9 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 transformer.

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.

A drawing furnishing the details of the internal earthing design shall be included in the manual.

3.3 **Windings**

3.3.1 The Contractor shall ensure that windings of all transformers are made in dust proof and conditioned atmosphere.

3.3.2 The conductors shall be of electrolytic grade copper free from scales and burrs.

3.3.3 The insulation of transformer windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse and be non-catalytic and chemically inactive in transformer oil during service.

3.3.4 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.

3.3.5 The coils would be made up, shaped and braced to provide for expansion and contraction due to temperature changes.

3.3.6 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.

3.4 **Unused inhibited Insulating Oil**

3.4.1 The insulating oil shall be virgin high grade inhibited, conforming to IEC-60296 & all parameters specified below, while tested at supplier's premises. The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned below, prior to dispatch of oil from refinery to site. Under no circumstances, poor quality oil shall be filled into the transformer and only thereafter be brought up to the specified parameter by circulation within the transformer.

Sl. No.	Property	Test Method	Limits
A1.	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 or ASTM D1298	(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.	Resistivity at 90 deg C	IEC 60247	150 X 10^12 Ohm –cm, (Min.) for records only.
9.	Negative impulse testing KV_p @ 25 deg C	ASTM D-3300	145 (Min.)
10.	Carbon type composition (% of Aromatic, Paraffins and Naphthenic compounds.)	IEC 60590 or ASTM D 2140	Max. Aromatic: 4 to12 % Paraffins : <50% & balance shall be Naphthenic compounds.
B1.	Refining / Stability		
1.	Acidity	IEC 62021-1 or ASTM D974	(Max) 0.01 mg KOH/g
2.	Interfacial tension at 27degC	ISO 6295 or ASTM D971	(Min) 0.04 N/m
3.	Total sulfur content	BS 2000 part 373 or ISO 14596	0.15 % (Max.)
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.)
C1.	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.	Gassing	IEC 60628A or ASTM D2300	No general requirement
3.	Oxidation stability (Rotating Bomb test)	IEC : 61125(Method B) / ASTM D2112 (e)	220 Minutes (Min.)
D1.	Health, safety and environment (HSE)		
1.	Flash point	ISO 2719	(Min.)135degC
2.	PCA content	BS 2000 Part 346	Max 3%
3.	PCB content	IEC 61619 or ASTM D4059	Not detectable (Less than 2 mg/kg)

3.4.2 i) Prior to filling in main tank at site and shall be tested for

1. Break Down voltage (BDV) : 70kV (min.)
2. Moisture content : 5 ppm (max.)
3. Tan-delta at 90 °C : 0.0025 (max)
4. Interfacial tension : More than 0.004 N/m

ii) Prior to energization at site oil shall be tested for following properties &acceptance norms as per below generally in line with IEC 60422:

1. Break Down voltage (BDV) : 70 kV (min.)
2. Moisture content : 10 ppm (max.)
3. Tan-delta at 90 °C : 0.01 (max.)
4. Resistivity at 90 °C : 6 X 10 ^12 ohm-cm (min.)
5. Interfacial tension : 0.035 N/m (min.)
6. *Oxidation Stability (Test method as per IEC 61125 method C, Test duration: 500hour for inhibited oil)
   a) Acidity : 0.3 (mg KOH /g) (max.)
   b) Sludge : 0.05 % (max.)

c) Tan delta at 90 °C : 0.05 (max.)

7. * Total PCB content : Not detectable (2 mg/kg total)

* For Sr. No. 6 & 7 separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning for approval of Consultant.

3.4.3 At manufacturer's works the quality of oil used for first filling, testing and impregnation of active parts shall meet at least parameters as mentioned in serial no. 1 to 5 of clause 3.4.2 ii) above. The oil test results shall form part of equipment test report.

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. For ONAN/ONAF cooled transformers, sample shall not be taken earlier than 2 hours after shutdown. The acceptance norms with reference to various gas generation rates shall be as per IEC 61181.

3.5 Terminal Arrangements

3.5.1 Bushings

3.5.1.1 The electrical and mechanical characteristics of bushings shall be in accordance with IEC 60137/ DIN 42530.

3.5.1.2 Bushing for various voltage rating shall be as follows

52 kV and above	Hermetically sealed Oil filled condenser type/ RIP bushing with porcelain or composite insulator.
36 kV and below	Solid porcelain or oil communicating type. Dimensions of 36 kV bushing shall conform to IEC

3.5.1.3 Oil Filled condenser type bushing shall be provided with at least the following fittings:

(a) Oil level gauge.

(b) Tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable.

3.5.1.4 Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.

3.5.1.5 Bushings of identical rating shall be interchangeable.

3.5.1.6 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.

3.5.1.7 Clamps and fittings shall be of hot dip galvanised steel.

3.5.1.8 Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.

3.5.1.9 No arcing horns shall be provided on the bushings.

3.5.1.10 Suitable insulating cap (preferably of porcelain) shall be provided on the terminal of Bushing of tertiary winding to avoid accidental external short circuit.

3.5.1.11 Installation procedures for the various voltage class bushings shall be clearly brought out in the Instruction manual.

3.5.2 Terminal Marking

The terminal marking and their physical position shall be as per IEC: 60076.

3.5.3 Neutral Earthing Arrangement

3.5.3.1 For 3-Phase Unit

The neutral terminals of 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) 75 x 6 mm galvanised steel flats connected to Employer's grounding mat.

3.5.3.2 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.

3.5.4 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.

3.5.5 Spare Unit connection arrangement (as applicable for 1-Phase Transformer)

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 up to 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. For connection of spare unit in place of other units, HV, LV, Tertiary delta and neutral connection changeover will be achieved by the help of manual connection changeover. Provision of manual changeover should be such that changeover can be achieved in very less time. However, the detail configuration and actual sizes of various items shall be finalized during detailed engineering and shall be subject to Employer’s approval. All associated materials like Bus post insulators, Aluminum tube, conductors, clamps & connectors, insulator strings, hardware, cables, support structures, required for the above-mentioned arrangement shall be provided by the contractor.

3.6 Cooling Equipment and its Control

3.6.1 Cooling Equipment

3.6.1.1 The cooler shall be designed using sufficient number of tank mounted radiators. Design of cooling system shall satisfy the performance requirements.

3.6.1.2 Tank mounted radiators shall have its cooling fans, shut off valves at the top and bottom of suitable 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.

3.6.1.3 Required number of standby fans of approximately 20% capacity shall also be provided with radiators.

3.6.1.4 Cooling fans shall be directly mounted on radiator. 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.

3.6.1.5 Cooling fans motors shall be suitable for operation from 400 volts, three phase 50 Hz power supply and shall conform to IEC. Each cooling fan 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.

3.6.1.6 The cooler and its accessories shall preferably be hot dip galvanised or corrosion resistant paint (as per clause 3.1.1.8) should be applied to it.

3.6.1.7 Air release device and oil plug shall be provided on oil pipe connections. Drain valves shall be provided in order that each section can be drained independently.

3.6.2 Cooling Equipment Control (ONAN/ONAF COOLING)

3.6.2.1 Automatic operation control of fans 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 from ONAN to ONAF. The setting shall be such that hunting i.e. frequent start-up operations for small temperature differential do not occur.

3.6.2.2 Suitable manual control facility for cooler fans shall be provided.

3.6.2.3 Selector switches and push buttons shall also be provided in the cooler control cabinet to disconnect the automatic control and start/stop the fans manually.

3.6.2.4 Indicating Devices

Following lamp indications shall be provided in cooler control cabinet:

a) Control Supply failure.

b) Cooling fan failure.

c) 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 for further wiring to Common Marshalling Box (CMB).

3.6.2.5 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.

3.6.2.6 Control and power supplies are to be given for Cooler circuits 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. The Contractor shall derive AC power for Cooler Control Circuitry from the AC feeder as mentioned above. 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.

3.6.2.7 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.

3.6.3 Auxiliary power supply distribution scheme shall be submitted for approval. 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 Owner's Control Panels/RTCC panels are also in the scope of the contractor.

3.6.4 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. All the necessary terminations for remote connection to Purchaser's panel shall be wired upto the Common Marshalling box.

3.6.5 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 Purchaser's Control panels / Digital RTCC Panel / SCADA and individual units under operation (i.e. any designated unit for bank or spare unit, if it replaces 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

3.6.6 **Valves**

3.6.6.1 All valves shall be of gun metal or of cast steel/cast iron. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel.

3.6.6.2 Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.

3.6.6.3 Each valve shall be provided with the indicator to show clearly the position of the valve.

3.6.6.4 All valves flanges shall have machined faces.

3.6.6.5 All valves in oil line shall be suitable for continuous operation with transformer oil at 115 deg. C.

3.6.6.6 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.

3.6.6.7 A valve or other suitable means shall be provided to fix (in future) on line dissolved gas monitoring system to facilitate continuous dissolved gas analysis. The location & size of the same shall be finalized during detail engineering stage

3.6.6.8 After testing, inside surface of all cast iron valves coming in contact with oil shall be applied with one coat of oil resisting paint/varnish with two coats of red oxide zinc chromate primer followed by two coats of fully glossy finishing paint conforming to international standards. Outside surface except gasket setting surface of butterfly valves

shall be painted with two coats of red oxide zinc chromate conforming to International Standards followed by two coats of fully glossy finishing paint.

3.6.6.9 All hardware used shall be cadmium plated/electro galvanised steel.

3.6.6.10 For estimation purpose of spares one set of valves would mean one valve of each type used in Transformer.

3.7 Tap Changing Equipment

Each transformer shall be provided with On Load Tap changing equipment.

3.7.1 On Load Tap Changing Gear (OLTC)

OLTC shall be motor operated for local as well as remote operation. An external handle shall be provided for local manual operation. This handle shall be suitable for operation by a man standing at ground level

3.7.1.1 Each 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 and without producing phase displacement.

3.7.1.2 The requirements of on load tap changing equipment are given here below:

a) The current diverting contacts shall be housed in a separate oil chamber not communicating with the oil in main tank of the transformer.

b) The contacts shall be accessible for inspection without lowering oil level in the main tank and the contact tips shall be replaceable.

c) The Bidder shall indicate the safeguards in order to avoid harmful arcing at the current diverting contacts in the event of operation of the OLTC gear under overload conditions of the transformer. Necessary tools and tackles shall be furnished for maintenance of OLTC gear.

d) The diverter switch or arcing switch oil chamber shall have oil filling and drain plug, oil sampling valve, relief vent and level glass. It shall also be fitted with a oil surge relay the outlet of which shall be connected to a separate conservator tank.

e) 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 ancillary 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.

f) Tap changer shall be so mounted that bell cover of transformer can be lifted without removing connections between windings and tap changer.

g) Local OLTC control cabinet shall be mounted on the tank in accessible position. It should be adequately ventilated and provided with anti-condensation metal clad heaters. All contactors relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.

h) Operating mechanism for on load tap changer shall be designed to go through one step of tap change per command. Subsequent tap changes shall be initiated only by a new or repeat command.

i) On load tap changer shall be equipped with a time delayed INCOMPLETE STEP alarm consisting of a normally open contact which closes, if the tap changer fails to make a complete tap change. The alarm shall not operate for momentary loss of auxiliary power.

j) The selsyn units or approved equivalents shall be installed in the local OLTC control cabinet to provide tap position indication for the transformer. The Bidder shall also provide a set of instruments for tap position indication in the control room. Complete mounting details shall be included in the approved diagram.

k) Transformer on load tap shall be equipped with a fixed resistor network capable of providing discrete voltage steps for input to the supervisory system.

l) Limit switches shall be provided to prevent overrunning of the mechanism and shall be directly connected in the circuit of the operating motor. In addition, a mechanical stop shall be provided to prevent over-running of the mechanism under any condition.

m) Limit switches may be connected in the control circuit of the operating motor provided that a mechanical de-clutching mechanism is incorporated.

n) Thermal device or other means shall be provided to protect the motor and control circuit. All relays, switches, fuses etc. shall be mounted in the local OLTC control cabinet and shall be clearly marked for the purpose of identification.

o) A permanently legible lubrication chart if required, shall be fitted within the local OLTC control cabinet.

p) Any 'DROP DOWN' tanks associated with the tap changing apparatus shall be fitted with guide rod to control the movements during lifting or lowering.

q) A counter of at least five digits shall be fitted to the tap changing equipment to indicate the number of operations completed and shall have no provision for resetting.

r) All relays and operating devices shall operate correctly at any voltage between the limits specified.

s) It shall not be possible to operate the electric drive when the manual operating gear is in use.

t) It shall not be possible for any two controls to be in operation at the same time.

u) The equipment shall be suitable for supervisory control and indication with make before break multi-way switch, having one potential free contact for each tap position. This switch shall be provided in addition to any other switch/switches which may be required for remote tap position indication.

v) Operation from the local or remote-control switch shall cause one tap movement only until the control switch is returned to the off position between successive operations.

w) All electrical control switches and the local operating gear shall be clearly labelled in a suitable manner to indicate the direction of tap changing.

x) Transfer of source in the event of failure of one AC supply shall not affect the tap changer.

3.7.1.3 OLTC Control of Three Phase Transformers

Each three phase transformer shall be suitable for local and remote control. The control feature shall provide the following:

3.7.1.3.1 Local Electrical Control

(a) 'Local-remote' selector switch mounted in the local OLTC control cabinet shall switch control of all load tap changers as followings:

i) When the selector switch is in 'local' position, it shall be possible to operate the 'raise-lower' control switches specified in clause 3.9.3.1(b) below. Remote control of the raise-lower functions shall be prevented.

ii) When the selector switch is in 'remote' position the local OLTC control cabinet mounted 'raise-lower' switch specified in clause 3.9.3.1(b) below shall be in-operative. Remote control of the raise/lower function shall be possible from the remote control panel. The 'local-remote' selector switch shall have at least two spare contacts per position which are closed in that position but open in the other position.

(b) A 'raise-lower' control switch/push button shall be provided in the local OLTC control cabinet. This switch shall be operative only when 'local remote' selector switch is in 'local' position.

(c) An OFF-ON tap changer control switch shall be provided in the local OLTC control cabinet of the transformer. The tap changer shall be in-operative in the OFF position. Also, the OFF-ON switch shall have at-least one spare contact per position which is closed in that position but open in the other position.

3.7.1.3.2 Manual Control

The cranking device for manual operation of the OLTC gear shall be removable and suitable for operation by a man standing at ground level. The mechanism shall be complete with the following:

a) Mechanical tap position indicator which shall be clearly visible from near the transformer.

b) A mechanical operation counters.

c) Mechanical stops to prevent over-cranking of the mechanism beyond the extreme tap positions.

d) The manual control considered as back up to the motor operated 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 HV terminal voltage and vice-versa.

3.7.1.3.3 Remote Electrical Group Control

The OLTC control scheme offered shall have provision of remote electrical group control during the parallel operation of transformer. This is in addition to independent control of OLTC:

i) A four position selector switch having Master, Follower, Independent and Off position shall be provided in the remote OLTC control panel for each transformer. This shall be wired to enable operator to select operation of OLTC in either Master, Follower or Independent mode.

ii) Out of step relays with timer contacts shall also be provided to give alarm and indication in case tap position in all the transformers under group control are not in same position.

iii) Master Position
If the selector switch is in Master position, it shall be possible to control the OLTC units in the follower mode by operating the controls of the master unit. Independent operation of the units under Follower mode shall have to be prevented. However, the units under independent mode will be controlled independently.

iv) Follower Position

If the selector switch is in Follower mode, control of OLTC shall be possible only from panel of the Master unit.

v) Independent Position

In this position of Selector Switch, Control of OLTC of individual unit shall only be possible.

3.7.1.5 The control circuits shall comply with following conditions:

3.7.1.5.1 An interlock to cut off electrical control automatically upon recourse being taken to the manual control in emergency.

3.7.1.5.2 Reinforcement of the initiating impulse for a tap change, ensuring a positive completion once initiated to the next (higher or lower) tap.

3.7.1.5.2.3 "Step-by-Step" operation ensuring only one tap change from each tap changing impulse and a lock-out of the mechanism if the control switch (or push button) remains in the "operate" position.

3.7.1.5.2.4 An interlock to cut-out electrical control when it tends to operate the gear beyond either of the extreme tap positions.

3.7.1.5.2.5 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.

3.7.1.5.2.6 Tap change in progress indication shall be provided by means of an indicating lamp at the Employer's control panel. Necessary contacts for this and for remote tap position indicator at Employer's control panel shall be provided by the Bidder.

3.7.1.5.2.7 Protective apparatus, considered essential by the Bidder according to specialties of the gear.

3.7.2 Local OLTC Control Cabinet, Cooler Control Cabinet and Remote Tap Changer Control Panel

3.7.2.1 Each three phase transformer unit shall be provided with local OLTC control cabinet, cooler control cabinet and RTCC panel.

3.7.2.2 Cabinets and Panels shall be tank mounted, provided with suitable lifting arrangement and have sloping roof.

3.7.2.3 A space heater, and cubicle lighting with ON-OFF switch shall be provided in each panel.

3.7.3 Necessary shorting of terminals shall be done at the cooler control cabinet, local OLTC cabinet and remote OLTC panel. All the CT secondary terminals in the cooler control cabinet shall have provision for short circuiting to avoid CT open circuit while it is not in use.

3.7.4 Cooler Control Cabinet

3.7.4.1 The cooler control cabinet shall have all necessary devices meant for cooler control and local temp 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 up to the terminal board in the cooler control cabinet. All the necessary terminals for remote connection to Employer's panel shall be wired up to the cooler control cabinet.

3.7.4.2 The cooler control cabinet shall have two (2) sections. One section shall have the control equipment exclusively meant for cooler control. The other section shall house the temperature indicators, aux. CTs and the terminal boards meant for termination of various alarm and trip contacts as well as various bushing CT secondary. Alternatively, the two sections may be provided as two separate panels depending on the standard practice of the Bidder.

3.7.4.3 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.

3.7.5 Local OLTC Control Cabinet

The Local OLTC control cabinet shall house all necessary devices meant for OLTC control and indication. It shall be complete with the following:

i) A circuit breaker/contactor with thermal overload devices for controlling the AC Auxiliary supply to the OLTC motor.

ii) Cubicle light with door switch.

iii) Space heaters to prevent condensation of moisture.

iv) Locking arrangement for hinged door of cabinet.

v) Cable terminal glands for power and control cables to the OLTC gear.

3.7.6 Remote Tap Changer Control Panel.

3.7.6.1 The Contractor shall supply a Remote Tap Changer Control (RTCC) panel suitable for remote operation of On Load Tap Changing gear.

3.7.6.2 The RTCC panel shall house actuating switch for electrical raise/lower control, tap position indicator, signal lamps for "Tap change in progress" and "Tap changer out of step", and all other auxiliary devices for remote electrical control of the OLTC. For tap position indicator, the dual output type OLTC transducer shall be provided in the RTCC panel. One of the outputs of this transducer shall be used for local indication of tap position in RTCC panel and other output (0-10 mA or 4-20 mA) shall be used for RTUs/automation system.

3.7.6.3 The RTCC panel shall be located in Employer's control room /Air conditioned switchyard panel room.

3.8 **Auxiliary Power Supply of OLTC, Cooler Control and Power Circuit**

3.8.1 Two auxiliary power supplies, 400 Volt, three phase four (4) wire shall be provided by the Employer at cooler control cabinet for OLTC and cooler control and power circuit.

3.8.2 All loads shall be fed by one of the two feeders through an electrically interlocked automatic transfer switch housed in the cooler control cabinet for on load tap changer control and cooler circuits.

Design features of the transfer switch shall include the following:

a) Provision for the selection of one of the feeders 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 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.

3.8.3 Power Supply for OLTC Circuits

a) AC feeder shall be brought to the local OLTC control cabinet by the Contractor after suitable selection at cooler control cabinet for which description is given in 3.10.2 above, for control power circuit of OLTC.

b) The Contractor shall derive AC power for OLTC control circuitry from the AC feeder as mentioned above by using appropriately rated dry type transformers. If the control circuit is operated by DC supply, then suitable main and standby converters shall be provided by the Contractor to be operated from AC power source.

3.8.4 Power Supply for Cooler Circuits

3.8.4.1 Control and power supplies are to be given for Cooler circuits after the selection as mentioned above.

3.8.4.2 The Contractor shall derive AC power for Cooler Control Circuitry by using appropriately rated dry type transformer in case of using supply voltage different from the Employer's auxiliary supply. If the control circuit is operated by DC supply then suitable main and standby convertors shall be provided by the Contractor, to be operated from AC power source.

3.8.5 Necessary isolating switches and MCBs/MCCBs shall be provided at suitable points as per Employer's approved scheme.

4 **Fittings**

4.1 The following fittings shall be provided with each three phase transformer covered in this specification.

4.1.1 Conservator for main tank with oil filling hole and cap, air cell, isolating valves, drain valve, magnetic oil level gauge with low level alarm contacts and dehydrating silica gel breather.

4.1.2 Pressure relief devices with alarm/trip contacts.

4.1.3 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 and trip contacts.

4.1.4 Air release plug.

4.1.5 Inspection openings and covers.

4.1.6 Bushing with metal parts and gaskets to suit the termination arrangement.

4.1.7 Winding temperature indicators for local and remote mounting. One remote winding temperature indicator with a four point selector switch shall be provided for the three windings for three phase unit to have selection of any of the three windings.

4.1.8 Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs.

4.1.9 Protected type mercury or alcohol in glass thermometer.

4.1.10 Bottom and top filter valves with threaded male adaptors, bottom sampling valve and drain valve.

4.1.11 Rating and diagram plates on transformers and auxiliary apparatus.

4.1.12 Flanged bi-directional wheels/Trolley for movement

4.1.13 Cooler cabinet.

4.1.14 Off load / On load tap changing gear.

4.1.15 Cooling equipment

4.1.16 Bushing current transformers.

4.1.17 Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently.

4.1.18 Terminal marking plates.

4.1.19 Valves schedule plates.

4.1.20 Oil temperature indicator for local and remote mounting

.

4.1.21 Oil flow indicator

4.1.22 Marshalling box/Common marshalling box

4.1.23 Suitable galvanized iron or stainless steel tray for cabling on main tank for better aesthetics.

4.1.24 Terminal clamp & connector

4.1.25 The fittings listed above are only indicative and other fittings which generally are required for satisfactory operation of the transformer are deemed to be included.

4.1.26 One set of hand tools 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 as used in the reactor 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) shall be supplied per Substation.

5 Inspection and Testing

The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the equipment. An indication of inspection envisaged by the Employer is given under Clause 5.1. 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.

5.1 Inspection

5.1.1 Tank and Conservator

5.1.1.1 Certification of chemical analysis and material tests of plates.

5.1.1.2 Check for flatness.

5.1.1.3 Electrical interconnection of top and bottom by braided tinned copper flexibles.

5.1.1.4 Welder's qualification and weld procedure.

5.1.1.5 Testing of electrodes for quality of base materials and coatings.

5.1.1.6 Inspection of major weld preparation.

5.1.1.7 Crack detection of major strength weld seams by dye penetration test.

5.1.1.8 Measurement of film thickness of:

i) Oil insoluble varnish.

ii) Zinc chromate paint.

iii) Finished coat.

5.1.1.9 Check correct dimensions between wheels, demonstrate turning of wheels through 90 deg C and further dimensional check.

5.1.1.10 Check for physical properties of materials for lifting lugs, jacking pads, etc. All load bearing welds including lifting lug welds shall be subjected to NDT.

5.1.1.11 Leakage test of the conservator.

5.1.1.12 Certification of all test results.

5.1.2 **Core**

5.1.2.1 Sample testing of core materials for checking specific loss, bend properties, nameled tion characteristics and thickness.

5.1.2.2 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.

5.1.2.3 Check on the amount of burrs.

5.1.2.4 Bow check on stampings.

5.1.2.5 Check for the overlapping of stampings. Corners of the sheet are to be part.

5.1.2.6 Visual and dimensional check during assembly stage.

5.1.2.7 Check for inter-laminar insulation between core sectors before and after pressing.

5.1.2.8 Visual and dimensional checks for straightness and roundness of core, thickness of limbs and suitability of clamps.

5.1.2.9 High voltage test (2 kV for one minute) between core and clamps.

5.1.2.10 Certification of all test results.

5.1.3 **Insulation Material**

5.1.3.1. Sample check for physical properties of materials.

5.1.3.2 Check for dielectric strength.

5.1.3.3 Visual and dimensional checks.

5.1.3.4 Check for the reaction of hot oil on insulating materials.

5.1.3.5 Dimension stability test at high temperature for insulating material.

5.1.3.6 Tracking resistance test on insulating material

5.1.3.7 Certification of all test results.

5.1.4 **Winding**

5.1.4.1 Sample check on winding conductor for mechanical properties and electrical conductivity.

5.1.4.2 Visual and dimensional checks on conductor for scratches, dent marks etc.

5.1.4.3 Sample check on insulating paper for pH value, bursting strength and electric strength.

5.1.4.4 Check for the reaction of hot oil on insulating paper.

5.1.4.5 Check for the bonding of the insulating paper with conductor.

5.1.4.6 Check and ensure that physical condition of all materials taken for windings is satisfactory and free of dust.

5.1.4.7 Check for absence of short circuit between parallel strands.

5.1.4.8 Check for brazed joints wherever applicable.

5.1.4.9 Measurement of voltage ratio to be carried out when core/yoke is completely restacked and all connections are ready.

5.1.4.10 Conductor enamel test for checking of cracks, leakage and pin holes.

5.1.4.11 Conductor flexibility test

5.1.4.12 Heat shrink test for enameled wire.

5.1.4.13 Certification of all test results.

5.1.5 **Checks Before Drying Process**

5.1.5.1 Check condition of insulation on the conductor and between the windings.

5.1.5.2 Check insulation distance between high voltage connections, cables and earth and other live parts.

5.1.5.3 Check insulating distances between low voltage connections and earth and other parts.

5.1.5.4 Insulation of core shall be tested at 2 kV/minute between core to bolts and core to clamp plates.

5.1.5.5 Check for proper cleanliness and absence of dust etc.

5.1.5.6 Certification of all test results.

5.1.6 **Checks During Drying Process**

5.1.6.1 Measurement and recording of temperature, vacuum and drying time during vacuum treatment.

5.1.6.2 Check for completeness of drying by periodic monitoring of IR and Tan delta.

5.1.6.3 Certification of all test results.

5.1.7 **Assembled Transformer**

5.1.7.1 Check completed transformer against approved outline drawings, provision for all fittings, finish level etc.

5.1.7.2 Test to check effective shielding of the tank.

5.1.7.3 Jacking test with oil on all the assembled transformers.

5.1.7.4 Dye penetration test shall be carried out after the jacking test.

5.1.8 **Bought Out Items**

5.1.8.1 The makes of all major bought out items shall be subject to Employer's approval.

5.1.8.2 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 Employer 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) Cooler cabinet.

h) ON Load / Off Load Tap change gear.

i) Oil pumps.

j) Terminal connectors.

k) Pressure relief device relay

l) Cables used for interconnecting Turret CT, equipment relays (exposed), with marshalling box.

The above list is not exhaustive and the Contractor shall also include other bought out items in his programme.

5.1.9 **Pre-Shipment Checks at Manufacturer's Works**

5.1.9.1 Check for interchangeability of components of similar transformers for mounting dimensions.

5.1.9.2 Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

5.1.9.3 Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

5.1.9.4 Gas tightness test to confirm tightness and record of dew point of gas inside the tank.

5.1.9.5 Derivation of leakage rate and ensure the adequate reserve gas capacity.

5.1.9.6 Measure and record the dew point of dry air /Nitrogen at the time of filling and after 24 hours in the transformer tank. Dew point of dry air / nitrogen at the time of transformer dispatch should be better than (-) 30 deg C. Also, the dew point of dry air / nitrogen cylinders attached for make up during transportation should of the order of (-) 50 deg C.

5.1.9.7 Functioning of impact recorder(s) at their works before installing on the tank.

5.2 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. Procedure for some of tests is given at annexure-I.

The contractor shall submit an Inspection and test plan (ITP) for approval. A typical test plan is indicated below.

No.	Item	Test Category
1.	Measurement of winding resistance	Routine
2.	Voltage ratio measurement	Routine
3.	Polarity & Vector group test	Routine
4.	No-load loss and current measurement	Routine
5.	Impedance voltage and load loss measurement	Routine
6.	Measurement of insulation resistance & Polarization Index	Routine
7.	Measurement of insulation power factor and capacitance between winding and earth	Routine
8.	Measurement of insulation power factor and capacitance of bushings	Routine
9.	Lightning impulse test	Routine
10a	Short duration induced AC withstand Test (ACSD) with PD measurement	Routine
11.	Separate source voltage withstand test	Routine
12.	On-load tap changer test (Ten complete cycle before LV test)	Routine
13.	Gas-in-oil analysis	Routine
14.	Core assembly dielectric and earthing continuity test	Routine
15.	Oil leakage test on transformer tank	Routine
16.	Appearance, construction and dimension check	Routine
17.	Magnetic balance test	Routine
18.	Measurement of no load current & Short circuit impedance with 400 V, 50 Hz AC.	Routine
19.	High voltage with stand test on auxiliary equipment and wiring after assembly	Routine
20.	Tank vacuum test	Routine
21.	Tank pressure test	Routine
22.	Frequency response analysis (Soft copy of test report in sfra format to be submitted to site along with O & M manual)	Routine
23.	Temperature rise test	*Type
24.	Measurement of harmonic level in no load current	*Type
25.	Measurement of acoustic noise level	*Type
26.	Measurement of Zero seq. reactance	*Type
27.	Measurement of power taken by fans and oil pumps	*Type

All tests shall be done in line with IEC: 60076 and as per “Annexure-A”. 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.

5.2.1 Measurement of capacitance and tan delta to determine capacitance between winding and earth. Tan delta value shall not be more than 0.5% at ambient temperature.

5.2.2 Measurement of capacitance and tan delta of RIP bushings. Tan delta value shall not be more than 0.4% at ambient temperature.

5.2.3 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 clause no. 9.0 of the Section-2 – GTR. The list of fittings and the type test requirement is:

1. Bushing (Type Test as per IEC: 60137, including snap back/seismic test)

2. Buchholz relay (Type Test as per IEC and IP-55 Test on terminal box)

3. OLTC (Temperature Rise of contact, Short circuit current test, Mechanical test and Dielectric Test as per IEC: 60214 and IP-55 test on driving mechanism box).

4. Cooling fan and motor assembly – Free air delivery, Temperature rise, sound level, running at reduced voltage, IP-55 degree of protection for terminal box.

5. Air Cell (Flexible air separator) – Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per BS: 903.

6. Cooler Control cabinet (IP-55 test)

7. 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 as per IP-55.

8. Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.

9. OTI & WTI – Switch setting & operation, switch differential, switch rating.

5.2.4 **Pre-Shipment Checks at Manufacturer's Works**

5.2.5 Check for interchangeability of components of similar transformers for mounting dimensions.

5.2.6 Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

5.2.7 Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

5.2.8 Gas tightness test to confirm tightness and record of dew point of gas inside the tank.

5.2.9 Derivation of leakage rate and ensure the adequate reserve gas capacity.

5.2.10 Measure and record the dew point of dry air /Nitrogen at the time of filling and after 24 hours in the transformer tank. Dew point of dry air / nitrogen at the time of transformer dispatch should be better than (-) 30 deg C. Also, the dew point of dry air / nitrogen cylinders attached for make up during transportation should of the order of (-) 50 deg C.

5.3 **Inspection and Testing at Site**

The Contractor/Manufacturer shall carry out a detailed inspection and testing programme for field activities covering areas right from the receipt of material stage upto commissioning stage. An indicative programme of inspection as envisaged by the Employer is given below. Pre-commissioning Procedures and Formats for equipments shall be contractor's responsibility to draw up and carry out such a programme.

5.3.1 **Receipt and Storage Checks**

5.3.1.1 Check and record condition of each package, visible parts of the transformer etc. for any damage.

5.3.1.2 Check and record the gas pressure in the transformer tank as well as in the gas cylinder. Measure and record the dew point of dry air /nitrogen in the transformer tank.

5.3.1.3 Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.

5.3.2 **Installation Checks**

5.3.2.1 Inspection and performance testing of accessories like tap changers etc.

5.3.2.2 (i) Check the direction of rotation of fans.

(ii) Check the bearing lubrication.

5.3.2.3 Check whole assembly for tightness, general appearance etc.

5.3.2.4 Oil leakage test

5.3.2.5 Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.

5.3.2.6 Leakage test on bushing before erection.

5.3.2.7 Measure and record the dew point of nitrogen/dry air in the main tank before assembly. Manufacturer shall submit dew point acceptable limits along with temperature correction factor and shall form part of instruction manual. In case dew point values are not within permissible limit suitable drying out process shall be applied for dry out of active part in consultation with the Manufacturer.

5.3.2.8 **Oil filling.**

5.3.2.8.1 Oil impregnation or drying under vacuum at site shall be done with the transformer and oil at a temperature not exceeding 70 deg C.

5.3.2.8.2 The duration of the vacuum treatment shall be demonstrated as adequate by means of water 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.

5.3.2.8.3 Vacuum shall not be broken until the transformer is oil filled up to the Buchholz relay. Whenever the active insulation or any paper insulated HV connections, especially those from the windings to the bushings are exposed, these shall be re-impregnated under vacuum along with the complete transformer. For this purpose, the transformer shall first be drained to expose all insulation material.

5.3.2.8.4 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.

5.3.2.8.5 Procedures for site drying, oil purification, oil filling etc shall be submitted for approval and complete instructions shall form part of the manual.

5.3.3 **Commissioning Checks**

5.3.3.1 Check the colour of silica gel in silica gel breather.

5.3.3.2 Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.

5.3.3.3 Check the bushing for conformity of connection to the lines etc,

5.3.3.4 Check for correct operation of all protection devices and alarms:

(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.

5.3.3.5 Check for the adequate protection on the electric circuit supplying the accessories.

5.3.3.6 Check resistance of all windings on all steps of the tap changer. Insulation resistance measurement for the following:

(i) Control wiring.

(ii) Main windings.

5.3.3.7 Check for cleanliness of the transformer and the surroundings.

5.3.3.8 Continuously observe the transformer operation at no load for 24 hours.

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.

5.3.3.9 Phase out and vector group test.

5.3.3.10 Ratio test on all taps.

5.3.3.11 Magnetizing current test.

5.3.3.12 Capacitance and Tan delta measurement of winding and bushing.

5.3.3.13 DGA of oil just before commissioning and after 24 hours energization at site.

5.3.3.14 Frequency response analysis (FRA) at site by the equipment to be provided by the bidder.

5.3.3.15 Contractor shall prepare a comprehensive commissioning report including all commissioning test results and forward to Employer for future record.

6.0 Technical Parameters

6.1 Technical Particulars / Parameters of Transformers (220/132/11) kV 3-Phase Auto Transformer)

Cl. No.	Description	Unit	TECHNICAL PARAMETERS		
1.1	Rated Capacity				
	HV	MVA	315	189	
	IV	MVA	315	189	
	LV (Tertiary: Active Loading)	MVA	6	8	
1.2	Voltage ratio (HV/IV/LV) (Line to line)	kV	(220/√3) / (132/√3) / 11		
1.3	Single / Three Phase Design		Three		
1.4	Applicable Standard		IEC 60076		
1.5	Frequency	Hz	50		
1.6	Cooling		ONAN/ONAF/(OFAF or ODAF) OR ONAN/ONAF1/ONAF2		

1.7	Rating at different cooling	%	60% / 80%/100%
1.8	Type of Transformer		Constant Ohmic impedance type (Refer Note1)
1.9	HV – IV Impedance at 75 Deg. C		
i)	Max. Voltage tap	%	9.6
ii)	Principal tap	%	11.7
iii)	Min. Voltage tap	%	13.3
iv)	Tolerance on Impedance	%	As per IEC
1.10	Service		OUTDOOR
1.11	Duty		CONTINUOUS
1.12	Overload Capacity		IEC 60076-7
1.13	Temperature rise over 50deg C Ambient Temp		
i)	Top oil measured by thermometer	^{o}C	50
ii)	Average winding measured by resistance method	^{o}C	55
1.14	Windings		
i)	System Fault level		
	HV	kA	40
	IV	kA	31.5
	LV	kA	25
	Neutral	kA	-
ii)	Lightning Impulse withstand Voltage		
	HV	kV_p	950
	IV	kV_p	550
	LV	kV_p	250 (or 170*)
	Neutral	kV_p	95
iii)	Switching Impulse withstand Voltage		
	HV	kV_p	750
iv)	One Minute Power Frequency withstand Voltage		
	HV	kV_{rms}	395
	IV	kV_{rms}	230
	LV	kV_{rms}	95(or 70*)
	Neutral	kV_{rms}	38
v)	Neutral Grounding		Solidly grounded
vi)	Insulation		
	HV		GRADED
	IV		GRADED
	LV		UNIFORM
vii)	Tertiary Connection (3 Phase Bank)		Ungrounded Delta
viii)	Tan delta of winding	%	<0.5%
1.15 ix)	Vector Group (3 – phase) (unless specified differently elsewhere)		YNa0Od11
1.16	Tap Changer		OLTC
i)	Tap Range & No. of steps		–5% to +10% of HV variation in the step of 1.25%, 12 Steps
ii)	Location of Tap		On the 132 kV side of the series winding

	changer		
iii)	Design		Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I
iv)	Tap control		Full capacity - on load tap changer suitable for group / independent, remote /local electrical and local manual operation and bi-directional power flow
1.17	Bushings		
i)	Rated voltage		
	HV	kV	245
	IV	kV	145
	LV	kV	52
	Neutral	kV	12
ii)	Rated current (Min.)		
	HV	A	800
	IV	A	1250
	LV	A	800
	Neutral	A	1000
iii)	Lightning Impulse withstand Voltage		
	HV	kVp	1050
	IV	kVp	650
	LV	kVp	250(or 170*)
	Neutral	kVp	170
iv)	Switching Impulse withstand Voltage		
	HV	kVp	850
v)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	505
	IV	kVrms	305
	LV	kVrms	105 (or77*)
	Neutral	kVrms	77
vi)	Minimum total creepage distances		
	HV	mm	6125
	IV	mm	3625
	LV	mm	1300 (or 900*)
	Neutral	mm	900
vii)	Tan delta of bushing		
	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
1.18	Max Partial discharge level at 1.5Um/√3	pC	100
1.19	Max Noise level at rated voltage and at principal tap on full load and all cooling active	dB	75

*** 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)".**

5. * mark rating is applicable in case tertiary rating is specified as 11kV in BPS.

6.2 Technical Particulars / Parameters of Transformers (220/132/33 kV 1-Phase Auto Transformer) (NOT APPLICABLE)

Cl. No.	Description	Unit	TECHNICAL PARAMETERS		
1.20	Rated Capacity				
	HV	MVA	10	33.33	53.33
	IV	MVA	10	33.33	53.33
	LV (Tertiary: Active Loading)	MVA	1	2	5
1.21	Voltage ratio (HV/IV/LV) (Line to line)	kV	(220/√3) / (132/√3) / 33		
1.22	Single / Three Phase Design		SINGLE		
1.23	Applicable Standard		IEC 60076		
1.24	Frequency	Hz	50		
1.25	Cooling		ONAN/ONAF		ONAN/ONAF/(OFAF or ODAF) : 60% / 80%/100% OR ONAN/ONAF1/ONAF2
1.26	Rating at different cooling	%	60 / 100		60% / 80%/100%
1.27	Type of Transformer		Constant Ohmic impedance type (Refer Note1)		
1.28	HV – IV Impedance at 75 Deg C				
i)	Max. Voltage tap	%	8.30	10.3	10.3
ii)	Principal tap	%	10.00	12.5	12.5
iii)	Min. Voltage tap	%	12.30	15.4	15.4
iv)	Tolerance on Impedance	%	As per IEC		
1.29	Service		OUTDOOR		
1.30	Duty		CONTINUOUS		
1.31	Overload Capacity		IEC 60076-7		
1.32	Temperature rise over 50deg C Ambient Temp				
i)	Top oil measured by thermometer	^{o}C	50		
ii)	Average winding measured by	^{o}C	55		

	resistance method				
1.33	Windings				
i)	System Fault level				
	HV	kA	40		
	IV	kA	31.5		
	LV	kA	25		
	Neutral	kA	-		
ii)	Lightning Impulse withstand Voltage				
	HV	kV_p	950		
	IV	kV_p	550		
	LV	kV_p	250		
	Neutral	kV_p	95		
iii)	Switching Impulse withstand Voltage				
	HV	kV_p	750		
iv)	One Minute Power Frequency withstand Voltage				
	HV	kV_{rms}	395		
	IV	kV_{rms}	230		
	LV	kV_{rms}	95		
	Neutral	kV_{rms}	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%		
1.34 ix)	Vector Group (3 –ph) (unless specified differently elsewhere)		YNa0Od11		
1.35	Tap Changer		OLTC		
i)	Tap Range & No. of steps		–5% to +15% of HV variation in the step of 1.25%, 16 steps		
ii)	Location of Tap changer		On the 132 kV side of the series winding		
iii)	Design		Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I		
iv)	Tap control		Full capacity - on load tap changer suitable for group / independent, remote /local electrical and local manual operation and bi-directional power flow		
1.36	Bushings				
i)	Rated voltage				
	HV	kV	245		
	IV	kV	145		
	LV	kV	52		
	Neutral	kV	36		
ii)	Rated current (Min.)				
	HV	A	800	800	800
	IV	A	800	800	1250

	LV	A	800	800	800
	Neutral	A	1000	1000	1000
iii)	Lightning Impulse withstand Voltage				
	HV	kVp	1050		
	IV	kVp	650		
	LV	kVp	250		
	Neutral	kVp	170		
iv)	Switching Impulse withstand Voltage				
	HV	kVp	850		
v)	One Minute Power Frequency withstand Voltage				
	HV	kVrms	505		
	IV	kVrms	305		
	LV	kVrms	105		
	Neutral	kVrms	77		
vi)	Minimum total creepage distances				
	HV	mm	6125		
	IV	mm	3625		
	LV	mm	1300		
	Neutral	mm	900		
vii)	Tan delta of bushing				
	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		
1.37	Max Partial discharge level at 1.5Um/√3	pC	100		
1.38	Max Noise level at rated voltage and at principal tap on full load and all cooling active	dB	75		

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)".**

6.3 Technical Particulars / Parameters of Transformers (132/33kV, 3-Phase Power Transformer)

Cl. No.	Description	Unit	TECHNICAL PARAMETERS					
1.39	Rated Capacity		Kushma Substation			New Butwal Substation		
	HV	MVA	30	27	24	63	51.5	40
	LV	MVA	30	27	24	63	51.5	40
1.40	Voltage ratio (HV/LV) Line to line	kV	132/33					
1.41	Single / Three Phase Design		3 (THREE)					
1.42	Applicable Standard		IEC 60076					
1.43	Frequency	Hz	50					
1.44	Cooling		ONAN/ONAF1/ONAF2					
1.45	Rating at different cooling	%	60 / 100					
1.46	Type of Transformer		Constant Ohmic impedance type (Refer note 1)					
1.47	HV-LV Impedance at 75 Deg C							
i)	Max. Voltage tap	%	10.3					
ii)	Principal tap	%	12.5					
iii)	Min. Voltage tap	%	15.4					
iv)	Tolerance on Impedance	%	As per IEC					
1.48	Service		OUTDOOR					
1.49	Duty		CONTINUOUS					
1.50	Overload Capacity		IEC 60076-7					
1.51	Temperature rise over 50deg C Ambient Temp							
i)	Top oil measured by thermometer	^{o}C	50					
ii)	Average winding measured by resistance method	^{o}C	55					
1.52	Windings							
i)	System Fault level							
	HV	kA	31.5					
	LV	kA	25					
	Neutral	kA	-					
ii)	Lightning Impulse withstand Voltage							
	HV	kV_p	550					
	LV	kV_p	170					
	Neutral	kV_p	95					
iii)	Switching Impulse withstand Voltage							
	HV	kV_p	460					

iv)	One Minute Power Frequency withstand Voltage		
	HV	kV_{rms}	230
	LV	kV_{rms}	70
	Neutral	kV_{rms}	38
v)	Neutral Grounding		Solidly grounded
vi)	Insulation		
	HV		GRADED
	LV		UNIFORM
vii)	Tan delta of winding	%	<0.5%
1.53	Vector Group (3 –ph.) (unless specified differently elsewhere)		YNynO
1.54	Tap Changer		OLTC
i)	Tap Range & No. of steps		–10% to +10% of HV variation in the step of 1.25%, 17 steps
ii)	Location of Tap changer		On Neutral side of 132 kV winding
iii)	Design		Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I
iv)	Tap control		Full capacity on load tap changer suitable for group/independent, remote /local electrical and local manual operation and bi-directional power flow.
1.55	Bushings		
i)	Rated voltage		
	HV	kV	145
	LV	kV	36
	Neutral	kV	36
ii)	Rated current (Min.)		
	HV	A	800
	LV	A	1250
	Neutral	A	1250
iii)	Lightning Impulse withstand Voltage		
	HV	kVp	650
	LV	kVp	170
	Neutral	kVp	170
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	305
	LV	kVrms	77
	Neutral	kVrms	77
v)	Minimum total creepage distances		
	HV	mm	3625
	LV	mm	900
	Neutral	mm	900

vi)	Tan delta of bushing		
	HV	%	<0.4
vii)	Max Partial discharge level at U_m		
	HV	pC	10
1.56	Max Partial discharge level at 1.5Um/√3	pC	100
1.57	Max Noise level at rated voltage and at principal tap on full load and all cooling active	dB	75

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)".**

6.4 Technical Particulars / Parameters of Transformers (33/11 kV, 3-Phase Power Transformer)

Cl. No.	Description	Unit	TECHNICAL PARAMETERS	
1.	Rated Capacity			
	HV	MVA	24	20
	LV	MVA	24	20
1.2	Voltage ratio (HV/LV) Line to line	kV	33/11	
1.3	Single / Three Phase Design		3 (THREE)	
1.4	Applicable Standard		IEC 60076	
1.5	Frequency	Hz	50	
1.6	Cooling		ONAN/ONAF	
1.7	Rating at different cooling	%	60 / 100	
1.8	Type of Transformer		Constant Ohmic impedance type (Refer note 1)	
1.9	HV-LV Impedance at 75 Deg C			
i)	Max. Voltage tap	%		
ii)	Principal tap	%	>11	
iii)	Min. Voltage tap	%		
iv)	Tolerance on Impedance	%	As per IEC	
1.10	Service		OUTDOOR	
1.11	Duty		CONTINUOUS	

1.12	Overload Capacity		IEC 60076-1
1.13	Temperature rise over 50deg C Ambient Temp		
i)	Top oil measured by thermometer	^{O}C	50
ii)	Average winding measured by resistance method	^{O}C	55
1.14	Windings		
i)	System Fault level		
	HV	kA	25
	LV	kA	25
	Neutral	kA	-
ii)	Lightning Impulse withstand Voltage		
	HV	kV_p	170
	LV	kV_p	95
	Neutral	kV_p	-
iii)	Switching Impulse withstand Voltage		
	HV	kV_p	-
iv)	One Minute Power Frequency withstand Voltage		
	HV	kV_{rms}	70
	LV	kV_{rms}	28
	Neutral	kV_{rms}	-
v)	Neutral Grounding		Solidly grounded
vi)	Insulation		
	HV		UNIFORM
	LV		UNIFORM
vii)	Tan delta of winding	%	<0.5%
1.15	Vector Group (3 –ph.) (unless specified differently elsewhere)		Dyn11
1.16	Tap Changer		OLTC
i)	Tap Range & No. of steps		–10% to +10% of HV variation in the step of 1.25%, 17 steps
ii)	Location of Tap changer		On Neutral side of 33 kV winding
iii)	Design		Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I
iv)	Tap control		Full capacity on load tap changer suitable for group/independent, remote /local electrical and local manual operation and bi-directional power flow.
1.17	Bushings		
i)	Rated voltage		
	HV	kV	36
	LV	kV	12
	Neutral	kV	
ii)	Rated current (Min.)		
	HV	A	100

	LV	A	1200
	Neutral	A	-
iii)	Lightning Impulse withstand Voltage		
	HV	kVp	170
	LV	kVp	95
	Neutral	kVp	-
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	75
	LV	kVrms	28
	Neutral	kVrms	-
v)	Minimum total creepage distances		
	HV	mm	900
	LV	mm	300
	Neutral	mm	-
vi)	Tan delta of bushing		
	HV	%	<0.4
vii)	Max Partial discharge level at U_m		
	HV	pC	10
1.18	Max Partial discharge level at 1.5Um/√3	pC	100
1.19	Max Noise level at rated voltage and at principal tap on full load and all cooling active	dB	75

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)".**

7.0 Bushing Current Transformer

7.1 Current transformers shall comply with IEC-60185.

7.2 It shall be possible to remove the turret mounted current transformers from the tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.

7.3 Current transformer secondary leads shall be brought out to a weather proof terminal box near each bushing. These terminals shall be wired out to cooler control cabinet/ marshalling box using separate cables for each core.

7.4 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.

7.5 Technical Parameters for Bushing CT

7.5.1 Technical Parameters of Current Transformers (for 160MVA, 100MVA & 50MVA 220/132kV 3-Ph Transformers and 53.33, 33.33 & 10 MVA 220/132kV 1-ph Transformer) (NOT APPLICABLE)

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	600V, TPS	600V, TPS	600V, TPS
CORE 2	0.5 Class 15VA ISF ≤ 5	0.5 Class 15VA ISF ≤ 5	-
(c)	Maximum CT Secondary Resistance		
CORE 1	1.5 Ohm	1.5 Ohm	1.5 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	100 mA	100 mA	100 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.

7.5.2 Technical Parameters of Current Transformers (for 63 MVA, 51.5MVA, 40 MVA, 132/33kV 3-Ph Transformers)

Description	Current Transformer Parameters (Transformer)

	HV Side	HV Neutral Side	LV Side	LV Neutral Side
(a) Ratio				
CORE 1	200/1	200/1	600/1	600/1
CORE 2	200/1	-	600/1	-
(b) Minimum knee point voltage or burden and accuracy class				
CORE 1	400V, TPS	400V, TPS	600V, TPS	600V, TPS
CORE 2	0.2 Class 15VA ISF ≤ 5	-	0.2 Class 15VA ISF ≤ 5	-
(c) Maximum CT Secondary Resistance				
CORE 1	1.5 Ohm	1.5 Ohm	1.5 Ohm	1.5 Ohm
CORE 2		-	-	-
(d) Application				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Metering	Restricted Earth Fault
CORE 2	Metering			-
(e) Maximum magnetization current (at knee point voltage)				
CORE 1	100mA	100 mA	100 mA	100 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.

8.0 Oil Storage Tank

8.1 General

This specification is for oil storage tank. Oil Storage tank shall be supplied if specified in Bid Price schedule.

8.2 Standard

The oil storage tank shall be designed and fabricated as per relevant standards.

8.3 Specifications

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. Size of the storage tank shall be as follows:

Diameter	:	1.5 meter (For 10 cubic meter capacity) 2.0 meter (For 20 cubic meter capacity)
Minimum Capacity	:	As mentioned in BPS

The tank shall be designed for storage of oil at a temperature of 100°C.

8.3.1 The Bidder may further note that maximum height of any part of the complete assembly of the storage tank shall not exceed 4.0 meters above road top.

8.3.2 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.

8.3.3 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. Bidder shall indicate the engine capacity in horse power to pull one tank completely fitted with oil. 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. Suitable arrangement shall also be provided to prevent overflow in the tank. Solenoid valve (Electro-mechanically operated) with centrifugal pump shall be provided at bottom inlet so that pump shall be utilized both ways during oil fill up and draining. Suitable arrangement shall also be provided to prevent overflow and drain from the tank/

8.3.4 The following accessories shall form part of supply along with each Oil storage tank.

i) Four numbers of suitable nominal bore rubber hoses for transformer oil application upto 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 suitable nominal bore vacuum hoses, suitable for full vacuum without collapsing and kinking, 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 230V 50Hz AC supply shall be supplied. Couplers and unions for sensor should block oil flow in the sensor. Sensor shall be provided with atleast 8 meter cable so as to suitably place the Vacuum gauge at ground level.

8.3.5 The painting of oil storage tank and its control panel shall be as per clause no 3.1.1.8.

8.3.6 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 3.0 (For 10 cubic meter capacity)/ 6.0 kl/hr. (For 20 cubic meter capacity) with a discharge head of 8.0m. The pump motor and the control cabinet shall be enclosed in a cubical with IP-55 enclosure.

9.0 OIL SAMPLING BOTTLE

9.1 Oil sampling bottles shall be suitable for collecting oil samples from transformers 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.

9.2 Oil sampling bottles shall be made of stainless steel having a capacity of one litre.

9.3 Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

9.4 The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.

9.5 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.

Annexure -A

All tests shall be carried out as per IEC: 60076 on transformer.

1) Magnetic Circuit Test

After assembly each core shall be tested for 1 minute at 2000 Volts between all bolts, side plates and structural steel work.

2) Tank Tests

(i) Oil Leakage Test

All tanks and oil filled compartments shall be tested for oil tightness by being 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 applying a pressure equal to the normal pressure plus 35 KN/Sq.m (5 psi) measured at the base of the tank. The pressure shall be maintained for a period of not less than 12 hours for oil and one hour for air during which time no leak shall occur.

(ii) Vacuum Test

All transformer tank of each size 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)**
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

(iii) Pressure Test

All transformer tank of each size, its radiator, conservator vessel and other fittings together or separately shall be subjected to an air pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 KN/m2 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.

3) **Measurement of capacitance and tan delta** to determine capacitance between winding and earth. Tan delta value shall not be more than 0.5% corrected at 20deg C. Temperature correction factor table shall be given by the Contractor and shall form the part of test results.

4) Temp. Rise Test (as per IEC 60076)

Gas chromatographic analysis on oil shall also be conducted before and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC 60567. For the evaluation of the gas analysis in temperature rise test the procedure shall be as IEC: 60567 and results will be interpreted as per IEC -61181. The DGA results shall generally conform to IEC/IEEE guidelines.

The temperature rise test shall be conducted at a tap for the worst combination of loading on the three windings of the transformer. The Contractor before carrying out such test shall

submit detailed calculations showing alternatives possible, on various taps of the transformer and shall recommend the combination that results in highest temperature rise for the test.

6) 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. The list of fittings and the type test requirement is:

a. Bushing (Type Test as per IEC: 60137)
b. Buchholz relay (Type Test and IP-55 Test on terminal box)
c. Marshalling box (IP-55 test)
d. 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. 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 as per IP-55.

e. Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.
f. Air Cell (Flexible air separator) –Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per BS: 903.
g. OTI & WTI – Switch setting & operation, switch differential, switch rating.

7) Inspection and Testing at Site

The Contractor/Manufacturer shall supervise testing & commissioning at site. Testing & commissioning shall be carried out by the owner (MOEP-2). Contractor shall submit a detailed procedure for Testing & Commissioning at site including receipt, storage & installation checks as mentioned below.

a) Receipt and Storage Checks

- Check and record condition of each package, visible parts of the transformer etc. for any damage.
- Check and record the gas pressure in the transformer tank as well as in the gas cylinder.
- Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.
- Check and record reading of impact recorder at receipt and verify the allowable limits as per manufacturer's recommendations.

b) Installation Checks

- Check whole assembly for tightness, general appearance etc.
- Oil leakage test
- Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.
- Leakage check on bushing before erection.
- Measure and record the dew point of nitrogen/dry air in the main tank before assembly. Manufacturer shall submit dew point acceptable limits along with temperature correction factor and shall form part of instruction manual. In case dew point values are not within permissible limit suitable drying out process shall be applied for dry out of active part in consultation with the Manufacturer.

c) Oil filling

Oil impregnation or drying under vacuum at site shall be done with the transformer and oil at a temperature not exceeding 70°C.

The duration of the vacuum treatment shall be demonstrated as adequate by means of water measurement with a cold trap or other suitable method but shall generally not be less than 72 hours. The vacuum shall be measured on the top of the transformer tank and should be less than 1mbar.

Vacuum shall not be broken until the transformer is oil filled up to the Buchholz relay. Whenever the active insulation or any paper insulated HV connections, especially those from the windings to the bushings are exposed, these shall be re-impregnated under vacuum along with the complete transformer. For this purpose, the transformer shall first be drained to expose all insulation material.

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.

Procedures for site drying, oil purification, oil filling etc shall be submitted for approval and complete instructions shall form part of the manual.

d) Commissioning Checks

- Check the colour of silica gel in silica gel breather.
- Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.
- Check the bushing for conformity of connection to the lines etc,
- Check for correct operation of all protection devices and alarms:
  (i) Buchholz relay.
  (ii) Excessive winding temperature.
  (iii)Excessive oil temperature.
  (iv)Low oil level indication.
- Check for the adequate protection on the electric circuit supplying the accessories.
- Check resistance of all windings on all steps of the tap changer. Insulation resistance measurement for the following:
  (i) Control wiring.
  (ii) Main windings.
- Check for cleanliness of the transformer and the surroundings.
- Continuously observe the transformer operation at no load for 24 hours.
- 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.
- Phase out and vector group test.
- Ratio test on all taps.
- Magnetizing current test.
- Capacitance and Tan delta measurement of winding and bushing.
- DGA of oil just before commissioning and after 24 hours energization at site.

SECTION 04– CIRCUIT BREAKERS

CONTENTS

1.0 GENERAL

1.1 The circuit breakers and accessories shall conform to IEC: 62271-100, IEC: 62271-01 and other relevant IEC standards except to the extent explicitly modified in the specification and shall also be in accordance with requirements specified in Chapter 2-GTR.

1.2 245/145 kV live tank type circuit breakers offered would be of sulphur hexafluoride (SF6) type only and of class C2-M2 as per IEC

1.3 The circuit breaker shall be complete with terminal connectors, operating mechanism, control cabinets, piping, interpole cable, cable accessories like glands, terminal blocks, marking ferrules, lugs, pressure gauges, density monitors (with graduated scale), galvanised support structure for CB and control cabinets, their foundation bolts and all other circuit breaker accessories required for carrying out all the functions the CB is required to perform.

All necessary parts to provide a complete and operable circuit breaker installation such as main equipment, terminals, control parts, connectors and other devices whether specifically called for herein or not shall be provided.

1.4 Painting shall be done in line with Chapter 2 –GTR. REL-5032 or similar shades can be used for painting. The support structure of circuit breaker shall be hot dip galvanised. Exposed hardware items shall be hot dip galvanised or Electro-galvanised.

1.5 The circuit breakers shall be designed for use in the geographic and meteorological conditions as given in Chapter 2--GTR.

2.0 DUTY REQUIREMENTS:

2.1 The circuit breakers shall be capable of performing their duties without opening resistors.

2.2 The circuit breaker shall meet the duty requirements for any type of fault or fault location also for line switching when used on a 245/145 kV effectively grounded system and perform make and break operations as per the stipulated duty cycles satisfactorily.

2.3 The breaker shall be capable of interrupting the steady state and transient magnetizing current corresponding of power transformers.

2.4 The circuit breaker shall also be capable of:

i) Interrupting line/cable charging current as per IEC without use of opening resistors.

ii) Clearing short line fault (Kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.

iii) Breaking 25% of the rated fault current at twice rated voltage under phase opposition condition.

2.5 The Breaker shall satisfactorily withstand the high stresses imposed on them during fault clearing, load rejection and re-energization of lines with trapped charges. The breaker shall also withstand the voltage specified under Clause 15 of this Chapter.

3.0 TOTAL BREAK TIME:

3.1 The total break time as specified under this Chapter shall not be exceeded under any of the following duties:

i) Test duties T10, T30, T60, T100a, T100s (TRV as per IEC: 62271-100)

ii) Short line fault L75, L90 (- do -)

3.2 The Bidder may please note that total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage, (70-110%) and arc extinguishing medium pressure etc. While furnishing the proof of the total break time of complete circuit breaker, the Bidders may specifically bring out the effect of non-simultaneity between contacts between poles and show how it is covered in the guaranteed total break time.

3.3 The values guaranteed shall be supported with the type test reports.

4.0 CONSTRUCTIONAL FEATURES:

The features and constructional details of circuit breakers shall be in accordance with requirements stated hereunder:

4.1 **Contacts**

4.1.1 The gap between the open contacts shall be such that it can withstand at least the rated phase to ground voltage for 8 hours at zero gauge pressure of SF6 gas due to the leakage. The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. 2 p.u. across the breaker continuously, for validation of which a power frequency dielectric with stand test conducted for a duration of at least 15 minutes is acceptable).

4.2 **The SF6 Circuit Breaker shall meet the following additional requirements:**

a) The circuit breaker shall be single pressure type. The design and construction of the circuit breaker shall be such that there is a minimum possibility of gas leakage and entry of moisture. There should not be any condensation of SF6 gas on the internal insulating surfaces of the circuit breaker.

b) All gasketted surfaces shall be smooth, straight and reinforced, if necessary, to minimize distortion and to make a tight seal, the operating rod connecting the operating mechanism to the arc chamber (SF6 media) shall have adequate seals. The SF6 gas leakage should not exceed 0.5% per year and the leakage rate shall be guaranteed for at least 10 years. In case the leakage under the specified conditions is found to be greater than 0.5% after one year of commissioning of circuit breaker, the manufacturer will have to supply free of cost, the total gas requirement for subsequent ten (10) years, based on actual leakage observed during first year of operation after commissioning.

c) In the interrupter assembly there shall be an absorbing product box to minimize the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be fully compatible with SF6 gas decomposition products.

d) Each pole shall form an enclosure filled with SF6 gas independent of two other poles (for 245 kV CBs) and the SF6 density of each pole shall be monitored. For CBs of voltage class of 145 kV or less, a common SF6 scheme/density monitor shall be acceptable.

e) The dial type SF6 density monitor shall be adequately temperature compensated to model the pressure changes due to variations in ambient temperature within the body of circuit breaker as a whole. The density monitor shall have graduated scale and shall meet the following requirements:

i) It shall be possible to dismantle the density monitor for checking/replacement without draining the SF6 gas by providing suitable interlocked non-return valve coupling.

f) Each Circuit Breaker shall be capable of withstanding a vacuum of minimum 8 millibars without distortion or failure of any part.

g) Sufficient SF6 gas including that will be required for gas analysis during filling shall be provided to fill all the circuit breakers installed. In addition, spare gas shall be supplied in separate unused cylinders as per requirement specified in Chapter 1---PSR.

4.3 Provisions shall be made for attaching an operational analyzer to record contact travel, speed and making measurement of operating timings, pre-insertion timings of closing resisters if used, synchronization of contacts in one pole.

5.0 SULPHUR HEXAFLUORIDE GAS (SF6 GAS):

a) The SF6 gas shall comply with IEC 60376, 60376A and 60376B and shall be suitable in all respects for use in the switchgear under the operating conditions.

b) The high pressure cylinders in which the SF6 gas is shipped and stored at site shall comply with requirements of the relevant standards and regulations.

c) Test: SF6 gas shall be tested for purity, dew point, air, hydrolysable fluorides and water content as per IEC 60376, 60376A and 60376B and test certificates shall be furnished to Employer indicating all the tests as per IEC 60376 for each lot of SF6 gas in stipulated copies as indicated in Chapter-GTR. Gas bottles should be tested for leakage during receipt at site.

6.0 INSULATORS:

a) The porcelain of the insulators shall conform to the requirements stipulated under Chapter 2-GTR.

b) The mechanical characteristics of insulators shall match with the requirements specified under this Chapter.

c) All hollow insulators shall conform to IEC-62155.

d) Hollow Porcelain for pressurized columns/chambers should be in one integral piece in green and fired stage.

7.0 SPARE PARTS AND MANDATORY MAINTENANCE EQUIPMENT:

The bidder shall include in his proposal spare parts and maintenance equipment in accordance with Chapter 1-PSR. Calibration certificates of each maintenance equipment shall be supplied along with the equipment.

8.0 OPERATING MECHANISM AND CONTROL

8.1 General Requirements

8.1.1 Circuit breaker shall be operated by spring charged mechanism or hydraulic mechanism or a combination of these. The mechanism shall be housed in a weather proof and dust proof control cabinet as stipulated in Chapter 2-GTR.

8.1.2 The operating mechanism shall be strong, rigid, not subject to rebound.

8.1.3 The mechanism shall be anti-pumping and trip free (as per IEC definition) under every method of closing.

8.1.4 The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause trip or closing operation of the power operating devices.

8.1.5 A mechanical indicator shall be provided to show open and close position of the breaker. It shall be located in a position where it will be visible to a man standing on the ground

level with the mechanism housing closed. An operation counter shall also be provided in the central control cabinet.

8.1.6 Working parts of the mechanism shall be corrosion resisting material, bearings which require grease shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or changing adjustment with repeated operation of the breaker.

8.1.7 The bidder shall furnish detailed operation and maintenance manual of the mechanism along with the operation manual for the circuit breaker. The instruction manuals shall contain exploded diagrams with complete storage, handling, and erection, commissioning, troubleshooting, servicing and overhauling instructions.

8.2 **Control:**

8.2.1 The close and trip circuits shall be designed to permit use of momentary contact switches and push buttons.

8.2.2 Each breaker shall be provided with two (2) independent tripping circuits, pressure switches and coils each to be fed from separate DC sources and connected to a different set of protective relays.

8.2.3 The breaker shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. However, provisions shall be made for local electrical control. For this purpose a local/remote selector switch and close and trip control switch/push buttons shall be provided in the Breaker central control cabinet.

8.2.4 The trip coils shall be suitable for trip circuit supervision during both open and close position of breaker. The trip circuit supervision relay would be provided on relay panels.

8.2.5 Closing coil and associated circuits shall operate correctly at all values of voltage between 85% and 110% of the rated voltage. Shunt trip coil and associated circuits shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage. However, even at 50% of rated voltage the breaker shall be able to open. If additional elements are introduced in the trip coil circuit their successful operation and reliability for similar applications on outdoor circuit breakers shall be clearly brought out in the additional information schedules.

8.2.6 Density Monitor contacts and pressure switch contact shall be suitable for direct use as permissive in closing and tripping circuits. The density monitor shall be placed suitably inclined in such a way so that the readings are visible from ground level with or without using binoculars. Separate contacts have to be used for each of tripping and closing circuits. If contacts are not suitably rated and multiplying relays are used then fail safe logic/schemes are to be employed. DC supplies for all auxiliary circuits shall be monitored and provision shall be made for remote annunciations and operation lockout in case of D.C. failures. Density monitors are to be so mounted that the contacts do not change on vibration during operation of circuit Breaker.

8.2.7 The auxiliary switch of the breaker shall be positively driven by the breaker operating rod.

8.3 **Spring operated mechanism:**

a) Spring operated mechanism shall be complete with motor in accordance with Chapter 2 -GTR. Opening spring and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit shall also be provided.

b) As long as power is available to the motor, a continuous sequence of the closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty.

c) After failure of power supply to the motor one close open operation shall be possible with the energy contained in the operating mechanism.

d) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring shall also be provided. The motor rating shall be such that it requires not more than 30 seconds for full charging of the closing spring.

e) Closing action of circuit breaker shall compress the opening spring ready for tripping.

f) When closing springs are discharged after closing a breaker, closing springs shall be automatically charged for the next operation and an indication of this shall be provided in the local and remote control cabinet.

g) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition. Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is already in the closed position.

h) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

9.0 SUPPORT STRUCTURE:

a) The structure design shall be such that during operation of circuit breaker vibrations are reduced to minimum.

10.0 TERMINAL CONNECTOR PAD:

The circuit breaker terminal pads shall be made up of high quality electrolytic copper or aluminum and shall be conforming to Australian standard AS-2935 for rated current. The terminal pad shall have protective covers which shall be removed before interconnections.

11.0 INTERPOLE CABLING:

11.1 All cables to be used by contractor shall be armoured and shall be as per IEC-502 (1100 Volts Grade). All cables within & between circuit breaker poles shall be supplied by the CB manufacturer.

11.2 Only stranded conductor shall be used. Minimum size of the conductor for inter-pole control wiring shall be 1.5 sq.mm. (Copper).

11.3 The cables shall be with oxygen index Min-29 and temp. Index as 250^{O}C as per relevant standards.

12.0 FITTINGS AND ACCESSORIES

12.1 Following is a partial list of some of the major fittings and accessories to be furnished by Contractor in the Central Control cabinet. Number and exact location of these parts shall be indicated in the bid.

i) Cable glands (Double compression type), Lugs, Ferrules etc.

ii) Local/remote changeover switch.

iii) Operation Counter

iv) Control switches to cut off control power supply.

v) Fuses as required.

vi) The number of terminals provided shall be adequate enough to wire out all contacts and control circuits plus 24 terminals spare for future use.

vii) Anti-pumping relay.

viii) Pole discrepancy relay (for electrically ganged CBs).

ix) D.C. Supervision relays.

xi) Rating and diagram plate in accordance with IEC incorporating year of manufacture.

13.0 ADDITIONAL DATA TO BE FURNISHED:

a) Drawing, showing contacts in close, arc initiation, full arcing, arc extinction and open position.

b) The temperature v/s pressure curves for each setting of density monitor along with details of density monitor.

c) Data on capabilities of circuit breakers in terms of time and number of operations at duties ranging from 100% fault currents to load currents of the lowest possible value without requiring any maintenance or checks.

d) The effect of non-simultaneity between contacts between poles and also show how it is covered in the guaranteed total break time.

e) Sectional view of non-return couplings if used for SF6 pipes.

f) Details & type of filters used in interrupter assembly and also the operating experience with such filters.

g) Details of SF6 gas:

i) The test methods used in controlling the quality of gas used in the circuit breakers particularly purity and moisture content.

ii) Proposed tests to assess the conditions of the SF6 within a circuit breaker after a period of service particularly with regard to moisture contents of the gas.

h) All duty requirements as applicable to 245 kV & 145 kV CBs specified under Clause 2.0 of this Chapter shall be provided with the support of adequate test reports.

14.0 TESTS:

14.1 In accordance with the requirements stipulated under Chapter 2 -GTR the circuit breaker along with its operating mechanism shall conform to IEC: 62271-100.

14.2 The test reports of the type tests and the following additional type tests shall also be submitted for Purchaser's review:

i) Out of phase closing test as per IEC: 62271-100.

ii) Line charging breaking current for proving parameters as per clause no. 15.9 of this Chapter.

iii) Test to demonstrate the Power Frequency withstand capability of breaker in open condition at Zero Gauge pressure and at lockout pressure (Ref. Clause 4.1.1).

iv) Seismic withstand test in unpressurised condition.

v) Verification of the degree of protection.

vi) Static Terminal Load test.

vii) Critical Currents test (if applicable).

14.3 **Routine Tests**

Routine tests as per IEC: 62271-100 shall be performed on all circuit breakers.

In addition to the mechanical and electrical tests specified by IEC, the following tests shall also be performed.

1) Speed curves for each breaker shall be obtained with the help of a suitable operation 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 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. where included in scope of supply shall be furnished and utilized. In case of substations where operation analyzer is existing, the bidder shall utilize the same. However necessary adopter and transducers etc. if required shall have to be supplied by the bidder.

2) Measurement of Dynamic Contact resistance measurement for arcing & main contacts. Signature of Dynamic contact resistance measurements shall be taken as reference for comparing the same during operation and maintenance in order to ascertain the healthiness of contacts.

15.0 TECHNICAL PARAMETERS:

(In addition to those indicated in Chapter 2 2-GTR)

I. 245 kV CIRCUIT BREAKER:

A15.1	Rated continuous current (A) at design ambient temperature.	3150 (as applicable)
A15.2	Rated short circuit current breaking capacity at rated voltage	40 kA / 50 kA (as applicable) with percentage DC component as per IEC: 62271-100 corresponding to minimum opening time under operating conditions specified.
A15.3	Symmetrical interrupting capability (kA_{rms})	40 / 50 (as applicable)
A15.4	Rated short circuit making current (kA_p)	100 / 125 (as applicable)
A15.5	Short time current carrying capability for one second (kA_{rms})	40 / 50 (as applicable)
A15.6	Rated operating duty	O-0.3sec-CO-3min-CO cycle
A15.7	Reclosing	Single phase & three phase auto-reclosing

A15.8	First pole to clear factor	1.3
A15.9	Rated line/cable charging interrupting current at 90 deg. leading power factor angle (A. rms)	As per IEC

(The breaker shall be able to interrupt the rated line/cable charging current with test voltage immediately before opening equal to the product of U/□3 & 1.4 as per IEC: 62271-100).

A15.10	Temperature rise over the design ambient temperature	As per IEC: 62271-100
A15.11	i) Total break time as per Cl.3.0 of this Chapter (ms)	65
A15.11	ii) Rated break time as per IEC (ms)	60
A15.12	Total closing time (ms)	Not more than 200
A15.13	Operating mechanism	spring
A15.14	Max. Difference in the instants of closing/ opening of contacts (ms)	
	i) Between poles (opening)	3.3
	ii) Between poles (closing)	5.0

The above shall be at rated control voltage and rated operating and quenching media pressures.

A15.15	Trip coil and closing coil voltage	220 V DC with variation as specified
A15.16	Noise level at base and upto 50 m (distance from base of breaker)	140 dB (Max.)
A15.17	Rated terminal load	As per IEC or as per the value calculated by Chapter 2-GTR, whichever is higher.
A15.18	Auxiliary contacts	besides requirement of specification, the bidder shall wire up 5 NO + 5 NC contacts for future use of purchaser.
A15.19	No of Terminals in common wired out up to common control cabinet for	All Contacts & control circuits to be Control cabinet plus 24 terminals exclusively Purchaser's use.

II. 145 kV CIRCUIT BREAKER:

B15.1	Rated continuous current (A) at design ambient temperature.	1600/2500

B15.2	Rated short circuit current breaking capacity at rated voltage	31.5 kA with percentage DC component as per IEC: 62271-100 corresponding to minimum opening time under operating Conditions specified
B15.3	Symmetrical interrupting capability (kA rms)	31.5
B15.4	Rated short circuit making current (kAp)	80
B15.5	Short time current carrying capability for one second (kA rms)	31.5
B15.6	Out of phase breaking current capacity (kA rms)	As per IEC
B15.6	Rated operating duty	O-0.3sec-CO-3min-CO cycle
B15.7	Reclosing	Single phase (for Line only) & three phase Auto-reclosing
B15.8	First pole to clear factor	1.3
B15.9	Rated line/cable charging interrupting current at 90 deg. leading power factor angle (A. rms)	As per IEC
	(The breaker shall be able to interrupt the rated line/cable charging current with test voltage immediately before opening equal to the product of U/□3 & 1.4 as per IEC: 62271-100).	
B15.10	Temperature rise over the design ambient temperature	As per IEC: 62271-100
B15.11	i) Total break time as per Cl.3.0 of this Chapter (ms)	65
B15.11	ii) Rated break time as per IEC (ms)	60
B15.12	Total closing time (ms)	Not more than 150
B15.13	Operating mechanism	spring
B15.14	Max. difference in the instants of closing/ opening of contacts (ms) between poles at rated control voltage and rated operating and quenching media pressures.	3.3
B15.15	Trip coil and closing coil voltage	220 V DC with variation as specified
B15.16	Noise level at base and upto 50 m (distance from base of breaker)	140 dB (Max.)

B15.17 Rated terminal load — As per IEC or as per the value calculated by Chapter-GTR, whichever is higher.

B15.18 Auxiliary contacts — Besides requirement of specification, the bidder shall wire up 5 NO + 5 NC contacts for future use of Purchaser.

B15.19 No. of Terminals in common control cabinet — All contacts & control circuits to be wired out upto common control cabinet plus 24 terminals exclusively for Purchaser's use.

III 33kV VACUUM CIRCUIT BREAKER (NOT APPLICABLE)

a) Rated operating duty cycle	0-3min-CO-3 min-CO
b) First pole to clear factor	1.3
c) Rated line/cable charging interrupting current at 90 deg. Leading power factor angle (A rms)	As per IEC
(The breaker shall be able to interrupt the rated line/cable charging current with test voltage immediately before opening equal to the product of U/(root)3 & 1.4 as per IEC –62271-100)	
e) Rated break-time as per IEC (ms)	45
f) Total closing time (ms)	Not more than 80
g) Operating mechanism	Pneumatic/Spring/Hydraulic/ or a combination of these
h) Max. difference in the instants of closing/opening of contacts between poles at rated control voltage and rated operating and quenching media pressures (ms).	3.3
i) Trip coil & closing coil voltage	250V DC with variation as specified
j) Noise level at base of CB and up to 50 mtr. distance from base of CB.	140 db (max)
k) Rated terminal load	As per IEC
l) Auxiliary contracts (Auxiliary switch shall also comply with requirements stipulated under chapter 2 GTR)	Besides requirement of specification, the bidder shall wire up to 5 NO + 5 NC contacts for future use of owner.
m) No. of Terminals in Common Control cabinet	All Contacts & control circuits to be wired out upto common control cabinet plus 24 terminals exclusively for owner's use.
n) Rated continuous current at design ambient temperature (amp).	1250/800 (as applicable)
o) Rated short circuit current breaking capacity at total voltage.	25 KA with percentage DC component as per IEC-62271-100 corresponding to minimum opening time & operating conditions specified.
p) Symmetrical interrupting capability (KA_{rms})	25
q) Rated short circuit making current (KAP)	As per IEC
r) Short time current carrying capability for 3 second (KA_{rms})	25
s) Reclosing	Three phase auto reclosing

16.0 PRE-COMMISSIONING TESTS

16.1 An indicative list of tests is given below. All routine tests except power frequency voltage dry withstand test on main circuit breaker shall be repeated on the completely assembled breaker at site. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates and shall furnish the list of instruments to the Employer for approval.

(a) Insulation resistance of each pole.

(b) Check adjustments, if any suggested by manufacturer.

(c) Breaker closing and opening time.

(d) Slow and Power closing operation and opening.

(e) Trip free and anti pumping operation.

(f) Minimum pick-up voltage of coils.

(g) Dynamic Contact resistance measurement.

(h) Functional checking of control circuits interlocks, tripping through protective relays and auto reclose operation.

(i) Insulation resistance of control circuits, motor etc.

(j) Resistance of closing and tripping coils.

(k) SF6 gas leakage check.

(l) Dew Point Measurement

(m) Operation check of pressure switches and gas density monitor during gas filling.

(n) Checking of mechanical 'CLOSE' interlock, wherever applicable.

(o) Resistance measurement of main circuit.

(p) Checking of operating mechanisms

(q) Check for annunciations in control room.

16.2 The contractor shall ensure that erection, testing and commissioning of circuit breaker shall be carried out under the supervision of the circuit breaker manufacturer's representative. The commissioning report shall be signed by the manufacturers' representative.

SECTION-05 – ISOLATORS

CONTENTS

1.0 GENERAL:

1.1 The Isolators and accessories shall conform in general to IEC: 62271-102 except to the extent explicitly modified in specification and shall be in accordance with requirement of Chapter 2-GTR.

1.2 Isolators shall be outdoor, off-load type. Earth switches shall be provided on isolators wherever called for, with possibility of being mounted on any side of the isolator. 220 kV & below rated isolators shall be double break type, unless specified otherwise.

1.3 Complete isolator with all the necessary items for successful operation shall be supplied including but not limited to the following:

1.3.1 Isolator assembled with complete Support Insulators, operating rod insulator, base frame, linkages, operating mechanism, control cabinet, interlocks etc.

1.3.2 All necessary parts to provide a complete and operable isolator installation, control parts and other devices whether specifically called for herein or not.

1.3.3 The isolator shall be designed for use in the geographic and meteorological conditions as given in Chapter 2-GTR.

2.0 DUTY REQUIREMENTS:

a) Isolators and earth switches shall be capable of withstanding the dynamic and thermal effects of the maximum possible short circuit current of the systems in their closed position. They shall be constructed such that they do not open under influence of short circuit current.

b) The earth switches, wherever provided, shall be constructionally interlocked so that the earth switches can be operated only when the isolator is open and vice versa. The constructional interlocks shall be built in construction of isolator and shall be in addition to the electrical interlocks. Suitable mechanical arrangement shall also be provided for delinking electrical drive for manual operation.

c) In addition to the constructional interlock, isolator and earth switches shall have provision to prevent their electrical and manual operation unless the associated and other interlocking conditions are met. All these interlocks shall be of fail-safe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from DC supply and within a variation range as stipulated in Chapter 2-GTR.

d) The earthing switches shall be capable of discharging trapped charges of the associated lines.

e) The isolator shall be capable of making/breaking normal currents when no significant change in voltage occurs across the terminals of each pole of isolator on account of make/break operation.

f) Isolator rated for above 72.5 kV shall be of extended mechanical endurance class - M2 as per IEC-62271-102. Isolator rated for 72.5 kV and below shall be of extended mechanical endurance class - M1 as per IEC-62271-102. All earth switches shall be of M0 duty.

3.0 CONSTRUCTIONAL FEATURES:

The features and constructional details of Double Break Isolators, earth switches and accessories shall be in accordance with requirements stated hereunder:

3.1 **Contacts:**

a) The contacts shall be self aligning and self cleaning and so designed that binding cannot occur after remaining closed for prolonged periods of time in a heavily polluted atmosphere.

b) No undue wear or scuffing shall be evident during the mechanical endurance tests. Contacts and spring shall be designed so that readjustments in contact pressure shall not be necessary throughout the life of the isolator or earthing switch. Each contact or pair of contacts shall be independently sprung so that full pressure is maintained on all contacts at all time.

c) Contact springs shall not carry any current and shall not loose their characteristics due to heating effects.

d) The moving contact of double break isolator shall have turn-and -twist type or other suitable type of locking arrangement to ensure adequate contact pressure.

3.2 **Base:**

Each single pole of the isolator shall be provided with a complete galvanized steel base provided with holes and designed for mounting on a supporting structure.

3.3 **Blades:**

a) All metal parts shall be of non-rusting and non-corroding material. All current carrying parts shall be made from high conductivity electrolytic copper/aluminum. Bolts, screws and pins shall be provided with lock washers. Keys or equivalent locking facilities if provided on current carrying parts, shall be made of copper silicon alloy or stainless steel or equivalent. The bolts or pins used in current carrying parts shall be made of non-corroding material. Ferrous parts, other than stainless steel shall not be used in close proximity of main current path. All ferrous castings, if used elsewhere shall be made of malleable cast iron or cast-steel. No grey iron shall be used in the manufacture of any part of the isolator.

b) The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces, where this is impracticable adequate corona rings shall be provided. **Corona shields are not acceptable.** Corona rings shall be made up of aluminum/aluminum alloy.

c) Isolators and earthing switches including their operating parts shall be such that they cannot be dislodged from their open or closed positions by short circuit forces, gravity, wind pressure, vibrations, shocks, or accidental touching of the connecting rods of the operating mechanism.

e) The switch shall be designed such that no lubrication of any part is required except at very infrequent intervals i.e. after every 1000 operations or after 5 years whichever is earlier.

f) Insulator:

a) The insulator shall conform to or IEC-60168. The porcelain of the insulator shall conform to the requirements stipulated under Chapter 2-GTR and shall

have a minimum cantilever strength of **1000**/600 Kgs. for 245/145 kV insulators respectively.

b) Pressure due to the contact shall not be transferred to the insulators after the main blades are fully closed.

c) The parameters of the insulators shall meet the requirements specified under Chapter 2-GTR.

d) Insulator shall be type and routine tested as per IEC-60168**.**

e) For 245 kV Insulator: (For Isolator)

Top PCD	=	127 mm
No. of holes	=	4 x M16
Bottom PCD	=	**275 mm**
No. of holes	=	8 x 18 dia

f) For 145 kV Insulator: (For Isolator)

Top PCD	=	127 mm
No. of holes	=	4 x M16
Bottom PCD	=	254 mm
No. of holes	=	8 x 18 dia

3.4 **Name Plate:**

The name plate shall conform to the requirements of IEC incorporating year of manufacture.

4.0 EARTHING SWITCHES:

a) Where earthing switches are specified these shall include the complete operating mechanism and auxiliary contacts.

b) The earthing switches shall form an integral part of the isolator and shall be mounted on the base frame of the isolator.

c) Earthing switches shall be only locally operated.

d) The earthing switches shall be constructionally interlocked with the isolator so that the earthing switches can be operated only when the isolator is open and vice versa. The constructional interlocks shall be built in construction of isolator and shall be in addition to the electrical interlocks. Suitable mechanical arrangement shall be provided for de-linking electrical drive for manual operation.

e) Each earth switch shall be provided with flexible copper/aluminum braids for connection to earth terminal. These braids shall have the same short time current carrying capacity as the earth blade. The transfer of fault current through swivel connection will not be accepted.

f) The plane of movement and final position of the earth blades shall be such that adequate electrical clearances are obtained from adjacent live parts in the course of its movement between ON and OFF position.

g) The frame of each isolator and earthing switches shall be provided with two reliable earth terminals for connection to the earth mat.

h) Isolator design shall be such as to permit addition of earth switches at a future date. It should be possible to interchange position of earth switch to either side.

i) The earth switch should be able to carry the same fault current as the main blades of the Isolators and shall withstand dynamic stresses.

j) 245 kV earth switches shall also comply with the requirements of IEC-62271-102, in respect of induced current switching duty as defined for Class-B and short circuit making capability class E-0 for earthing switches.

5.0 OPERATING MECHANISM:

a) The bidder shall offer motor operated Isolators and earth switches. Isolators of 36 kV and below and earth switches of 72.5 kV and below rating shall be manual operated.

b) Control cabinet/operating mechanism box shall conform to the requirement stipulated in Chapter 2-GTR and shall be made of cast aluminium/aluminum sheet of adequate thickness (minimum 3 mm).

c) A “Local/Remote” selector switch and a set of open/ close push buttons shall be provided on the control cabinet of the isolator to permit its operation through local or remote push buttons.

d) Provision shall be made in the control cabinet to disconnect power supply to prevent local/remote power operation.

e) Motor shall be an AC motor and conform to the requirements of Chapter 2-GTR.

f) Suitable reduction gearing shall be provided between the motor and the drive shaft of the isolator. The mechanism shall stop immediately when motor supply is switched off. If necessary a quick electromechanical brake shall be fitted on the higher speed shaft to effect rapid braking.

g) Manual operation facility (with handle) should be provided with necessary interlock to disconnect motor.

h) Gear should be of forged material suitably chosen to avoid bending/jamming on operation after a prolonged period of non-operation. Also, all gear and connected material should be so chosen/surface treated to avoid rusting.

i) The test report for blocked rotor test of motor shall be submitted as per the requirement of clause 23.0 of Chapter 2: GTR of Technical Specification.

j) Only stranded conductor shall be used for wiring. Minimum size of the conductor for control circuit wiring shall be 1.5 sq.mm. (Copper).

k) The operating mechanism shall be located such that it can be directly mounted on any one of the support structures.

6.0 OPERATION:

a) The main Isolator and earth switches shall be gang operated in case of 245 kV, 145 kV & 36kV. However, 245 kV Tandem Isolators shall be individual-

pole operated. The operating mechanism of the three poles shall be well synchronized and interlocked.

b) The design shall be such as to provide maximum reliability under all service conditions. All operating linkages carrying mechanical loads shall be designed for negligible deflection. The length of inter insulator and interpole operating rods shall be capable of adjustments, by means of screw thread which can be locked with a lock nut after an adjustment has been made. The isolator and earth switches shall be provided with “over center” device in the operating mechanism to prevent accidental opening by wind, vibration, short circuit forces or movement of the support structures.

c) Each isolator/pole of isolator and earth-switch shall be provided with a manual operating handle enabling one man to open or close the isolator with ease in one movement while standing at ground level. Non-detachable type manual operating handle shall have provision for padlocking. For detachable type manual operating handles, suitable provision shall be made inside the operating mechanism box for parking the detached handles. The provision of manual operation shall be located at a convenient operating height from the base of isolator support structure.

d) The isolator shall be provided with positive continuous control throughout the entire cycle of operation. The operating pipes and rods shall be sufficiently rigid to maintain positive control under the most adverse conditions and when operated in tension or compression for isolator closing. They shall also be capable of withstanding all torsional and bending stresses due to operation of the isolator. Wherever supported the operating rods shall be provided with bearings on either ends. The operating rods/ pipes shall be provided with suitable universal couplings to account for any angular misalignment.

e) All rotating parts shall be provided with grease packed roller or ball bearings in sealed housings designed to prevent the ingress of moisture, dirt or other foreign matter. Bearings pressure shall be kept low to ensure long life and ease of operation. Locking pins wherever used shall be rustproof.

f) Signaling of closed position shall not take place unless it is certain that the movable contacts, have reached a position in which rated normal current, peak withstand current and short time withstand current can be carried safely. Signaling of open position shall not take place unless movable contacts have reached a position such that clearance between contacts is atleast 80% of the isolating distance.

g) The position of movable contact system (main blades) of each of the Isolators and earthing switches shall be indicated by a mechanical indicator at the lower end of the vertical rod of shaft for the Isolators and earthing switch. The indicator shall be of metal and shall be visible from operating level.

h) The contractor shall furnish the following details along with quality norms, during detailed engineering stage.

   (i) Current transfer arrangement from main blades of isolator along with millivolt drop immediately across transfer point.

   (ii) Details to demonstrate smooth transfer of rotary motion from motor shaft to the insulator along with stoppers to prevent over travel.

7.0 TERMINAL CONNECTOR STUD/PAD:

The isolator terminal pads/studs shall be made of high quality copper or aluminium and shall be conforming to Australian standard AS-2935 for rated current. The terminal pad shall have protective covers which shall be removed before interconnections.

8.0 SUPPORT STRUCTURE:

245 kV/145/36 kV Isolators shall be suitable for mounting on support structures to be supplied in accordance with stipulations of Chapter 2-GTR.

9.0 TESTS:

9.1 In continuation to the requirements stipulated under Chapter 2-GTR the isolator along with its earthing switch and operating mechanism should have been type tested as per IEC and shall be subjected to routine tests in accordance with IEC-62271-102. – Minimum 1000 Nos. mechanical operations in line with mechanical endurance test, M0 duty, shall be carried out on 1 (one) isolator out of every lot of Isolators, assembled completely with all accessories, as acceptance test for the lot. The travel characteristics measured at a suitable location in the base of insulator along with motor current/power drawn, during the entire travel duration are to be recorded at the start and completion and shall not vary by more than (+/-) 10% after completion of 1000 cycles of operation. After completion of test, mechanical interlock operation to be checked**.**

9.2 The test reports of the type tests and the following additional type tests (additional type tests are required for isolators rated above 72.5 kV only) shall also be submitted for the Purchaser's review.

(i) Radio interference voltage test.

(ii) Seismic withstand test on isolator mounted on Support structure. The test shall be performed in the following position:

Isolator open	E/S Closed
Isolator open	E/S Open
Isolator Closed	E/S Open

10.0 SPARE PARTS AND MAINTENANCE EQUIPMENT:

Bidder shall include in his proposal mandatory spare parts in accordance with the requirements stipulated in Chapter 1 - PSR.

11.0 TECHNICAL PARAMETERS:
(In addition to those specified under Chapter 2-GTR)

I. 245 kV ISOLATORS:

A11.1	Type	Outdoor
A11.2	Rated current at 50^{O}C ambient temperature	1600A / 2500 A (As applicable).

A11.3	Rated short time withstand current of isolator and earth switch (for 1 Sec.)	40 kA/ 50 kA (as applicable)
A11.4	Rated dynamic short circuit withstand current of isolator and earth switch	100 kAp / 125 kAp (as applicable)
A11.5	Temperature rise over design ambient temperature	As per table V of IEC-694.
A11.6	Rated mechanical terminal load	As per table III of IEC-62271-102 or as per value calculated in Chapter 2-GTR whichever is higher.
A11.7	Operating mechanism of isolator/earth switch	A.C. Motor operated
A11.8	No. of auxiliary contacts each isolator	Besides requirement of this spec., on bidder shall wire up 5 NO + 5 NC to TBs (Reversible) for Purchaser's future use.
A11.9	No. of auxiliary contacts on each earthing switch	Besides requirement of this spec., the bidder shall wire up 3 NO + 3 NC to TBs (Reversible) for Purchaser's future use.
A11.10	Operating time	15 sec. or less
A11.11	Number of terminals in control cabinet (Interpole cabling shall be supplied by Contractor)	All contacts & control circuits are to be wired upto control cabinet plus 24 spare terminals evenly distributed.
II.	**145 kV ISOLATORS:**	
B11.1	Type	Outdoor
B11.2	Rated current at 50^{o}C ambient temperature	1600/2500 A
B11.3	Rated short time withstand current of isolator and earth switch	31.5 kA for 1 Sec.
B11.4	Rated dynamic short circuit withstand current of isolator and earth switch	80 kAp
B11.5	Temperature rise over design ambient temperature	As per table V of IEC-694.
B11.6	Rated mechanical terminal load.	As per table III of IEC-62271-102 or as per value calculated in Chapter 2-GTR whichever is higher.

B11.7	Operating mechanism of isolator/earth switch	A.C. Motor operated
C11.8	No. of auxiliary contacts on each isolator	Besides requirement of this spec., 5 NO + 5 NC to contacts, wired to terminal block exclusively for Purchaser's use in future.
B11.9	No. of auxiliary contacts on each earthing switch	Besides requirement of this spec., the bidder shall wire up 3 NO + 3 NC to TBs (Reversible) for Purchaser's future use.
B11.10	Operating time	15 sec. or less
B11.11	Number of terminals in control cabinet (Interpole cabling shall be supplied by Contractor)	All contacts & control circuits are to be wired upto control cabinet plus 24 spare terminals evenly distributed.

III. 33kV ISOLATOR (NOT APPLICABLE)

C11.1	Type	Outdoor (Double Break)
C11.2	Temperature rise over design ambient temperature	As per table V of IEC 62271-1
C11.3	Rated mechanical terminal load	As per table-III of IEC 62271-102 IEC 129(1984) or as per value calculated in Chapter 2-GTR whichever is higher
C11.4	Number of terminals in control cabinet (Interpole cabling shall be Supplied by contractor)	All contacts and control circuits are to be wired upto control cabinet plus 24 terminals exclusively for Owner's use.
C11.5	Rated current at design ambient temperature	1250/800 Amps(as applicable).
C11.6	Rated short time withstand current of isolator and earth-switch	25 kA for 3 Sec
C11.7	Rated dynamic short circuit withstand current of isolator and earth switch	As per IEC
C11.8	Operating mechanism for Isolator and Earth switch	Manual
C11.9	No. of auxiliary contacts on each isolator	5 NO + 5 NC contacts, wired to terminal block exclusively for Owner's use in future.

C11.10	No. of auxiliary contacts on each earthing switch	3 NO + 3 NC contacts wired to terminal block exclusively for Owner's use in future.

C.I The porcelain of the 36 kV insulators shall have minimum cantilever strength of 450 KGS

C.II 33 kV Isolator shall be gang operated for main blades and earth switches.

12.0 PRE-COMMISSIONING TESTS

12.1 An indicative list of tests on isolator and earth switch is given below. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./instructions of the equipment Supplier or Purchaser without any extra cost to the Purchaser. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates and shall furnish the list of instruments to the Purchaser for approval.

(a) Insulation resistance of each pole.

(b) Manual and electrical operation and interlocks.

(c) Insulation resistance of control circuits and motors.

(d) Ground connections.

(e) Contact resistance.

(f) Proper alignment so as to minimize vibration during operation.

(g) Measurement of operating Torque for isolator and Earth switch.

(h) Resistance of operating and interlocks coils.

(i) Functional check of the control schematic and electrical & mechanical interlocks.

(j) 50 operations test on isolator and earth switch.

12. 2 The contractor shall ensure that erection, testing and commissioning of Isolators above 72.5 kV class shall be carried out under the supervision of the Isolator manufacturer's representative. The commissioning report shall be signed by the manufacturer's representative.

SECTION-6: INSTRUMENT TRANSFORMERS
CONTENTS

1.0 GENERAL:

1.1 The instrument transformers and accessories shall conform to the latest version of the standards specified below except to the extent explicitly modified in the specification and shall be in accordance with the requirements in Chapter 2-GTR.

Current Transformers IEC: 60044-1

Capacitive Voltage Transformers IEC: 60044-5 / IEC-60358

Inductive Voltage Transformers IEC: 60044-2

1.2 The instrument transformers shall be complete with its terminal box and a common marshalling box for a set of 3 instrument transformers.

1.3 The external surface of instrument transformer, if made of steel, shall be hot dip galvanized or painted as per **Chapter 2-GTR.**

1.4 The impregnation details along with tests/checks to ensure successful completion of impregnation cycle shall be furnished for approval.

1.5 The instrument transformers shall be designed for use in geographic and meteorological conditions as given in Chapter 2-GTR.

2.0 CONSTRUCTION FEATURES:

The features and constructional details of instrument transformers shall be in accordance with requirements stipulated hereunder:

2.1 a) Instrument transformers shall be of 245/145 kV class, oil filled/ SF6 gas filled, suitable for outdoor service and upright mounting on steel structures. 245/145 kV Instrument transformers shall be with shedded porcelain/ polymer bushings/Insulators

b) Bushings/Insulators shall conform to requirements stipulated in Section-GTR. The bushing/insulator for CT shall be one piece without any metallic flange joint.

c) Oil filling and drain plugs, oil sight glass shall be provided for CT and for electromagnetic unit of CVT etc. The Instrument transformer shall have cantilever strength of not less than 350 kg and 350 kg respectively for 245kV and 145 kV Instrument transformers. For CVT with polymer housing, the cantilever strength shall not be less than 150kg. Oil filling and drain plugs are not required with SF6 gas filled CT.

d) Instruments transformers shall be hermetically sealed units. Bidder/ Manufacturer shall furnish details of the arrangements made for the sealing of instrument transformers *during detailed engineering*.

Bidder/Manufacturer shall also furnish the details of site tests to check the effectiveness of hermetic sealing for approval.

e) Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.

f) In case of SF_6 filled CTs/Inductive VTs, it shall be provided with a suitable SF_6 gas density monitoring device, with NO/NC contacts to facilitate the remote annunciation and tripping in case of SF_6 leakage. Provisions shall be made for online gas filling. Suitable rupture disc shall be provided to prevent explosion.

2.2 **Terminal box/Marshalling Box:**

Terminal box shall conform to the requirements of Chapter 2-GTR.

2.3 **Insulating Oil:**

a) Insulating oil to be used for instrument transformers shall be of EHV grade and shall conform to IEC - 60296 (required for first filling). Non–PCB based synthetic insulating oil conforming to IEC 60867 can also be used in the capacitor units of CVT with specific approval from the owner, the proposal for which shall be submitted during detailed engineering stage.

b) The SF6 gas shall comply with IEC-60376, 60376A and 60376B and shall be suitable in all respects for use in the switchgear under operating conditions.

2.4 **Name Plate:**

Name plate shall conform to the requirements of IEC incorporating the year of manufacture. The rated current, extended current rating in case of current transformers and rated voltage, voltage factor in case of voltage transformers shall be clearly indicated on the name plate. The rated thermal current in case of CT shall also be marked on the name plate.

The intermediate voltage in case of capacitor voltage transformer shall be indicated on the name plate.

3.0 CURRENT TRANSFORMERS:

a) Current transformers shall have single primary either ring type, or hair pin type and suitably designed for bringing out the secondary terminals in a weather proof (IP 55) terminal box at the bottom. PF Terminal for measurement of tan delta and capacitance of the unit shall be provided. These secondary terminals shall be terminated to stud type non-disconnecting terminal blocks inside the terminal box. In case “Bar primary” inverted type current transformers are offered the manufacturer will meet following additional requirements:

(i) The secondaries shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution.

(ii) The lowest part of the insulation assembly shall be properly secured to avoid any risk of damage due to transportation stresses.

(iii) The upper part of insulation assembly resting on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly & top dome.

(iv) Nitrogen if used for hermetic sealing (in case of live tank design) should not come in direct contact with oil.

(v) Bidder/Manufacturer shall recommend whether any special storage facility is required for spare CT.

b) Different ratios specified shall be achieved by secondary taps only and primary reconnection shall not be accepted.

c) Core lamination shall be of cold rolled grain oriented silicon steel or other equivalent alloys. The cores used for protection shall produce undistorted secondary current under transient conditions at all ratios with specified CT parameters.

d) The expansion chamber at the top of the porcelain insulators should be suitable for expansion of oil.

e) Facilities shall be provided at terminal blocks in the marshalling box for star delta formation, short circuiting and grounding of CT secondary terminals.

f) Current transformer's guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

g) For 245/145 kV class CTs, the rated extended primary current shall be 120% (or 150% if applicable) on all cores of the CTs as specified in the Chapter 1 – GTS.

h) For 245/145 kV current transformer, characteristics shall be such as to provide satisfactory performance of burdens ranging from 25% to 100% of rated burden over a range of 5% to 120%(or specified rated extended current whichever is higher) of rated current in case of metering CTs and up to the accuracy limit factor/knee point voltage in case of relaying CTs.

i) The current transformer shall be suitable for horizontal transportation. It shall be ensured that the CT is able to withstand all the stresses imposed on it while transporting and there shall be no damage in transit. The Contractor shall submit the details of packing design to the Purchaser for review.

j) For 245/145 kV CTs the instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be inbuilt construction of the CTs. In case these are to be mounted separately these shall be mounted in the central marshalling box suitably wired upto the terminal blocks.

k) The wiring diagram plate for the interconnections of the three single phase CTs shall be provided inside the marshalling box. A typical wiring diagram No. 0000-000-T-E-L-028 (Sh. 1 & 2) is enclosed herewith to be followed by the Bidder/Manufacturer

l) The current transformers should be suitable for mounting on lattice support structure or pipe structure to be provided by the Contractor in accordance with stipulations of Chapter 2-GTR.

m) The CT shall be so designed as to achieve the minimum risks of explosion in service. Bidder/Manufacturer shall bring out in his offer, the measures taken to achieve this.

n) 245/145 kV current transformers shall be suitable for high speed auto reclosing.

4.0 VOLTAGE TRANSFORMERS:

a) 245/145 kV Voltage transformers shall be capacitor voltage divider type with electromagnetic units and shall be suitable for carrier coupling.36kV Voltage transformers shall be Inductive Type.

b) Voltage transformers secondaries shall be protected by HRC cartridge type fuses for all the windings. In addition, fuses shall be provided for the protection and metering windings for fuse monitoring scheme. The secondary terminals of the VTs shall be terminated to the stud type non - disconnecting terminal blocks in the individual phase secondary boxes via the fuse.

c) VTs shall be suitable for high frequency (HF) coupling required for power line carrier communication. Carrier signal must be prevented from flowing into potential transformer (EMU) circuit by means of a RF choke/reactor suitable for effectively blocking the carrier signals over the entire carrier frequency range i.e. 40 to 500 KHz. Details of the arrangement shall be furnished along with the bid. H.F. terminal of the VT shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling filters of the carrier communication equipment, when utilized. Further, earthing link with fastener to be provided for HF terminal.

d) The electromagnetic unit comprising compensating reactor, intermediate transformer and protective and damping devices should have separate terminal box with all the secondary terminals brought out.

e) The damping device, which should be permanently connected to one of the secondary windings, should be capable of suppressing the ferro-resonance oscillations.

f) The accuracy of 0.2 on secondary III for all VTs should be maintained through out the entire burden range upto 50 VA on all the windings without any adjustments during operation.

g) 245/145 kV VTs shall be suitable for mounting on tubular GI pipe in accordance with stipulations of Chapter 2-GTR.

h) It should be ensured that access to secondary terminals is without any danger of access to high voltage circuit.

i) A protective surge arrester shall be provided *if required,* to prevent breakdown of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor/primary winding, tuning reactor/RF choke etc. due to short circuit in transformer secondaries. In case of an alternate arrangement, bidder shall bring out the details in the bid.

j) The wiring diagram for the interconnection of the three single phase CVTs shall be provided inside the marshalling box in such a manner that it does not deteriorate with time. *A typical wiring diagram no.: 0000-000-T-E-L-029 is enclosed herewith to be followed by the Bidder/Manufacturer.*

5.0 TERMINAL CONNECTORS:

The terminal connectors shall meet the requirements as given in Chapter 2-GTR.

6.0 TESTS:

6.1 In accordance with the requirements in Section-GTR, Current and Voltage Transformers should have been type tested and shall be subjected to routine tests in accordance with IEC:60044-1 and IEC: 60044-5/60044-2 respectively.

6.2 The test reports of the type tests and the following additional type tests (additional type tests are required for Instrument Transformers, rated above 72.5 kV only) shall also be submitted for the Purchaser's review.

a) **Current Transformers:**

i) Radio interference voltage test as per IEC 60044-1.

ii) Seismic withstand test.

iii) Thermal stability test, i.e. application of rated voltage and rated extended thermal current simultaneously by synthetic test circuit. (not applicable for SF6 filled CT)

iv) Thermal co-efficient test i.e. measurement of tan delta as a function of temperature (at ambient and between 80^{O}C & 90^{O}C) and voltage (at 0.3, 0.7, 1.0 and 1.1 Um/□3) (not applicable for SF6 filled CT)

v) The current transformer shall be subjected to Multiple chopped impulse test (not applicable for SF6 filled CT) by any one of the following two methods given below to assess the CT performance in service to withstand the high frequency over voltage generated due to closing & opening operation of isolators. Alternatively, method as per IEC: 60044-1 may be followed:

Method I*: 600 negative polarity lightning impulses chopped on crest will be applied to current transformer. The opposite polarity amplitude must be limited to 50% of crest value when the wave is chopped. One impulse per minute shall be applied and every 50 impulse high frequency currents form the windings and total current to earth will be recorded and be compared with reference currents recorded applying one or more (max 20) reduced chopped impulses of 50% of test value.*

Oil samples will be taken before and 3 days after the test. Gas analysis must not show appreciable rate of increase in various gases related with the results of the analysis performed before test.

Total sum of crest values of current through secondaries must not exceed 5% of the crest value of total current to earth.

CT must withstand dielectric tests after this test to pass the test.

Method II*: 100 negative polarity impulses with a rise and fall time of less than 0.25 microsecond corrected to atmospheric condition shall be applied at one-minute interval and total current through insulation of earth will be recorded. The amplitude of first opposite polarity should be limited to 50% of the chopped impulse crest value. Voltage and total current wave shapes shall be recorded after every 10 impulses, and will be compared with reference wave shapes recorded before test at 50% of test values.*

Oil sample shall be taken before and 3 days after the test and CT shall be deemed to have passed the test if the increase in gas content before and after test is not appreciable.

b) **Voltage transformers:**

i) High frequency capacitance and equivalent series resistance measurement (as per IEC-60358) for CVT.

ii) Seismic withstand test.

iii) Stray capacitance and stray conductance measurement of the low voltage terminal (as per IEC-60358) for CVT.

iv) Determination of temperature coefficient test (as per IEC-60358).

v) Radio interference voltage test as per IEC-60044-5/IEC-60044-2. However, the RIV level shall be as specified in clause Major Technical Parameters in Section-GTR.

vi) Apart from the above, report of all special tests mentioned in IEC-60044-5 for Capacitive voltage transformer shall also be submitted for approval.

6.3 The current and voltage transformer shall be subjected to the following routine tests in addition to routine tests as per IEC.

a) **CURRENT TRANSFORMERS:**

ROUTINE TESTS:

for Oil filled CTs

i) Measurement of Capacitance.

ii) Oil leakage test.

iii) Measurement of tan delta at 0.3, 0.7, 1.0 and 1.1 Um/□3.

for SF6 filled CTs

i) Dew point measurement

ii) SF6 alarm/ lockout check.

iii) SF6 leakage test. Gas leakage rate shall be maintained within 0.2% per annum.

b) **VOLTAGE TRANSFORMERS:**

Routine tests on Capacitive voltage transformer shall be done in line with IEC-60044-5.

7.0 SPARE PARTS AND MAINTENANCE EQUIPMENT:

The Bidder shall include in his proposal spare parts equipment in accordance with Section-Project.

8.0 TECHNICAL PARAMETERS:

A. 245 kV CURRENT TRANSFORMERS:

A8.1	Rated Primary current	2500/ 1600 A
A8.2	Rated short time thermal current	40 kA for 1 sec/50 kA for 1 sec. (as applicable)
A8.3	Rated dynamic current kA (peak)	100 / 125 (as applicable)
A8.4	Maximum temperature rise over design ambient temperature	As per IEC: 60044-1
A8.5	One minute power frequency withstand voltage sec. terminal & earth	5 kV
A8.6	Number of terminals	All terminals of control circuits are to be wired upto marshaling box plus 20% spare terminals evenly distributed on all TBs.
A8.7	Type of insulation	Class A

Current transformers shall also comply with requirements of Table - IIA.

B. 145 kV CURRENT TRANSFORMERS:

B8.1	Rated Primary current	800/ 1600A

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B8.2	Rated short time thermal current	31.5 kA for 1 sec.
B8.3	Rated dynamic current	80 kA (peak)
B8.4	Maximum temperature rise over design ambient temperature	As per IEC: 60044-1
B8.5	One minute power frequency withstand voltage sec. terminal & earth	5 kV
B8.6	Number of terminals	All terminals of control circuits are to be wired upto marshaling box plus 20% spare terminals evenly distributed on all TBs.
B8.7	Type of insulation	Class A

Current transformers shall also comply with requirements of Table – IIB/ or IIC as applicable.

C. 33 kV CURRENT TRANSFORMERS:

C8.1	Rated Primary current -	600/ 1200A(as applicable)
C8.2	Rated Extended Primary current	120% (on all cores)
C8.3	Rated short time thermal Current	25 kA for 3 sec.
C8.4	Rated dynamic current	As per IEC
C8.5.	Maximum temperature rise over design ambient Temperature	As per IEC:44-1
C8.6.	One minute power frequency with stand voltage sec. terminal & earth	5 kV
C8.7	Number of terminals	All terminals of control circuits are to be wired upto marshaling box plus 20% spare terminals evenly distributed on all TBs.
C8.8	Type of insulation	Class A

Current transformers shall also comply with requirements of Table IID/IIE as applicable.

D. 245 KV VOLTAGE TRANSFORMERS:

D8.1	System fault level (for 1 second)	40 kA / 50 kA (as applicable)
D8.2	Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement

D8.3	High frequency capacitance entire carrier frequency range	Within 80% to 150% of rated for capacitance **(for CVT only)**
D8.4	Equivalent series resistance over the entire carrier frequency range	Less than 40 ohms **(for CVT only)**
D8.5	Stray capacitance and stray conductance of the LV terminal over entire carrier frequency range	As per IEC: 358 **(for CVT only)**
D8.6	One minute power frequency withstand voltage:	
	i) Between LV (HF) terminal and earth terminal	10 kV (rms) for exposed terminals and 4 KV (rms) for terminals enclosed in a weather proof box
	ii) For secondary winding	3 kV (rms)
D8.7	Maximum temperature rise over design ambient temperature	As per IEC: 60044-2 or 60044-5
D8.8	Number of terminals in control cabinet (interpole cabling is to be supplied by Purchaser)	All terminals are wired upto marshaling box plus 12 terminals exclusively for Purchaser's use.
D8.9	Rated Total Thermal burden (VA)	300 (100VA/winding)

Voltage Transformers shall also comply with the requirements of Table-IA of this Section.

E. 145 KV VOLTAGE TRANSFORMERS:

E8.1	System fault level	31.5 kA for 1 second
E8.2	Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement
E8.3	High frequency capacitance for entire carrier frequency range	Within 80% to 150% of rated capacitance **(for CVT only)**
E8.4	Equivalent series resistance over the entire carrier frequency range	Less than 40 ohms **(for CVT only)**
E8.5	Stray capacitance and stray conductance of the LV terminal over entire carrier frequency range	As per IEC: 358 **(for CVT only)**
E8.6	One minute power frequency withstand voltage:	
	i) Between LV (HF) terminal and earth terminal	10 kV (rms) for exposed terminals and 4 KV (rms) for terminals enclosed in a weather proof box
	ii) For secondary winding	3 kV (rms)

E8.7	Maximum temperature rise over design ambient temperature	As per IEC: 60044-2 or 60044-5
E8.8	Number of terminals in control cabinet (interpole pole cabling is to be supplied by Purchaser)	All terminals are wired upto marshaling box plus 12 terminals exclusively for Purchaser's use.
E8.9	Rated Total Thermal burden (VA)	300 (100VA/winding)

Voltage Transformers shall also comply with the requirements of Table-IB of this Section.

F. 33 kV POTENTIAL TRANSFORMERS

F8.1	**System Fault level**	25kA for 3 sec
F8.2	Standard reference range of frequencies for which the Accuracies are valid	96% to 102% for protection and 99% to 102% for measurement
F8.3	One minute power frequency Withstand voltage:	
	i) Between LV terminal and earth terminal	10kVrms for exposed terminals and 4kVrms for terminals enclosed in a weather proof box.
	ii) For secondarywinding	2 kVrms
F8.4	Maximum temperature rise over design ambient temperature	As per IEC 186
F8.5	Number of terminals in control Cabinet	All terminals of control circuits are wired upto marshalling box Plus spare 20% terminals evenly distributed on all TBs
F8.6	Rated total thermal burden	75 VA

Voltage Transformers shall also comply with the requirements of Table-IC of this Section

9.0 PRE-COMMISSIONING TESTS

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

9.2 **Current Transformers**

(a) Insulation Resistance Test for primary and secondary.

(b) Polarity test

(c) Ratio identification test - checking of all ratios on all cores by primary injection of current.

(d) Dielectric test of oil (wherever applicable).

(e) Magnetizing characteristics test.

(f) Tan delta and capacitance measurement

(g) Secondary winding resistance measurement

(h) Contact resistance measurement (wherever possible/accessible).

(i) Test for SF6 (for SF6 filled CTs) – Dew point measurement, SF6 alarm/ lockout check.

(j) DGA test of oil.

Dissolved gas analysis to be carried out at the time of commissioning. CTs must have adequate provision for taking oil samples from the bottom of the CT without exposure to atmosphere. Bidder/Manufacturer shall recommend the frequency at which oil samples should be taken and norms for various gases in oil after being in operation for different durations. Bidder/Manufacturer should also indicate the total quantity of oil which can be withdrawn from CT for gas analysis before refilling or further treatment of CT becomes necessary.

9.3 **Voltage Transformers/Capacitive Voltage Transformers**

(a) Insulation Resistance test for primary (if applicable) and secondary winding.

(b) Polarity test

(c) Ratio test

(d) Dielectric test of oil (wherever applicable).

(e) Tan delta and capacitance measurement of individual capacitor stacks.

(f) Secondary winding resistance measurement.

TABLE - IA

REQUIREMENTS OF 245 KV CAPACITIVE VOLTAGE TRANSFORMERS

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	245		
2.	Type	Single phase capacitor VT		
3.	No. of secondaries	3		
4.	Rated voltage factor	1.2 continuous 1.5 - 30 seconds		
5.	Phase angle error	± 10 minutes (For metering core)		
6.	Capacitance (pf)	4400/8800 (As applicable)	+ 10% - 5%	
		Secon-dary I	Secon-dary II	Secon-dary III
7.	Voltage Ratio	220/0.11	220/0.11	220/0.11
8.	Application	Protec-tion	Protec-tion	Meter-ing
9.	Accuracy	3 P	3 P	0.2
10.	Output burden (VA) (minimum)	50	50	50

TABLE - IB

REQUIREMENTS OF 145 KV CAPACITIVE VOLTAGE TRANSFORMERS

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	145		
2.	Type	Single phase capacitor VT		
3.	No. of secondaries	3		
4.	Rated voltage factor	1.2 continuous		
		1.5 - 30 seconds		
5.	Phase angle error	± 10 minutes (For metering core)		
6.	Capacitance (pf)	8800	+ 10%/ -5%	
		Secon-dary I	Secon-dary II	Secon-dary III
7.	Voltage Ratio	132/0.11	132/0.11	132/0.11
8.	Application	Protec-tion	Protec-tion	Meter-ing
9.	Accuracy	3 P	3 P	0.2
10.	Output burden (VA) (minimum)	50	50	50

TABLE- IC

REQUIREMENTS OF 33 KV POTENTIAL TRANSFORMERS

S.No.	PARTICULAR				
1.	Rated primary voltage (kV rms)	36			
2.	Type	Single phase PT			
3.	No. of secondaries	3			
4.	Rated voltage factor	1.2 continuous 1.5 - 30 seconds			
5.	Phase angle error	+/- 20 minutes (for metering core)			
6.	Standard reference range of frequencies for which the Accuracies are valid	96% to 102% for protection and 99% to 102% for measurement			
7.	One minute power frequency Withstand voltage:				
	i) Between LV terminal and earth earth terminal	10kVrms for exposed terminals and 4kVrms for terminals enclosed in a weather proof box.			
	ii) For secondarywinding	2 kVrms			
8.	Maximum temperature rise over design ambient temperature	As per IEC 186			
9.	Number of terminals in control Cabinet	All terminals of control circuits are wired upto marshalling box Plus spare 20% terminals evenly distributed on all TBs			
10.	Rated total thermal burden	75 VA			
		Secon-dary I	Secon-daryII	Secon-daryIII	
11.	.Voltage Ratio	33/0.11	33/0.11	33/0.11	
12.	Application	Protec-tion	Protec-tion	Meter-ing	
13.	Accuracy	3 P	3 P	0.5	
14.	Output burden (VA) (minimum)	50	50	25	

TABLE - IIA

REQUIREMENTS FOR 245 KV CURRENT TRANSFORMERS

No.of Excit-Cores Vk	Core sec.wdg. (in mA)	Appli-cation No.	Current ation cur-	Output ratio (VA)	Accuracy burden per IEC:	Min. knee class as age (Vk)	Max. CT pt.volt-resist-ance(ohms)	Max. rent at
5	1	BUS DIFF CHECK	1600-800/1	-	PX	1600/800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	2	BUS DIFF MAIN	1600-800/1	-	PX	1600/800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	3	METERING	1600-800/1	20	**0.2S**	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	1600-800/1	-	PX	1600/800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	5	TRANS. DIFF/LINE PROTN	1600-800/1	-	PX	1600/800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap

All relaying CTs shall be of accuracy class PX as per IEC

TABLE - IIB

REQUIREMENTS FOR 145 KV CURRENT TRANSFORMERS

No.of Excit-Cores Vk	Core sec.wdg. (in mA)	Appli-cation No.	Current cation ation cur-	Output ratio (VA)	Accuracy burden per IEC:	Min. knee class as age Vk	Max. CT pt.volt-resist-ance(ohms)	Max. rent at
5	1	BUS DIFF CHECK	1200-	- 600/1	-	1200/	12/6 600	25 on 1200/1 Tap; 50 on 600/1 Tap
	2	BUS DIFF MAIN	1200-	- 600/1	-	1200/	12/6 600	25 on 1200/1 Tap; 50 on 600/1 Tap
	3	METERING	1200-600/1	20	**0.2S**	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	1200-600/1	-	-	1200/ 600	12/6	25 on 1200/1 Tap; 50 on 600/1 Tap
	5	TRANS. DIFF/LINE PROTN	1200-600/1	-	-	1200/ 600	12/6	25 on 1200/1 Tap; 50 on 600/1 Tap

All relaying CTs shall be of accuracy class PX as per IEC.

TABLE – II C

REQUIREMENTS FOR 145 kV CURRENT TRANSFORMERS

No.of Excit-Cores Vk	Core sec.wdg. (in mA)	Appli-cation No.	Current cation cur-ation	Output ratio (VA)	Accuracy burden per IEC: 44-1	Min. knee class as age Vk	Max. CT pt.volt-resist-ance(ohms)	Max. rent at
5	1	BUS DIFF CHECK	600-300/1	-	-	600/300	6/3	30 on 600/1 Tap; 60 on 300/1 Tap
	2	BUS DIFF MAIN	600-300/1	-	-	600/300	6/3	30 on 600/1 Tap; on 300/1 Tap
	3	METERING	300-150/1	20	**0.2S**	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	600-300/1	-	-	600/300	6/3	30 on 600/1 Tap; 60 on 300/1 Tap
	5	TRANS. DIFF/LINE PROTN	600-300/1	-	-	600/300	6/3	30 on 600/1 Tap; 60 on 300/1 Tap

All relaying CTs shall be of accuracy class PX as per IEC.

TABLE – IID

REQUIREMENTS FOR 33 kV CURRENT TRANSFORMERS

Current Transformer (600A)

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden(VA)	Accuracy class as per IEC: 44-1	Min. knee pt.volt-age Vk	Max.CT sec.wdg. resis-ance(ohms)	Max.Excit-ation cur-rent at V (in mA)
3	1	O/C & E/F	400-200/1	-	PX.	600/300	4/2	40 on 400/1 Tap; 80 on 200/1 Tap
	2	METERING	400-200-100/1	20	0.2	-	-	-

All relaying CTs shall be of accuracy class PX as per IEC

TABLE – IIE
REQUIREMENTS FOR 33 kV CURRENT TRANSFORMERS

Current Transformer (1200A)

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden(VA)	Accuracy class as per IEC:	Min. knee pt.volt-age Vk	Max.CT sec.wdg. resis-ance(ohms)	Max.Excit-ation cur-rent at Vk (in mA)	Remarks
3	1	O/C & E/F	1200-600/1	-	PX	1200/600	6	60 on 1200/1 Tap; 12/30 on 600/1 Tap	
	2	METERING	1200-600-600/1	30	0.2	-	-	-	
	3	TRANS. DIFF PROTN	1200-600/1	-	PX	1200/600	6	60 on 1000/1 Tap; 12/30 on 500/1 Tap	

TABLE – IIF
REQUIREMENTS FOR 220 kV CURRENT TRANSFORMERS

Current Transformer (2500A/3000A)

Core no.	Application	Current Ratio	Output Burden (VA)	Accuracy class as per IEC	Min knee point voltage V_K	Max. CT sec. Wdg resistance (ohms)	Max. Excitation current at V_K (in mA)
1	protection	2500-1600-800/1	-	PX	2500-1600-800	12.5/ 8/ 4	24 on 2500/1 37.5 on 1600/1 75 on 800/1
2	protection	2500-1600-800/1	-	PX	2500-1600-800	12.5/ 8/ 4	24 on 2500/1 37.5 on 1600/1 75 on 800/1
3	Metering	2500-1600-800/1	20	0.2S	-	-	-
4	protection	2500-1600-800/1	-	PX	2500-1600-800	12.5/ 8/ 4	24 on 2500/1 37.5 on 1600/1 75 on 800/1
5	protection	2500-1600-800/1	-	PX	2500-1600-800	12.5/ 8/ 4	24 on 2500/1 37.5 on 1600/1 75 on 800/1

All relaying CTs shall be of accuracy class PX as per IEC.

SECTION-07 - SURGE ARRESTERS

CONTENTS

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. 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.

d. 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 245 kV system	Lightning Surge for 145 kV system
Power transformer	± 950	± 550
Instrument Transformer	± 1050	± 650
Reactor	--	--
CB/Isolator Phase to ground	± 1050	± 650
CB/Isolator Across open contacts	± 1050(for CB) ± 1200(for Isolator	± 750

g. The duty cycle of CB installed in 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 along with 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 along with necessary quality checks used for individual blocks along with 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 along with 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 350 kg for 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) 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 along with 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 Ionization 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. Watt-loss 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 Ionization 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. 245 kV CLASS SURGE ARRESTER

A7.0(a)	Rated arrester voltage	216 kV
A7.0(b)	Nominal discharge current	10 kA of 8/20 microsecond wave
A7.0(c)	Minimum discharge capability	5kJ/kV (referred to rated arrester voltage corresponding to minimum discharge characteristics.
A7.0(d)	Continuous operating voltage at 50 deg.C	168 kV rms
A7.0(e)	Max. switching surge residual voltage (1kA)	500 kVp
A7.0(f)	Max. residual voltage at	

	i) 5 kA	560 kVp
	ii) 10 kA nominal discharge current	600 kVp
A7.0(g)	Max. steep current impulse residual voltage at 10 kA.	650 kVp
A7.0(h)	Long duration discharge class	3
A7.0(i)	High current short duration test value (4/10 micro second wave)	100 kAp
A7.0(j)	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.	**145 kV CLASS SURGE ARRESTER**	
B7.0(a)	Rated arrester voltage	120 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	102 kV rms
B7.0(e)	Max. switching surge residual voltage (1kA)	280 kVp
B7.0(f)	Max. residual voltage at	
	i) 5 kA	310 kVp
	ii) 10 kA nominal discharge current	330 kVp
B7.0(g)	Long duration discharge class	3
B7.0(h)	High current short duration test value (4/10 micro second wave)	100 kAp
B7.0(i)	Current for pressure relief test	40 kA rms
B7.0(j)	Low current long duration test value (2400 micro sec)	As per IEC.
B7.0(k)	Pressure relief class	31.5 kA

C	**33kV Surge Arresters**	
C7.0(a)	Rated arrester voltage	30 kV
C7.0(b)	Nominal discharge capability	10 kA of 8/20 microsecond wave
C7.0(c)	Minimum discharge capability	5kJ/kV (referred to rated arrester voltage corresponding to minimum discharge characteristics).
C7.0(d)	Continuous operating voltage at 50 deg.C	24 kV rms
c7.0(e)	Max. switching surge residual voltage (0.5kA)	63 kVp
C7.0(f)	Max. residual voltage (i) 5 kA (ii) 10 kA nominal discharge current	 80 kVp 85 kVp
C7.0(g)	Long duration discharge class	2
C7.0(h)	High current short duration test value (4/10 micro second wave)	100 kAp
C7.0(i)	Current for Pressure Relief test	40kA rms
C7.0(j)	Low current long duration test value (2000 micro sec)	As per IEC.
C7.0(k)	Pressure relief class as per IEC-60099-1	A

8.0 PRE-COMMISSIONING TESTS

8.1 An indicative list of tests is given below.

(a) Operation check of LA counter.

(b) Insulation resistance measurement

(c) Capacitance and Tan delta measurement of individual stacks.

(d) Third harmonic resistive current measurement (to be conducted after energization.)

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 along with calibration certificates and shall furnish the list of instruments to the Purchaser for approval.

SECTION-8: CONTROL AND RELAY PANELS

Table of contents

1. TYPE OF PANELS

1.1 Simplex Panel

Simplex panel shall consist of a vertical front panel with equipment mounted thereon and having wiring access from rear for control panels &–front–for relay/protection panels. In case of panel having width more than 800mm, double leaf-doors shall be provided. Doors shall have handles with either built-in locking facility or will be provided with pad-lock.

1.2 Duplex Panel

Duplex panel shall be walk-in tunnel type comprising two vertical front and rear panel sections connected back-on-back by formed sheet steel roof tie members and a central corridor in between. The corridor shall facilitate access to internal wiring and external cable connections. In case of number of duplex panels located in a row side by side, the central corridor shall be aligned to form a continuous passage. Both ends of the corridor shall be provided with double leaf doors with lift off hinges. Doors shall have handles either with built-in locking facility or shall be provided with pad-locks. Separate cable entries shall be provided for the front and rear panels. However, inter-connections between front and back panels shall be by means of inter panel wiring at the top of the panel.

2. CONSTRUCTIONAL FEATURES

2.1. Control and Relay Board shall be of panels of simplex or duplex type design as indicated in bill of quantity. It is the responsibility of the Contractor to ensure that the equipment specified and such unspecified complementary equipment required for completeness of the protective/control schemes be properly accommodated in the panels without congestion and if necessary, **either add more number of panels or** provide panels with larger dimensions. No price increase at a later date on this account shall be allowed. However, the width of panels that are being offered to be placed in existing switchyard control rooms, should be in conformity with the space availability in the control room.

2.2. Panels shall be completely metal enclosed and shall be dust, moisture and vermin proof. The enclosure shall provide a degree of protection not less than IP-31 in accordance with IEC 60529 (Part-1).

2.3. Panels shall be free standing, floor mounting type and shall comprise structural frames completely enclosed with specially selected smooth finished, cold rolled sheet steel of thickness not less than 3 mm for weight bearing members of the panels such as base frame, front sheet and door frames, and 2.0mm for sides, door, top and bottom portions. There shall be sufficient reinforcement to provide level transportation and installation.

2.4. All doors, removable covers of panels shall be gasketed all around with synthetic gaskets Neoprene/EPDM. However, XLPE gaskets can also be used for fixing protective glass doors. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh

2.5. Design, materials selection and workmanship shall be such as to result in neat appearance, inside and outside with no welds, rivets or bolt head apparent from outside, with all exterior surfaces tune and smooth.

2.6. Panels shall have base frame with smooth bearing surface, which shall be fixed on the embedded foundation channels/insert plates. Anti vibration strips made of shock absorbing materials that shall be supplied by the contractor, which shall be placed between panel & base frame.

2.7. Cable entries to the panels shall be from the bottom. Cable gland plate fitted on the bottom of the panel shall be connected to earthing of the panel/station through a flexible braided copper conductor rigidly.

2.8. Relay/protection panels of modern modular construction would also be acceptable.

3. MOUNTING

3.1. All equipment on and in panels shall be mounted and completely wired to the terminal blocks ready for external connections. The equipment on front of panel shall be mounted

flush.

3.2. Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent devices and are readily accessible without use of special tools. Terminal marking on the equipment shall be clearly visible.

3.3. The Contractor shall carry out cut out, mounting and wiring of the free issue items supplied by others which are to be mounted in his panel in accordance with the corresponding equipment manufacturer's drawings. Cut outs if any, provided for future mounting of equipment shall be properly blanked off with blanking plate.

3.4. The centre lines of switches, push buttons and indicating lamps shall not be less than 750mm from the bottom of the panel. The centre lines of relays, meters and recorders shall not be less than 450mm from the bottom of the panel.

3.5. The centre lines of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Likewise, the top lines of all meters, relays and recorders etc. shall be matched.

3.6. No equipment shall be mounted on the doors.

3.7. At existing station, panels shall be matched with other panels in the control room in respect of dimensions, colour, appearance and arrangement of equipment (centre lines of switches, push buttons and other equipment) on the front of the panel.

4. PANEL INTERNAL WIRING

4.1. Panels shall be supplied complete with interconnecting wiring provided between all electrical devices mounted and wired in the panels and between the devices and terminal blocks for the devices to be connected to equipment outside the panels. When panels are arranged to be located adjacent to each other all inter panel wiring and connections between the panels shall be carried out internally

4.2. All wiring shall be carried out with 650V grade, single core, stranded copper conductor wires with PVC insulation. The minimum size of the multi-stranded copper conductor used for internal wiring shall be as follows:

- All circuits except current transformer circuits and voltage transfer circuits meant for energy metering - one 1.5mm sq. per lead.
- All current transformer circuits - one 2.5 sq.mm per lead.
- Voltage transformer circuit (for energy meters): Two 2.5 mm sq. per lead.

4.3. All internal wiring shall be securely supported, neatly arranged, readily accessible and connected to equipment terminals and terminal blocks. Wiring gutters & troughs shall be used for this purpose.

4.4. Auxiliary bus wiring for AC and DC supplies, voltage transformer circuits, annunciation circuits and other common services shall be provided near the top of the panels running throughout the entire length of the panels.

4.5. Wire termination shall be made with solderless crimping type and tinned copper lugs, which firmly grip the conductor. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wire and shall not fall off when the wire is disconnected from terminal blocks. All wires directly connected to trip circuit breaker or device shall be distinguished by the addition of red coloured unlettered ferrule.

4.6. Longitudinal troughs extending throughout the full length of the panel shall be preferred for inter panel wiring. Inter-connections to adjacent panel shall be brought out to a separate set of terminal blocks located near the slots of holes meant for taking the inter-connecting wires.

4.7. Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.

5. TERMINAL BLOCKS

5.1. All internal wiring to be connected to external equipment shall terminate on terminal blocks. Terminal blocks shall be 650 V grade and have 10 Amps. Continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Markings on the terminal blocks shall correspond to wire number and terminal numbers on the wiring diagrams. All terminal blocks shall have shrouding with transparent unbreakable material.

5.2. Disconnecting type terminal blocks for current transformer and voltage transformer secondary leads shall be provided. Also, current transformer secondary leads shall be provided with short circuiting and earthing facilities.

5.3. At least 20% spare terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks.

5.4. Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors of external cable on each side

- All CT & PT circuits: minimum of two of 2.5mm Sq. copper.
- AC/DC Power Supply Circuits: One of 6mm Sq. Aluminium.
- All other circuits: minimum of one of 2.5mm Sq. Copper.

5.5. There shall be a minimum clearance of 250mm between the first row of terminal blocks and the associated cable gland plate or panel side wall. Also, the clearance between two rows of terminal blocks edges shall be minimum of 150mm.

5.6. Arrangement of the terminal block assemblies and the wiring channel within the enclosure shall be such that a row of terminal blocks is run in parallel and close proximity along each side of the wiring-duct to provide for convenient attachment of internal panel wiring. The side of the terminal block opposite the wiring duct shall be reserved for the external cable connections. All adjacent terminal blocks shall also share this field wiring corridor. All wiring shall be provided with adequate support inside the panels to hold them firmly and to enable free and flexible termination without causing strain on terminals.

5.7. The number and sizes of the Owner's multi core incoming external cables will be furnished to the Contractor after placement of the order. All necessary cable terminating accessories such as gland plates, supporting clamps & brackets, wiring troughs and gutters etc. (except glands & lugs) for external cables shall be included in the scope of supply.

6. PAINTING

The painting shall be carried out as detailed in Chapter 2–GTR.

7. MIMIC DIAGRAM

7.1. Coloured mimic diagram and symbols showing the exact representation of the system shall be provided in the front of control panels.

7.2. Mimic diagram shall be made preferably of anodised aluminium or plastic of approved fast colour material, which shall be screwed on to the panel and can be easily cleaned. The mimic bus shall be 2mm thick. The width of the mimic bus shall be 10mm for bus bars and 7mm for other connections. Painted overlaid mimic is also acceptable.

7.3. Mimic bus colour will be decided **during detailed Engineering.**

7.4. When semaphore indicators are used for equipment position, they shall be so mounted in the mimic that the equipment in close position shall complete the continuity of mimic.

7.5. Indicating lamp, one for each phase, for each bus shall be provided on the mimic to indicate bus charged condition.

8. NAME PLATES AND MARKINGS

8.1. All equipment mounted on front and rear side as well as equipment mounted inside the panels shall be provided with individual name plates with equipment designation engraved. Also, on the top of each panel on front as well as rear side, large and bold nameplates shall be provided for circuit/feeder designation.

8.2. All front mounted equipment shall also be provided at the rear with individual name plates engraved with tag numbers corresponding to the one shown in the panel internal wiring to facilitate easy tracing of the wiring.

8.3. Each instrument and meter shall be prominently marked with the quantity measured e.g. KV, A, MW, etc. All relays and other devices shall be clearly marked with manufacturer's name, manufacturer's type, serial number and electrical rating data.

8.4. Name Plates shall be made of non-rusting metal or 3 ply lamicoid. Name plates shall be black with white engraving lettering.

8.5. Each switch shall bear clear inscription identifying its function e.g. 'BREAKER' '52A', "SYNCHRONISING" etc. Similar inscription shall also be provided on each device whose function is no other-wise identified. If any switch device does not bear this inscription separate name plate giving its function shall be provided for it. Switch shall also have clear inscription for each position indication e.g. "Trip- Neutral-Close", "ON-OFF", "R-Y-B-OFF" etc

8.6. All the panels shall be provided with name plate mounted inside the panel bearing LOA No & Date, Name of the Substation & feeder and reference drawing number.

9. MISCELLANEOUS ACCESSORIES

9.1. **Plug Point**: 230V, Single phase 50Hz, AC socket with switch suitable to accept 5 Amps and 15 Amps pin round standard Indian plug, shall be provided in the interior of each cubicle with ON-OFF switch.

9.2. **Interior Lighting**: Each panel shall be provided with a fluorescent lighting fixture rated for 230 Volts, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch. Adequate lighting shall also be provided for the corridor in Duplex panels.

9.3. **Switches and Fuses**: Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with Fuses. Selection of the main and sub-circuit Fuses rating shall be such as to ensure selective clearance of sub-circuit faults. Voltage transformer circuits for relaying and metering shall be protected by fuses. All fuses shall be HRC cartridge type conforming to 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'.

9.4. **Space Heater**: Each panel shall be provided with a thermostatically connected space heater rated for 230V, single phase, 50 Hz AC supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with switch unit.

10. EARTHING

10.1. All panels shall be equipped with an earth bus securely fixed. Location of earth bus shall ensure no radiation interference from earth systems under various switching conditions of isolators and breakers. The material and the sizes of the bus bar shall be at least 25 X 6 sq.mm copper with threaded holes at a gap of 50 mm with provision of bolts and nuts for connection with cable armours and mounted equipment etc for effective earthing. When several panels are mounted adjoining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply of Contractor. Provision shall be made for extending the earth bus bars to future adjoining panels on either side.

10.2. Provision shall be made on each bus bar of the end panels for connecting Substation earthing grid. Necessary terminal clamps and connectors for this purpose shall be included in the scope of supply of Contractor.

10.3. All metallic cases of relays, instruments and other panel mounted equipment including gland plate, shall be connected to the earth bus by copper wires of size not less than 2.5 sq. mm. The colour code of earthing wires shall be green.

10.4. Looping of earth connections which would result in loss of earth connection to other devices when the loop is broken, shall not be permitted. However, looping of earth connections between equipment to provide alternative paths to earth bus shall be provided.

10.5. VT and CT secondary neutral or common lead shall be earthed at one place only at the terminal blocks where they enter the panel. Such earthing shall be made through links so that earthing may be removed from one group without disturbing continuity of earthing system for other groups.

10.6. An electrostatic discharge **arrangement** shall be provided in each panel **so as to discharge human body before he handles the equipment inside the panels**.

11. INDICATING INSTRUMENTS & TRANSDUCERS FOR CONTROL PANEL:

All instruments, meters and transducers shall be enclosed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. All megawatt, megavar, Bus voltage and frequency indicating instruments shall be provided with individual transducers and these shall be calibrated along with transducers to read directly the primary quantities. They shall be accurately adjusted and calibrated at works and shall have means of calibration check and adjustment at site. The supplier shall submit calibration certificates at the time of delivery. However, no separate transducers are envisaged for digital bus voltmeters and digital frequency meters and the indicating meters provided in the synchronising equipment.

11.1. Indicating Instruments

11.1.1. Unless otherwise specified, all electrical indicating instruments shall be of digital type suitable for flush mounting.

11.1.2. Instruments shall have 4-digit display; display height being not less than 25 mm

11.1.3. Instrument shall confirm to relevant IEC and shall have an accuracy class of 1.5 or better. Watt and Var meters shall have an indication of (+) and (-) to indicate EXPORT and IMPORT respectively.

11.1.4. Digital voltage and frequency meters shall be of class: 0.5 and shall have digital display of 5 and 4 digits respectively, with display size, not less than 25mm (height).

11.2. Transducers

11.2.1. Transducers (for use with Indicating Instruments and Telemetry/Data Communication application) shall in general conform to IEC:688-1

11.2.2. The transducers shall be suitable for measurement of active power, reactive power, voltage, current and frequency in three phase four wire unbalanced system.

11.2.3. The input to the transducers will be from sub-station current & potential transformers. The output shall be in milli ampere D.C. proportional to the input & it shall be possible to feed the output current directly to the telemetry terminal or indicating instruments.

11.2.4. The transducer characteristic shall be linear throughout the measuring range.

11.2.5. The transducer output shall be load independent.

11.2.6. The input & output of the transducer shall be galvanically isolated.

11.2.7. Each transducer shall be housed in a separate compact case and have suitable terminals for inputs & outputs.

11.2.8. The transducers shall be suitably protected against transient high peaks of voltage & current.

11.2.9. The transducer shall withstand indefinitely without damage and work satisfactorily at

120% of the rated voltage and 120% of the rated input current as applicable.

11.2.10. All the transducers shall have an output of 4-20 mA.

11.2.11. The response time of the transducers shall be less than 1 second.

11.2.12. The accuracy class of transducers shall be 1.0 or better for voltage/current transducer, 0.5 or better for watt/VAR transducer and 0.2 or better for frequency transducer.

11.2.13. The transducers shall have a low AC ripple on output less than 1%.

11.2.14. The transducer shall have dual output.

12. ANNUNCIATION SYSTEM for Control Panel

12.1. Alarm annunciation system shall be provided in the control board by means of visual and audible alarm in order to draw the attention of the operator to the abnormal operating conditions or the operation of some protective devices. The annunciation equipment shall be suitable for operation on the voltages specified in this specification.

12.2. The visual annunciation shall be provided by annunciation facia, mounted flush on the top of the control panels.

12.3. The annunciation facia shall be provided with translucent plastic window for alarm point with approximate size of 35mm x 50mm. The facia plates shall be engraved in black lettering with respective inscriptions. Alarm inscriptions shall be engraved on each window in not more than three lines and size of the lettering shall not be less than 5 mm.

12.4. Each annunciation window shall be provided with two white lamps in parallel to provide safety against lamp failure. Long life lamps shall be used. The transparency of cover plates and wattage of the lamps provided in the facia windows shall be adequate to ensure clear visibility of the inscriptions in the control room having high illumination intensity (350 Lux), from the location of the operator's desk.

12.5. All Trip facia shall have red colour and all Non-trip facia shall have white colour.

12.6. The audible alarm shall be provided by Buzzer/ Hooter /Bell having different sounds and shall be used as follows.

Hooter	Alarm Annunciation
Bell	Annunciation DC failure
Buzzer	AC supply failure

12.7. Sequence of operation of the annunciator shall be as follows:

Sl. NO.	Alarm Condition	Fault Contact	Visual Annunciation	Audible Annunciation
1.	Normal	Open	OFF	OFF
2.	Abnormal	Close	Flashing	ON
3.	Accept Push Button Pressed	Close	Steady On	OFF
		Open	Steady On	OFF
4.	Reset Push Button Pressed	Close	On	OFF
		Open	Off	OFF
5.	Lamp Test Push Button Pressed	Open	Steady On	OFF

12.8. Audible annunciation for the failure of DC supply to the annunciation system shall be provided and this annunciation shall operate on 230 Volts AC supply. On failure of the DC to the annunciation system for more than 2 or 3 seconds (adjustable setting), a bell shall sound. A separate push button shall be provided for the cancellation of this

audible alarm alone but the facia window shall remain steadily lighted till the supply to annunciation system is restored.

12.9. A separate voltage check relay shall be provided to monitor the failure of supply (230V AC) to the scheme mentioned in Clause above. If the failure of supply exists for more than 2 to 3 seconds, this relay shall initiate visual and audible annunciation. Visual and audible annunciation for the failure of AC supply to the annunciation system shall be provided and this annunciation shall operate on Annunciation DC and buzzer shall sound.

12.10. The annunciation system described above shall meet the following additional requirements:

a) The annunciation system shall be capable of catering to at least 20 simultaneous signals at a time.

b) One set of the following push buttons shall be provided on each control panel:

- Reset push button for annunciation system
- Accept push button for annunciation system
- Lamp test push button for testing the facia windows

c) One set of the following items shall be provided common for all the control panel (not applicable for extension of substation):

- Flasher relay for annunciation system
- Push button for Flasher test
- Three Push buttons for test of all audible alarm systems

d) These testing circuits shall be so connected that while testing is being done, it shall not prevent the registering of any new annunciation that may land during the test.

e) The annunciation shall be repetitive type and shall be capable of registering the fleeting signal. Minimum duration of the fleeting signal registered by the system shall be 15 milli seconds.

f) In case of static annunciator scheme, special precaution shall be taken to ensure that spurious alarm condition does not appear due to influence of external electromagnetic/ electrostatic interference on the annunciator wiring and switching disturbances from the neighbouring circuits within the panels and the static annunciator shall meet the high voltage susceptibility test , impulse voltage withstand test , high frequency disturbance test– class III and fast transient disturbance test –level III as per IEC 60255.

12.11. The annunciation system to be supplied for existing sub-stations shall be engineered as an extension to the existing scheme.

13. SWITCHES

13.1. Control and instrument switches shall be rotary operated type with escutcheon plates clearly marked to show operating position and circuit designation plates and suitable for flush mounting with only switch front plate and operating handle projecting out.

13.2. The selection of operating handles for the different types of switches shall be as follows:

Breaker, Isolator control switches	:	Pistol grip, black
Synchronising switches	:	Oval, Black, Keyed handle (one common removable handle for a group of switches or locking facility having common key)
synchronising Selector switches	:	Oval or knob, black
Instrument switches	:	Round, knurled, black

Protection Transfer switch : Pistol grip, lockable and black.

13.3. The control switch of breaker and isolator shall be of spring return to neutral type. The switch shall have spring return from close and trip positions to "after close" and "after trip" positions respectively.

13.4. Instrument selection switches shall be of maintained contact (stay put) type. Ammeter selection switches shall have make-before-break type contacts so as to prevent open circuiting of CT secondary when changing the position of the switch. Voltmeter transfer switches for AC shall be suitable for reading all line- to-line and line-to-neutral voltages for non- effectively earthed systems and for reading all line to line voltages for effectively earthed systems.

13.5. Synchronising switches shall be of maintained contact (stay put) type having a common removable handle for a group of switches. The handle shall be removable only in the OFF position and it shall be co-ordinated to fit into all the synchronising switches. These switches shall be arranged to connect the synchronising equipment when turned to the 'ON' position. One contact of each switch shall be connected in the closing circuit of the respective breaker so that the breaker cannot be closed until the switch is turned to the 'ON' position.

13.6. Lockable type of switches which can be locked in particular positions shall be provided when specified. The key locks shall be fitted on the operating handles.

13.7. The contacts of all switches shall preferably open and close with snap action to minimise arcing. Contacts of switches shall be spring assisted and contact faces shall be with rivets of pure silver or silver alloy. Springs shall not be used as current carrying parts

13.8. The contact combination and their operation shall be such as to give completeness to the interlock and function of the scheme.

13.9. The contact rating of the switches shall be as follows:

Description	**Contact Rating in Amps**		
	220V DC	**50V DC**	**230V AC**
Make and carry Continuously	10	10	10
Make and carry for 0.5 sec.	30	30	30
Break for Resistive load	3	20	7
Break for Inductive load with L/R = 40m sec.	0.2	-	-

14. INDICATING LAMPS

14.1. Indicating lamps shall be of cluster LED type suitable for panel mounting with rear terminal connections. Lamps shall be provided with series connected resistors preferably built in the lamp assembly. Lamps shall have translucent lamp covers to diffuse lights coloured red, green, amber, clear white or blue as specified. The lamp cover shall be preferably of screwed type, unbreakable and moulded from heat resisting

material.

14.2. The lamps shall be provided with suitable resistors.

14.3. Lamps and lenses shall be interchangeable and easily replaceable from the front of the panel. Tools, if required for replacing the bulbs and lenses shall also be included in the scope of the supply.

14.4. The indicating lamps with resistors shall withstand 120% of rated voltage on a continuous basis.

15. POSITION INDICATORS (if Applicable)

15.1. Position indicators of "SEMAPHORE" type shall be provided when specified as part of the mimic diagrams on panels for indicating the position of circuit breakers, isolating/earthing switches etc. The indicator shall be suitable for semi-flush mounting with only the front disc projecting out and with terminal connection from the rear. Their strips shall be of the same colour as the associated mimic.

15.2. Position indicator shall be suitable for DC Voltage as specified. When the supervised object is in the closed position, the pointer of the indicator shall take up a position in line with the mimic bus bars, and at right angles to them when the object is in the open position. When the supply failure to the indicator occurs, the pointer shall take up an intermediate position to indicate the supply failure.

15.3. The rating of the indicator shall not exceed 2.5 W.

15.4. The position indicators shall withstand 120% of rated voltage on a continuous basis.

16. SYNCHRONISING EQUIPMENT

16.1. For sub-station equipped with sub-station Automation system, the requirement of synchronisation is specified in chapter Sub-station Automation System and the same shall prevail. For other sub-station which is not equipped with Sub-sub-station automation system following shall be applicable as per requirement.

16.1. The synchronising instruments shall be mounted either on a synchronising trolley or on a synchronising panel. The panel/ trolley shall be equipped with double analog voltmeters and double analog frequency meters, synchroscope and lamps fully wired. The size of voltmeters and frequency meters provided in the synchronising panel shall not be less than 144 X 144 sq.mm. Suitable auxiliary voltage transformers wherever necessary shall also be provided for synchronising condition. In case the synchroscope is not continuously rated, a synchroscope cut-off switch shall be provided and an indicating lamp to indicate that the synchroscope is energised, shall also be provided

16.1. Synchronising check relay with necessary ancillary equipment's shall be provided which shall permit breakers to close after checking the requirements of synchronising of incoming and running supply. The phase angle setting shall not exceed 35 degree and have voltage difference setting not exceeding 10%. This relay shall have a response time of less than 200 milliseconds when the two system conditions are met within present limits and with the timer disconnected. The relay shall have a frequency difference setting not exceeding 0.45% at rated value and at the minimum time setting. The relay shall have an adjustable time setting range of 0.5-20 seconds. A guard relay shall be provided to prevent the closing attempt by means of synchronising check relay when control switch is kept in closed position long before the two systems are in synchronism

16.1. The synchronising panel shall be draw out and swing type which can be swivelled in left and right direction. The synchronising panel shall be placed along with control panels and the number of synchronising panels shall be as indicated in BPS. The incoming and running bus wires of VT secondary shall be connected and run as bus wires in the control panels and will be extended to synchronising panel for synchronisation of circuit breakers. The selector switch provided for each circuit breaker in respective control panels shall be lockable type with a common key so that only one selector switch is kept in synchronising mode at a time.

16.1. Alternatively, the trolley shall be of mobile type with four rubber-padding wheels

capable of rotating in 360 degree around the vertical axis. Suitable bumpers with rubber padding shall be provided all around the trolley to prevent any accidental damage to any panel in the control room while the trolley is in movement. The trolley shall have two meter long flexible cord fully wired to the instruments and terminated in a plug in order to facilitate connecting the trolley to any of the panels. The receptacle to accept the plug shall be provided on the panel.

16.1. At existing sub-stations, the synchronising scheme shall be engineered to be compatible with the existing synchronising scheme and synchronising socket/switch on the panel. In substations, where synchronising panels are available, the bidder shall carry out the shifting of the above panels, if required, to facilitate the extension of control panel placement.

17. RELAYS

17.1. All relays shall conform to the requirements of IS: 3231/IEC-60255/IEC 61000 or other applicable standards. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear.

17.2. All protective relays shall be of numerical type and communication protocol shall be as per IEC 61850. Further, the test levels of EMI as indicated in IEC 61850 shall be applicable to these relays.

17.3. All protective relays shall be in draw out or plug-in type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied loose and shall be included in contractor's scope of supply.

17.4. All AC operated relays shall be suitable for operation at 50 Hz. AC Voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for 1 amp CT secondary. All DC operated relays and timers shall be designed for the DC voltage specified, and shall operate satisfactorily between 80% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.

17.5. The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. also required for the complete protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme; contacts shall be silver faced with spring action. Relay case shall have adequate number of terminals for making potential free external connections to the relay coils and contacts, including spare contacts.

17.6. Timers shall be of solid state type. Time delay in terms of milliseconds obtained by the external capacitor resistor combination is not preferred and shall be avoided.

17.7. No control relay, which shall trip the power circuit breaker when the relay is de-energised, shall be employed in the circuits.

17.8. Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.

17.9. Auxiliary seal-in-units provided on the protective relays shall preferably be of shunt reinforcement type. If series relays are used the following shall be strictly ensured:

(a) The operating time of the series seal-in-unit shall be sufficiently shorter than that of the trip coil or trip relay in series with which it operates to ensure definite operation of the flag indicator of the relay.

(b) Seal-in-unit shall obtain adequate current for operation when one or more relays operate simultaneously.

(c) Impedance of the seal-in-unit shall be small enough to permit satisfactory operation of the trip coil on trip relays when the D.C. Supply Voltage is minimum.

(d) Trip-circuit seal-in is required for all trip outputs, irrespective of the magnitude of the interrupted current. The trip-circuit seal-in logic shall not only seal-in the trip output(s), but also the relevant initiation signals to other scheme functions, (e.g. initiate signals to the circuit-breaker failure function, reclosing function etc.), and the alarm output signals.

(e) Two methods of seal-in are required, one based on the measurement of AC current, catering for those circumstances for which the interrupted current is above a set threshold, and one based on a fixed time duration, catering for those circumstances for which the interrupted current is small (below the set threshold).

(f) For the current seal-in method, the seal-in shall be maintained until the circuit-breaker opens, at which time the seal-in shall reset and the seal-in method shall not now revert to the fixed time duration method. For this seal-in method, the seal-in shall be maintained for the set time duration. For the line protection schemes, this time duration shall be independently settable for single- and three-pole tripping.

(g) Seal-in by way of current or by way of the fixed duration timer shall occur irrespective of whether the trip command originates from within the main protection device itself (from any of the internal protection functions), or from an external device with its trip output routed through the main protection device for tripping. Trip-circuit seal-in shall not take place under sub-harmonic conditions (e.g. reactor ring down).

17.10. The setting ranges of the relays offered, if different from the ones specified shall also be acceptable if they meet the functional requirements.

17.11. Any alternative/additional protections or relays considered necessary for providing complete effective and reliable protection shall also be offered separately. The acceptance of this alternative/ additional equipment shall lie with the OWNER.

17.12. All relays and their drawings shall have phase indications as R-Red, Y-yellow, B-blue

17.13. For numerical relays, the scope shall include the following:

a) Necessary software and hardware to up/down load the data to/from the relay from/to the personal computer installed in the substation. However, the supply of PC is not covered under this clause.

b) The relay shall have suitable communication facility for future connectivity to SCADA. The relay shall be capable of supporting IEC-61850 protocol.

c) In case of line protection and transformer/reactor protection, the features like fault recorder and event logging function as available including available as optional feature in these relays shall be supplied and activated at no extra cost to the owner. Also, necessary software/ hardware for automatic uploading to station HMI/DR work station (as applicable) shall be supplied. It is to be clearly understood that these shall be in addition to Fault recorder function as specified at clause no. 28.

18. TRANSMISSION LINE PROTECTION

18.1. All relays shall be suitable for series compensated line.

18.2. The line protection relays are required to protect the line and clear the faults on line within shortest possible time with reliability, selectivity and full sensitivity to all type of faults on lines. The general concept is to have two main protections having equal performance requirement specially in respect of time as called Main-I and Main-II for 220KV transmission lines and Main and back up protection for 132 KV transmission lines.

18.3. The Transmission system for which the line protection equipment are required is **indicated in Chapter 1 – General Technical Specification (GTS)**

18.4. The maximum fault current could be as high as 63kA but the minimum fault current could be as low as 20% of rated current of CT secondary. The starting & measuring relays characteristics should be satisfactory under these extremely varying conditions.

18.5. The protective relays shall be suitable for use with capacitor voltage transformers having non-electronic damping and transient response as per IEC.

18.6. Fault Recorder, Distance to fault Locator and Over voltage relay (stage -1/2) functions if offered as an integral part of line protection relays, shall be acceptable provided these meet the technical requirements as specified in the respective clauses.

18.7. Auto reclose relay function if offered as an integral part of line distance protection relay, shall be acceptable **for 132 KV lines only** provided the auto reclose relay feature meets the technical requirements as specified in the respective clause.

18.8. The following protections shall be provided for each of the Transmission lines:

For 220KV

Main-I: Numerical distance protection scheme

Main-II: Numerical distance protection scheme of a make different from that of Main – I

For 132KV

Main: Numerical distance protection scheme

Back up: Directional Over Current and Earth fault Protection

The detailed description of line protections is given here under.

18.9. **Main-I and Main-II Distance Protection scheme**:

(a) shall have continuous self monitoring and diagnostic feature

(b) shall be non-switched type with separate measurements for all phase to phase and phase to ground faults

(c) shall have stepped time-distance characteristics and three independent zones (zone 1, zone-2 and zone-3)

(d) shall have mho or quadrilateral or other suitably shaped characteristics for zone-1, zone-2 and zone- 3

(e) shall have following maximum operating time (including trip relay time, if any) under given set of conditions and with CVT being used on line (with all filters included)

(i) for 220 KV lines:

For Source to Impedance ratio:	**4**	**15**
Relay setting (Ohms)	(10 or 20) and 2	2
Fault Locations (as % of relay setting)	50	50
Fault resistance (Ohms)	0	0
Maximum operating time (Milliseconds)	40 for all faults	45 for 3 ph. Faults & 60 for all other faults

(ii) for 132 KV lines:

A relaxation of 5 ms in above timings is allowed for 132 KV lines.

(f) The relay shall have an adjustable characteristics angle setting range of 30 -85 degree or shall have independent resistance(R) and reactance (X) setting.

(g) shall have two independent continuously variable time setting range of 0-3 seconds for zone-2 and 0-5 seconds for zone-3

(h) shall have resetting time of less than 55 milli-seconds (including the resetting time of trip relays)

(i) shall have facilities for offset features with adjustable 10-20% of Zone-3 setting

(j) shall have variable residual compensation

(k) shall have memory circuits with defined characteristics in all three phases to ensure correct operation during close-up 3 phase faults and other adverse conditions and shall operate instantaneously when circuit breaker is closed to zero-volt 3 phase fault

(l) shall have weak end in-feed feature

(m) shall be suitable for single & three phase tripping

(n) shall have a continuous current rating of two times of rated current. The voltage circuit shall be capable of operation at 1.2 times rated voltage. The relay shall also be capable of carrying a high short time current of 70 times rated current without damage for a period of 1 sec.

(o) shall be provided with necessary self-reset type trip duty contacts for completion of the scheme (Minimum number of these trip duty contacts shall be four per phase) either through built in or through separate high-speed trip relays. Making capacity of these trip contacts shall be 30 amp for 0.2 seconds with an inductive load of L/R > 10 mill seconds. If separate high speed trip relays are used, the operating time of the same shall not be more than 10 milliseconds

(p) shall be suitable for use in permissive under reach/ over reach/ blocking communication mode

(q) shall have suitable number of potential free contacts for Carrier aided Tripping, Auto reclosing, CB failure, Disturbance recorder & Data acquisition system

(r) include power swing blocking protection which shall

- have suitable setting range to encircle the distance protection described above
- block tripping during power swing conditions
- release blocking in the event of actual fault

(s) include fuse failure protection which shall monitor all the three fuses of C.V.T. and associated cable against open circuit

- inhibit trip circuits on operation and initiate annunciation
- have an operating time less than 7 milliseconds
- remain inoperative for system earth faults

(t) include a directional back up Inverse Definite Minimum Time (IDMT) earth fault relay with normal inverse characteristics as per IEC 60255-3 as a built-in feature or as a separate unit for 220KV transmission lines

(u) Must have a current reversal guard feature.

18.10. **Back-up Directional Over Current and Earth fault protection scheme**

(a) shall have three over current and one earth fault element(s) which shall be either independent or composite unit(s)

(b) shall include necessary VT fuse failure relays for alarm purposes

(c) **over current elements** shall

- have IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting
- have a variable setting range of 50-200% of rated current
- have a characteristic angle of 30/45 degree lead
- include hand reset flag indicators or LEDs

(d) **earth fault element** shall

- have IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting

- have a variable setting range of 20-80% of rated current
- have a characteristic angle of 45/60 degree lag
- include hand reset flag indicators or LEDs
- include necessary separate interposing voltage transformers or have internal feature in the relay for open delta voltage to the relay

18.11. **LINE OVER VOLTAGE PROTECTION RELAY** shall

(a) monitor all three phases

(b) have two independent stages

(c) stage- I & II as built-in with line distance relays Main I & II respectively are acceptable

(d) have an adjustable setting range of 100-170% of rated voltage with an adjustable time delay range of 1 to 60 seconds for the first stage

(e) have an adjustable setting range of 100-170% of rated voltage with a time delay of 100-200 mill seconds for the second stage

(f) be tuned to power frequency

(g) provided with separate operation indicators (flag target) for each stage relays

(h) have a drop-off to pick-up ratio greater than 95%

(i) provide separate out-put contacts for each 'Phase' and stage for breaker trip relays, event logger and other scheme requirements

18.12. All trip relays used in transmission line protection scheme shall be of self/electrical reset type depending on application requirement.

19. **CIRCUIT BREAKER PROTECTION:**

This shall include following functions:

19.1. **Numerical AUTO RECLOSING** function shall

(a) have single phase reclosing facilities

(b) have a continuously variable single phase dead time range of 0.1-2 seconds

(c) have a continuously variable reclaim time range of 5-300 seconds

(d) Incorporate a **two-position** selector switch, from which single phase auto-reclosure and non-auto reclosure mode can be selected. Alternatively, the mode of auto reclosing can be selected through programming.

(e) be of single shot type

(f) have priority circuit to closing of both circuit breakers in case one and half breaker arrangements to allow sequential closing of breakers

(g) However, Auto-reclose as in built function of bay controller unit (BCU) provided for sub-station automation system is also acceptable.

19.2. **LOCAL BREAKER BACK-UP PROTECTION SCHEME** shall

(a) be triple pole type

(b) have an operating time of less than 15 milli seconds

(c) have a resetting time of less than 15 milli seconds

(d) have three over current elements

(e) be arranged to get individual initiation from the corresponding phase of main protections of line for each over current element. However, common three phase initiation is acceptable for other protections and transformer /reactor equipment protections

(f) have a setting range of 20-80% of rated current

(g) have a continuous thermal withstand two times rated current irrespective of the setting

(h) have a timer with continuously adjustable setting range of 0.1-1 seconds

(i) have necessary auxiliary relays to make a comprehensive scheme

(j) be similar relays for complete scope of work as per specification

20. REACTOR PROTECTION

20.1. **Differential Protection Relay shall**

(a) be triple pole type

(b) have operation time less than 25 milli-seconds at 5 times setting

(c) be tuned to system frequency

(d) have current setting range of 10 to 40% of 1 Amp. or a suitable voltage setting range

(e) be high impedance / biased differential type

(f) be stable for all external faults

20.2. **Restricted Earth Fault Protection Relay** shall

(a) be single pole type

(b) be of current/voltage operated high impedance type

(c) have a current setting of 10-40% of 1 Amp/ have a suitable voltage setting range

(d) be tuned to system frequency

(e) have a suitable non-linear resistor to limit the peak voltage to 1000 Volts

20.3. **Back up impedance protection Relay** shall

(a) be triple pole type, with faulty phase identification/ indication

(b) be single step polarised 'mho' distance/ impedance relay suitable for measuring phase to ground and phase to phase faults

(c) have adequate ohmic setting range to cover at least 60% of the impedance of the reactor and shall be continuously variable

(d) have an adjustable characteristic angle of 30-80 degree

(e) have a definite time delay relay with a continuously adjustable setting range of 0.2-2.0 seconds

(f) include VT failure relay which shall block the tripping during VT fuse failure condition

Further, Reactor auxiliary protections contacts (Buchholz, PRV, Oil Temperature, Winding Temperature etc.) can be wired suitably in above protections or provide separate Flag relays/Auxiliary relays as per scheme requirements.

21. TRANSFORMER PROTECTION

All transformer protection functions may be grouped into Group-I and Group-II protections in the following manner:

Group-I Protection: Following protection functions may be provided in Group-I Transformer protection relay:

a) Differential Protection as per clause no. 21.1

b) Over fluxing Protection for HV side as per clause no. 21.2

c) Direction Over current and earth fault protection for HV side as per clause no. 21.4

d) Over Load Protection as per clause no. 21.5

Group-II Protection: Following protection functions may be provided in Group-II Transformer protection relay:

e) REF Protection as per clause no. 21.3

f) Over fluxing Protection for IV/LV side as per clause no. 21.2

g) Direction Over current and earth fault protection for IV/LV side as per clause no. 21.4

h) Neutral Current Relay for Single Phase Transformer Bank

The various protections as built-in function of Group I/II protections shall be accepted only if the functional requirements of corresponding protections as specified in clause no. 21.1 to 21.6 are met otherwise separate protection relay(s) shall be offered.

21.1. **Transformer differential protection scheme shall**

(a) be triple pole type, with faulty phase identification/ indication

(b) have an operating time not greater than 30 milli seconds at 5 times the rated current

(c) have three instantaneous high set over-current units

(d) have an adjustable bias setting range of 20-50%

(e) be suitable for rated current of 1 Amp.

(f) have second harmonic or other inrush proof features and also should be stable under normal over fluxing conditions. Magnetising inrush proof feature shall not be achieved through any intentional time delay e.g. use of timers to block relay operation or using disc operated relays

(g) have an operating current setting of 15% or less

(h) include necessary separate interposing current transformers for angle and ratio correction or have internal feature in the relay to take care of the angle & ratio correction

(i) have a fault recording feature to record graphic form of instantaneous values of following analogue channels during faults and disturbances for the pre-fault and post fault period:

current in all three windings in nine analogue channels in case of 400kV class and above transformers or 6 analogue channels for lower voltage transformers and Voltage in one channel

The disturbance recorder shall have the facility to record the following external digital channel signals apart from the digital signals pertaining to differential relay:

1. REF protection operated
2. HV Breaker status (Main and tie)
3. IV Breaker status
4. Bucholz /OLTC Bucholz alarm / trip etc.
5. WTI/OTI/PRD alarm/trip of transformer etc.

Necessary hardware and software, for automatic up-loading the data captured by disturbance recorder to the personal computer (DR Work Station) available in the substation, shall be included in the scope.

21.2. **Over Fluxing Protection Relays** shall

(a) operate on the principle of Voltage to frequency ratio and shall be phase to

phase connected

(b) have inverse time characteristics, matching with transformer over fluxing withstand capability curve

(c) provide an independent 'alarm' with the time delay continuously adjustable between 0.1 to 6.0 seconds at values of 'v/f' between 100% to 130% of rated values

(d) tripping time shall be governed by 'v/f' Vs. time characteristics of the relay

(e) have a set of characteristics for Various time multiplier settings. The maximum operating time of the relay shall not exceed 3 seconds and 1.5 seconds at 'v/f' values of 1.4 and 1.5 times, the rated values, respectively.

(f) have an accuracy of operating time, better than ±10%

(g) have a resetting ratio of 95 % or better

21.3. **Restricted Earth Fault Protection** shall

(a) be single pole type

(b) be of current/voltage operated type

(c) have a current setting range of 10-40% of 1 Amp/have a suitable voltage setting range

(d) be tuned to the system frequency

21.4. **Back-up Over Current and Earth fault protection scheme with high set feature**

(a) Shall have three over current and one earth fault element(s) which shall be either independent or composite unit(s).

(b) The scheme shall include necessary VT fuse failure relays for alarm purposes

(c) Over current relay shall

- have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 50-200% of rated current
- have low transient, over reach high set instantaneous unit of continuously variable setting range 500-2000 % of rated current
- have a characteristic angle of 30/45 degree lead
- include hand reset flag indicators or LEDs.

(d) Earth fault relay shall

- have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current
- have low transient, over reach high set instantaneous unit of continuously variable setting range 200-800 % of rated current
- have a characteristic angle of 45/60 degree lag
- include hand reset flag indicators or LEDs
- include necessary separate interposing voltage transformers or have internal feature in the relay for open delta voltage to the relay

21.5. **Transformer Overload Protection Relay** shall

(a) be of single pole type

(b) be of definite time over-current type

(c) have one set of over-current relay element, with continuously adjustable setting range of 50-200% of rated current

(d) have one adjustable time delay relay for alarm having setting range of 1 to 10.0 seconds, continuously.

(e) have a drop-off/pick-up ratio greater than 95%.

21.6. **Transformer Neutral Current Protection relay** (for 1-Phase transformer bank neutral) shall

(a) have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current

21.7. **Further, Transformer auxiliary protections contacts (Buchholz, PRV, Oil Temperature, Winding Temperature, OLTC Buchholz etc.) can be wired suitably in above protections or provide separate Flag relays/Auxiliary relays as per scheme requirements.**

22. TEE DIFFERENTIAL PROTECTION RELAYS

22.1. **TEE-1 Differential protection relay** shall

(a) be triple pole type

(b) have an operating time less than 30 milliseconds at 5 times the rated current

(c) have three instantaneous high set over current units

(d) have an adjustable bias setting range of 20-50%

(e) have an operating current setting of 15% of 1 Amp or less

22.2. **TEE-2 Differential Protection relay** shall

(a) be triple pole type

(b) have operating time less than 25 milliseconds at 5 times setting

(c) be tuned to system frequency

(d) have current setting range of 20 to 80% of 1 Amp

(e) be voltage operated, high impedance type

(f) be stable for all external faults

(g) be provided with suitable non-linear resistors across the relay to limit the peak voltage to 1000 volts

23. TRIP CIRCUIT SUPERVISION RELAY

(a) The relay shall be capable of monitoring the healthiness of each 'phase' trip-coil and associated circuit of circuit breaker during 'ON' and 'OFF' conditions.

(b) The relay shall have adequate contacts for providing connection to alarm and event logger.

(c) The relay shall have time delay on drop-off of not less than 200 milli seconds and be provided with operation indications for each phase

24. TRIPPING RELAY

High Speed Tripping Relay shall

(a) be instantaneous (operating time not to exceed 10 milli-seconds).

(b) reset within 20 milli seconds

(c) be D.C. operated

(d) have adequate contacts to meet the requirement of scheme, other functions

like auto-reclose relay, LBB relay as well as cater to associated equipment like event logger, Disturbance recorder, fault Locator, etc.

(e) be provided with operation indicators for each element/coil.

25. **DC SUPPLY SUPERIVISION RELAY**

(a) The relay shall be capable of monitoring the failure of D.C. supply to which, it is connected.

(b) It shall have adequate potential free contacts to meet the scheme requirement.

(c) The relay shall have a 'time delay on drop-off' of not less than 100 milli seconds and be provided with operation indicator/flag.

26. **BUS BAR PROTECTION**

26.1. Single bus bar protection scheme shall be provided for each main bus and transfer bus (as applicable) for 220KV and 132 KV voltage levels

26.2. Each Bus Bar protection scheme shall

(a) have maximum operating time up to trip impulse to trip relay for all types of faults of 25 milli seconds at 5 times setting value.

(b) operate selectively for each bus bar

(c) give hundred percent security up to 63 KA fault level for 220KV and 31.5 KA for 132 KV

(d) incorporate continuous supervision for CT secondary against any possible open circuit and if it occurs, shall render the relevant zone of protection inoperative and initiate an alarm

(e) not give false operation during normal load flow in bus bars

(f) incorporate clear zone indication

(g) be of phase segregated and triple pole type

(h) provide independent zones of protection (including transfer bus if any). If the bus section is provided then each side of bus section shall have separate set of bus bar protection schemes

(i) include individual high speed electrically reset tripping relays for each feeder. However, in case of distributed Bus bar protection, individual trip relay shall not be required if bay unit is having trip duty contacts for breaker tripping.

(j) be transient free in operation

(k) include continuous D.C. supplies supervision

(l) not cause tripping for the differential current below the load current of heaviest loaded feeder. Contractor shall submit application check for the same.

(m) shall include necessary C.T. switching relays wherever C.T. switching is involved and have 'CT' selection incomplete alarm

(n) include protection 'IN/OUT' switch for each zone

(o) shall include trip relays, CT switching relays (if applicable), auxiliary CTs (if applicable) as well as additional power supply modules, input modules etc. as may be required to provide a Bus-bar protection scheme for the complete bus arrangement i.e. for all the bays or breakers including future bays as per the Single line diagram for new substations. However, for extension of bus bar protection scheme in existing substations, scope shall be limited to the bay or breakers covered under this specification. Suitable panels (if required) to mount these are also included in the scope of the work.

(p) In case of distributed Bus bar Protection, the bay units for future bays may be installed in a separate panel and the same shall be located in switchyard

panel room where bus bar protection panel shall be installed.

26.3. Built-in Local Breaker Backup protection feature as a part of bus bar protection scheme shall also be acceptable.

26.4. At existing substations, Bus-bar protection scheme with independent zones for each bus, will be available. All necessary co-ordination for 'AC' and 'DC' interconnections between existing schemes (Panels) and the bays proposed under the scope of this contract shall be fully covered by the bidder. Any auxiliary relay, trip relay, flag relay and multi tap auxiliary CTs (in case of biased differential protection) required to facilitate the operation of the bays covered under this contract shall be fully covered in the scope of the bidder.

26.5. The test terminal blocks (TTB) to be provided shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material with boxes and barriers moulded integrally. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting and testing facilities for CT circuits.

27. WEATHER PROOF RELAY PANELS (If Applicable)

(a) This panel shall include necessary number of electrically reset relays each with at least eight contacts for isolator auxiliary contacts multiplication and for changing the CT and DC circuits to relevant zones of bus bar protection.

(b) The panel shall be sheet steel enclosed and shall be dust, weather and vermin proof. Sheet steel used shall be at least 2.0 mm thick and properly braced to prevent wobbling.

(c) The enclosures of the panel shall provide a degree of protection of not less than IP-55 (as per IEC-60529).

(d) The panel shall be of free standing floor mounting type or pedestal mounting type as per requirement.

(e) The panel shall be provided with double hinged doors with padlocking arrangement.

(f) All doors, removable covers and panels shall be gasketed all around with synthetic gaskets Neoprene/EPDM. However, XLPE gaskets can also be used for fixing protective glass doors. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh

(g) Cable entries shall be from bottom. Suitable removable cable gland plate shall be provided on the cabinet for this purpose.

(h) All sheet steel work shall be degreased, pickled, phosphated and then applied with two coats of zinc chromates primer and two coats of finishing synthetic enamel paint, both inside and outside. The colour of the finishing paint shall be light grey.

(i) Suitable heaters shall be mounted in the panel to prevent condensation. Heaters shall be controlled by thermostats so that the cubicle temperature does not exceed $30^{O}C$. On-off switch and fuse shall be provided. Heater shall be suitable for 230V AC supply Voltage.

(j) The test terminal blocks (TTB) to be provided shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material with boxes and barriers moulded integrally. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting and testing facilities for CT circuits.

28. **FAULT RECORDER**

28.1. The fault recorder shall be provided for transmission line and the fault recorder as in-built feature of line distance relay is also acceptable provided the requirements of

following clauses are met.

28.2. Fault recorder shall be microprocessor based and shall be used to record the graphic form of instantaneous values of voltage and current in all three phases, open delta voltage & neutral current, open or closed position of relay contacts and breakers during the system disturbances.

28.3. The Fault recorder shall consist of individual acquisition units, one for each feeder and an Evaluation unit which is common for the entire Substation. Whenever, more than one acquisition units are connected to an Evaluation unit, necessary hardware and software shall also be supplied for on line transfer of data from all acquisition units to Evaluation unit.

28.4. The acquisition unit is connected with evaluation unit being supplied as described in chapter 17 sub-station automation through bus conforming to IEC 61850. In case of extension sub-station which is equipped with Sub-station Automation System based on IEC 61850, one set of evaluation software shall be supplied and loaded in existing fault recorder evaluation unit. Automatic uploading of disturbance files from acquisition unit to evaluation unit shall be done through existing station bus only conforming to IEC 61850. Necessary configuration/updation including hardware if any shall be in the scope of the contractor.

28.5. In case of extension of existing substation(s) which are without sub-station automation system, one set of Evaluation unit shall be supplied for each substation where ever disturbance recorders are required to be supplied along with necessary evaluation software as specified above. The Evaluation unit shall consist of a desktop personal computer (including at least 17" TFT colour monitor, mouse and keyboard) and printer. The desktop PC shall have Pentium - IV processor or better and having a clock speed 3.0GHz or better. The hard disk capacity of PC shall not be less than 300 GB and RAM capacity shall not be less than 3 GB

28.6. The evaluation unit hardware, for substations having SAS, shall be as described in clause no. 4.0 of chapter sub-station automation system.

28.7. Fault recorder shall have atleast 8 analogue and 16 digital channels for each feeder.

28.8. Acquisition units shall acquire the Disturbance data for the pre-fault and post fault period and transfer them to Evaluation unit automatically to store in the hard disk. The acquisition units shall be located in the protection panels of the respective feeders.

28.9. The acquisition unit shall be suitable for inputs from current transformers with 1A rated secondary and capacitive voltage transformers with 63.5V (phase to neutral voltage) rated secondary. Any device required for processing of input signals in order to make the signals compatible to the Fault recorder equipment shall form an integral part of it. However, such processing of input signals shall in no way distort its waveform.

28.10. The equipment shall be carefully screened, shielded, earthed and protected as may be required for its safe functioning. Also, the Fault recorder shall have stable software, reliable hardware, simplicity of maintenance and immunity from the effects of the hostile environment of EHV switchyard which are prone to various interference signals typically from large switching transients.

28.11. Necessary software for transferring the data automatically from local evaluation unit to a remote station and receiving the same at the remote station through owner's PLCC/VSAT/LEASED LINE shall be provided.

28.12. Evaluation software shall be provided for the analysis and evaluation of the recorded data made available in the PC under WINDOWS environment. The Software features shall include repositioning of analog and digital signals, selection and amplification of time and amplitude scales of each analogue and digital channel, calculation of MAX/MIN frequency, phase difference values, recording of MAX/MIN values etc. of analogue channel, group of signals to be drawn on the same axis etc, listing and numbering of all analogue and digital channels and current, voltage, frequency and phase difference values at the time of fault/tripping. Also, the software should be capable of carrying out Fourier /Harmonic analysis of the current and voltage wave forms. The Disturbance records shall also be available in COMTRADE format (IEEE

standard- Common Format for Transient data Exchange for Power System)

28.13. The Evaluation unit shall be connected to the printer to obtain the graphic form of disturbances whenever desired by the operator.

28.14. Fault recorder acquisition units shall be suitable to operate from 220V DC or 110V DC as available at sub-station. Evaluation unit along with the printer shall normally be connected to 230V, single phase AC supply. In case of failure of AC supply, Evaluation unit and printer shall be switched automatically to the station DC through Inverter of adequate capacity which shall form a part of Fault recorder system. The inverter of adequate capacity shall be provided to cater the requirement specified in chapter sub-station automation clause no. 8.0 and DR evaluation unit.

28.15. The acquisition unit shall have the following features

(a) Facility shall exist to alarm operator in case of any internal faults in the acquisition units such as power supply fail, processor / memory fail etc and same shall be wired to annunciation system.

(b) The frequency response shall be 5 Hz on lower side and 250 Hz or better on upper side.

(c) Scan rate shall be 1000 Hz/channel or better.

(d) Pre-fault time shall not be less than 100 milliseconds and the post fault time shall not be less than 2 seconds (adjustable). If another system fault occurs during one post-fault run time, the recorder shall also be able to record the same. However, the total memory of acquisition unit shall not be less than 5.0 seconds

(e) The open delta voltage and neutral current shall be derived either through software or externally by providing necessary auxiliary transformers.

(f) The acquisition unit shall be typically used to record the following digital channels:

1 Main CB R phase open

2 Main CB Y phase open

3 Main CB B phase open

4 Main-1 carrier received

5 Main-1 protection operated

6 Main/Tie /TBC Auto reclosed operated

7 Over Voltage -Stage-1 /2 operated

8 Reactor / Stub/TEE-1/2/UF protection operated

9 Direct Trip received

10 Main-2 carrier received

11 Main- 2/ Back Up protection operated

12 Bus bar protection operated

13 LBB operated of main /tie/TBC circuit breaker

14 Tie/TBC CB R phase open

15 Tie/TBC CB Y phase open

16 Tie/TBC CB B phase open

(g) In case the Fault recorder is in-built part of line distance protection, above digital channels may be interfaced either externally or internally.

(h) Any digital signal can be programmed to act as trigger for the acquisition unit. Analog channels should have programmable threshold levels for triggers and

selection for over or under levels should be possible.

28.16. The **colour laser** printer shall be provided which shall be compatible with the desktop PC and shall use Plain paper. The print out shall contain the Feeder identity, Date and time (in hour, minute and second up to 100th of a second), identity of trigger source and Graphic form of analogue and digital signals of all the channels. Two packets of **A4 size** paper (500 sheets in each packet) suitable for printer shall be supplied.

28.17. Each Fault recorder shall have its own time generator and the clock of the time generator shall be such that the drift is limited to ±0.5 seconds/day, if allowed to run without synchronisation. Further, Fault recorder shall have facility to synchronise its time generator from Time Synchronisation Equipment having output of following types

- Voltage signal: (0-5V continuously settable, with 50m Sec. minimum pulse duration)
- Potential free contact (Minimum pulse duration of 50 m Sec.)
- IRIG-B
- RS232C

The recorder shall give annunciation in case of absence of synchronising within a specified time.

28.18. Substations where Time Synchronisation Equipment is not available, time generator of any one of the Fault recorders can be taken as master and time generators of other Fault recorders and Event loggers in that station shall be synchronised to follow the master.

29. **DISTANCE TO FAULT LOCATOR** shall

a) be electronic or microprocessor based type

b) be 'On-line' type

c) be suitable for breaker operating time of 2 cycles

d) have built-in display unit

e) the display shall be directly in percent of line length or kilometres without requiring any further calculations

f) have an accuracy of 3% or better for the typical conditions defined for operating timings measurement of distance relays

g) The above accuracy should not be impaired under the following conditions:

- presence of remote end infeed
- predominant D.C. component in fault current
- high fault arc resistance
- severe CVT transients

h) shall have mutual zero sequence compensation unit if fault locator is to be used on double circuit transmission line

i) built in feature of line distance relay is acceptable provided the requirements of above clauses are met

30. TIME SYNCHRONISATION EQUPMENT

30.1. The Time synchronisation equipment shall receive the co-ordinated Universal Time (UTC) **transmitted** through Geo Positioning Satellite System (GPS) and synchronise equipment to the Nepal Standard Time in a substation.

30.2. Time synchronisation equipment shall include antenna, all special cables and processing equipment etc.

30.3. It shall be compatible for synchronisation of Event Loggers, Disturbance recorders and

SCADA at a substation through individual port or through Ethernet realised through optic fibre bus.

30.4. Equipment shall operate up to the ambient temperature of 50 degree centigrade and 80% humidity.

30.5. The synchronisation equipment shall have 2 micro-second accuracy. Equipment shall give real time corresponding to IST (taking into consideration all factors like voltage, & temperature variations, propagation & processing delays etc).

30.6. Equipment shall meet the requirement of IEC 60255 for storage & operation.

30.7. The system shall be able to track the satellites to ensure no interruption of synchronisation signal.

30.8. The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse, as per requirement.

30.9. The equipment offered shall have six (6) output ports. Various combinations of output ports shall be selected by the customer, during detailed engineering, from the following:

- Potential free contact (Minimum pulse duration of 50 milli Seconds.)
- IRIG-B
- RS232C
- SNTP Port

30.10. The equipment shall have a periodic time correction facility of one second periodicity.

30.11. Time synchronisation equipment shall be suitable to operate from 220V DC or 110V DC as available at Substation.

30.12. Equipment shall have real time digital display in hour, minute, second (24 hour mode) & have a separate time display unit to be mounted on the top of control panels having display size of approx. 100 mm height.

31. RELAY TEST KIT

31.1. One relay test kit shall comprise of the following equipment as detailed here under

3 sets	Relay tools kits
2 nos.	Test plugs **for TTB**
2 nos.	Test plugs for using with modular type relays (if applicable)

32. TYPE TESTS

32.1. The reports for following type tests shall be submitted during detailed engineering for the Protective relays, Fault Recorder, Fault locator and Disturbance recorder:

a) Insulation tests as per IEC 60255-5

b) DC Voltage dips and interruptions/Variation as per IEC 6100-4-29.

c) High frequency disturbance test as per IEC 61000-4 16, Class IV (Not applicable for electromechanical relays)

d) Electrostatic discharges as per IEC 61000-4-2, level; 4 (not applicable for Electromechanical relays)

e) Fast transient test as per IEC 61000, Level I**V** (Not applicable for electromechanical relays)

f) Relay characteristics, performance and accuracy test as per IEC 60255

- Steady state Characteristics and operating time
- Dynamic Characteristics and operating time for distance protection relays

and current differential protection relays

- Conformance test as per IEC 61850-10.

For Fault recorder, Disturbance recorder; only performance tests are intended under this item.

g) Tests for thermal and mechanical requirements as per IEC 60255-6

h) Tests for rated burden as per IEC 60255-6

i) Contact performance test as per IEC 60255-0-20 (not applicable for Distance to fault locator and Disturbance recorder)

In case there is a change either in version or in model (Except firmware) of the relay, the contractor has to submit the type test reports for the offered revision/model.

32.2. Steady state & Dynamic characteristics test reports on the distance protection relays, as type test, shall be based on test programme specified in Appendix A on simulator/network analyser/PTL. Alternatively, the files generated using Electromagnetic transient Programme (EMTP) can also be used for carrying out the above tests. Single source dynamic tests on transformer differential relay shall be/ should have been conducted based on general guidelines specified in CIGRE committee 34 report on Evaluation of characteristics and performance of Power system protection relays and protective systems.

33. CONFIGURATION OF RELAY AND PROTECTION PANELS

The following is the general criteria for the selection of the equipment to be provided in each type of panel. However, contractor can optimise the requirement of panels by suitably clubbing the feeder protection and CB relay panels. It may be noted that Main-I and Main-II protections for line cannot be provided in single panel. Similarly, Group-I & Group-II protections for transformer cannot be provided in single panel.

CONTROL PANEL

Various types of control panels shall consist of the following

a	Ammeter Transformer	3 set for each Line, BC, TBC Bus section, Bus Reactor and
b	Ammeter with Selector switch	1 set for each line reactor
c	Wattmeter with transducer	1 set for each line, transformer
d	Varmeter with transducer	1 set for each line, transformer, Bus reactor
e	Varmeter with transducer	1 set for each Line Reactor
f	CB Control switch	1 no. for each Circuit breaker
g	Isolator Control switch	1 no. for each isolator
h	Semaphore	1 no. for each earth switch

i	Red indicating lamp	1 no.	for each Circuit breaker
j	Red indicating lamp	1 no.	for each isolator
k	Green indicating lamp	1 no.	for each Circuit breaker
l	Green indicating lamp	1 no.	for each isolator
m	White indicating lamp (DC healthy lamp)	2 nos.	for each feeder
n	Annunciation windows with associated annunciation relays	18 nos.	for each feeder
o	Push button for alarm Accept/reset/lamp test	3 nos.	for each control panel
p	Synchronising Socket	1 no.	for each Circuit Breaker if required
q	Synchronising selector Switch required	1 no.	for each Circuit Breaker switch if
r	Protection Transfer Switch	1 no.	for each breaker in case of DMT /DM*/SMT scheme (Except TBC And BC Breaker)-*with Bypass ISO
s	Mimic to represent SLD	Lot	in all control panels
t	Voltmeter with selector reactor Switch	1 no	for each line, transformer, bus
u	Cut out, mounting and wiring for RWTI and selector switch	Lot	for transformers/reactors

Notes:

1 For transformer feeders, all equipment of control panel shall be provided separately for HV and MV sides.

2. In case of incomplete diameter (D and I type layouts), control panel shall be equipped fully as if the diameter is complete, unless otherwise specified. Annunciation relays shall also be provided for the same and if required, necessary panel shall be supplied to accommodate the same.

3. The above list of equipment mentioned for control panel is generally applicable

unless it is defined elsewhere and in case of bay extension in existing substations, necessary equipment for matching the existing control panel shall be supplied.

4. Common synchronising switch is also acceptable in Synchronising trolley for new Substations. In this case, individual synchronising selector switch is not required for each Circuit Breaker in control panel

5. Each line /HV side of transformer/MV/LV side of transformer /Bus reactor /TBC /BC/ Bus Section shall be considered as one feeder for above purpose.

LINE PROTECTION PANEL (220 & 132kV)

The Line Protection panel for transmission lines shall consist of following protection features/schemes

Sl. No.	Description	220kV	132kV
1.	Main-1 Numerical Distance protection scheme	1 Set	1 Set
2.	Main-2 Numerical Distance protection scheme	1 Set	NIL
3.	Over Voltage Protection Scheme	NIL	NIL
4.	Fault Recorder	1 Set	NIL
5.	Distance to fault Locator	1 Set	1 Set
6.	3 Phase Trip Relays	2 Nos.	2 Nos.
7.	Flag relays, carrier receive relays, aux. Relays, timers etc as per scheme requirements	As required	As required
8.	Under Voltage protection relay for isolator/earth switch	2 Nos	2 Nos
9. .	Cut-out and wiring with TTB for supplied energy meter	1 Set	1 Set
10.	Directional Back up Over current and E/F protection scheme	NIL	1 Set

In a substation where 220 KV lines are under the scope of the contract, bidder is required to give identical Main-1 and Main-2 distance protection schemes for all voltage levels.

a) 33 KV LINE CONTROL & PROTECTION PANEL (For Substation with Automation)

Sl No.	DESCRIPTION	QTY
1	Bay Control Unit/Bay Control & Protection Unit	1NO.
2	Numerical Non-Directional Over Current and Earth Fault Relay 1No.with High Set Feature and in built LBB protection (LBB function as part of BCU is acceptable)	1NO.
3	Electronic Trivector Meter with 0.2 Class Accuracy with RS 485, RS 232 & Front Optical port)	1NO.
4	Master Trip Relay with adequate no of contacts 1 No. and Electrical Resettable type	1NO.
5	CB Troubles and Alarm (Part of BCU)	1 SET
6	Metering (part of BCU)	1 SET

b) 132/33kV TRANSFORMER CONTROL & PROTECTION RELAY PANEL

I. The protection panel for 132/33kV Transformer shall consist of the following equipment.

		132kV Side	33kV
1	Transformer Differential protection scheme	1 no	NIL
2	Restricted Earth fault protection scheme	1 no	1 no
3	Directional back up over current and E/F Relay With non-directional high set feature	1set	Nil
4	Non-Directional back up over current and E/F Relay with non-directional high set feature (Part of 33kV BCU is acceptable)	NIL	1 Set
5	Over fluxing protection scheme	Nil	1No.
6	Over load protection scheme	1No.	Nil
7	Three phase trip relays	2No.	2No.
8	Trip supervision relay	2No.	2No.
9	Scheme requirements including transformer Alarms and trip function	Lot	Lot
10	Disturbance Recorder	1No.	-------
11	Revenue Energy meter (As per T.S. Chapter-1)	1No.	1No.

$ BCU for 220kV&132kV Bays has been included in the BOQ details of SAS.

c) 33kV BREAKER RELAY PANEL
(Acceptable as Part of Line /transformer Relay panel)

The breaker relay panel for 33kV shall comprise of the following:

	Without A/R
1. DC supply supervision relay	2 no.
2.Trip circuit supervision relays	2 nos.
3. Emergency CB TNC Switches	1 No.
4. Flag relays, aux. relays, timers, trip relays etc. As per scheme requirements. (Acceptable as part of BCU)	Lot

d) <u>TRANSFORMER PROTECTION PANEL (220/132kV)</u>

The protection panel for Auto transformer/Transformer shall consists of the following features/schemes:

S. No.	Description	HV side	MV/LV side
1.	Transformer Differential Protection scheme	1 Nos.	Nil
2.	Restricted Earth fault protection scheme	1 no.	1 no@
	@ Not applicable for auto-transformer		
3.	Directional back up O/C and E/F relay with non-directional high set feature	1 set	1 set
4.	Over Fluxing Protection scheme	1 no.	--
5.	Overload protection scheme	1 no.	NIL
6.	Three phase trip relays	2 nos.	2 nos.
7.	CVT selection relays as per scheme requirement	Lot	Lot
8.	Cut-out and wiring with TTB for supplied energy meter	1 set	1 set
9.	Transformer Neutral Current relay for 1-Phase transformer bank	1 Set	
1(	Flag Relays/Aux. Relays for wiring Transformer auxiliary protection contacts such as Buchholz, Oil Temperature, Winding Temperature, PRV, OLTC Buchholz etc. as per scheme requirements	As required	

The above protection schemes may be clubbed in Group-I/II as per clause no. 21 of technical specification.

e) REACTOR PROTECTION PANEL (220kV & 132kV)

The protection panel for Reactor shall consist of the following protection features/schemes:

Sl. No.	Description	Qty.
1.	Reactor Differential Protection scheme	1 no.
2.	Restricted Earth fault Protection scheme	1 no.
3.	Reactor back up impedance protection scheme	1 set
4.	Three phase trip relays	2 nos.
5.	CVT selection relay as per scheme requirement	Lot
6.	Flag Relays/Aux. Relays for wiring Reactor auxiliary protection contacts such as Buchholz, Oil Temperature, Winding Temperature, PRV etc. as per scheme requirements	As required

f) BREAKER RELAY PANEL (220kV & 132kV)

The breaker relay panel shall comprise of the following:

Sl. No.	Description	With A/R	Without A/R
1.	Breaker failure Protection Scheme	1 No.	1 No.
2.	DC supply Supervision relay	2 Nos.	2 Nos.
3.	Trip Circuit supervision relays#	6 Nos.	6 Nos.
4.	Auto-reclose scheme (if standalone)	1 Nos.	NIL
5.	Flag relays, aux relays, timers, trip	As required	As required

relays as per scheme requirements

Trip supervision relays shall be 2 or 6 numbers as per no. of trip coils for each 132KV Circuit breaker

Note: Equipment/relays to be provided under CB Relay Panel may be accommodated in the Protection Panels to be provided for Transmission Line/Transformer/Reactor as applicable.

34. ERECTION AND MAINTENANCE TOOL EQUIPMENTS

All special testing equipment required for the installation and maintenance of the apparatus, instruments devices shall be furnished in relevant schedule

35. TROPICALISATION

Control room will be normally air-cooled/air- conditioned. All equipment shall however be suitable for installation in a tropical monsoon area having hot, humid climate and dry and dusty seasons with ambient conditions specified in the specification. All control wiring, equipment and accessories shall be protected against fungus growth, condensation, vermin and other harmful effects due to tropical environment.

Test programme for distance relays

General Comments:

1. These test cases are evolved from the report of working group 04 of study committee 34 (Protection) on evaluation of characteristics and performance of power system protection relays and protective systems. For any further guidelines required for carrying out the tests, reference may be made to the above document.
2. The test shall be carried out using network configuration and system parameters as shown in the figure-1
3. All denotations regarding fault location, breakers etc are referred in figure –1
4. The fault inception angles are referred to R- N voltage for all types of faults
5. The fault inception angle is zero degree unless otherwise specified
6. Where not stated specifically, the fault resistance (Rf) shall be zero or minimum as possible in simulator
7. Single pole circuit breakers are to be used
8. The power flow in double source test is 500 MW

System parameters

System voltage =400KV

CTR= 1000/1

PTR = 400000/110 (with CVT, the parameters of CVT model are shown in figure –2)

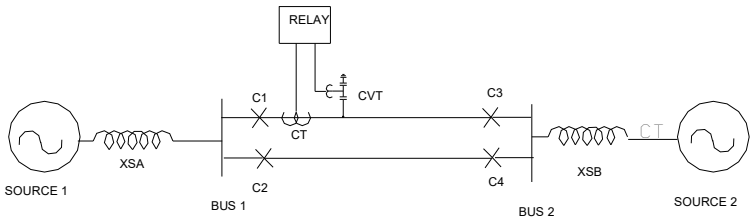

FIGURE 1

Line parameters/km

Positive Sequence Resistance, (r1)	= 0. 02897 Ω
Positive Sequence Reactance (x1)	= 0.3072 Ω
Zero Sequence Resistance (r0)	= 0.2597 Ω
Zero Sequence Reactance (x1)	= 1.0223 Ω
Zero Sequence Mutual Resistance (rm)	= 0.2281 Ω
Zero Sequence Mutual Reactance (xm)	= 0.6221 Ω
Zero Sequence succeptance (bo)	= 2.347 μ mho
Positive Sequence succeptance (b1)	=3.630 μ mho

Type of line	Short		Long
Secondary line impedance	2 Ω		20 Ω*
Length of line in Kms	23.57		235.7
SIR	4	15	4
Source impedance (pry) (at a time constant of 50 ms)	29.09 Ω (5500 MVA)	109.09 Ω (1467 MVA)	290.9 Ω (550 MVA)

* Alternatively, the tests can be done with 10 Ω secondary impedance and source impedance may accordingly be modified

CVT Model

XC1	1.455 μ mho
XC2	27.646 μ mho
RI	320 Ω
XLI	34243 Ω
Ra	4.200 Ω
Xla	197.92 Ω
Rc	14.00 Ω
Transformation ratio of Intermediate transformer	181.8

Details of fault cases to be done

Sl no	Description	Single source with short line (2 Ω)		Single source long line (20 Ω)	Double source with short double line (2 Ω)	Double source with long single line (20 Ω)
		CLOSE C1, OPEN C2,C3,C4		CLOSE C1, OPEN C2,C3,C4	CLOSE C1, C2,C3,C4	CLOSE C1,C3 OPEN C2,C4
		SIR=4	SIR=15	SIR =4	SIR = 4	SIR=4
1	Dynamic accuracy for zone 1	Tests to be done at 2 locations (84 % and 76 % of line length	Tests to be done at 2 locations (84 % and 76 % of line length) X 4 faults (RN , YB, YBN, RYB)	Tests to be done at 2 locations (84 % and 76 % of line length) X 4		Tests to be done at 2 locations (84% and 76% of line length) X 4

Sl no	Description	Single source with short line (2 Ω)		Single source long line (20 Ω)	Double source with short double line (2 Ω)	Double source with long single line (20 Ω)
		) X 4 faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°, 90°)= 16 cases	X 2 fault inception angle (0°,90°)= 16 cases	faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°,90°)= 16 cases		faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°, 90°)= 16 cases
2	Operating time for zone 1 at SIR =4	Tests to be done at 3 locations (0% , 40% and 64% of line length) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°, 30°,60° and 90°) = 48 cases	Tests to be done at 3 locations (0 % , 40 % and 64 % of line length) X 4 faults (RN , YB, YBN, RYB) X 4 fault inception angle (0°,30°,60°and 90°)= 48 cases	Tests to be done at 3 locations (0 % , 40 % and 64 % of line length) X 4 faults (RN , YB, YBN, RYB) X 4 fault inception angle (0°, 30°,60° and 90°)= 48 cases	Tests to be done at 1 location (40 % of line length) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°,30°,60° and 90 °)= 16 cases	Tests to be done at 1 location (40 % of line length) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°,30°,60° and 90°)= 16cases
3	Operating time for zone II and Zone III	Tests to be done at 1 location (100 % of line length) X 1 faults (RN, YB, YBN, RYB) X 2 zones (II and III) = 2 cases	Tests to be done at 1 location (100 % of line length) X 1 faults (RN , YB, YBN, RYB) X 2 zones (II and III) = 2 cases	Tests to be done at 1 location (100 % of line length) X 1 faults (RN , YB, YBN, RYB) X 2 Zones (II and III) = 2 cases		
4	Switch on to fault feature			Tests to be done at 2 location (0 % and 32 %) X 1 faults (RYB) Any fault inception angle = 2 cases		
5	Operation during current				Tests to be done at 2	

Sl no	Description	Single source with short line (2 Ω)		Single source long line (20 Ω)	Double source with short double line (2 Ω)	Double source with long single line (20 Ω)
	reversal				location (0 % and 80 % of line length) X 1 faults (RN) X 1 fault inception angle (0 degrees) = 2 cases	
		CLOSE C1, OPEN C2,C3,C4		CLOSE C1, OPEN C2,C3,C4	CLOSE C1, C2,C3,C4	CLOSE C1,C3 OPEN C2,C4
		SIR=4	SIR=15	SIR =4	SIR = 4	SIR=4
6	Operation at simultaneous faults				Tests to be done at 2 location (8 % and 64 % of line length) X 2 faults (RN in circuit 1 to BN in circuit 2 and RN in circuit 1 to RYN in circuit 2 in 10 ms) X 1 fault inception angle (0 °) = 4 cases (*1)	
7	Directional sensitivity					Tests to be done at 1 location (0% reverse) X 6 faults (RN ,YB, YBN , RYB,RN with Rf=13.75 ohm(sec) and RYN with Rf= 13.75 Ohm (sec) X 2 fault inception angle (0° ,90°) = 12cases
8	Limit for fault resistance					Tests to be done at 2 location (0% and 68 % of

Sl no	Description	Single source with short line (2 Ω)		Single source long line (20 Ω)	Double source with short double line (2 Ω)	Double source with long single line (20 Ω)
						line length) X 1 fault (RN with Rf=13.75 ohm(sec) X 2 fault inception angle (0°,90°) = 4 cases
9	Operation at evolving faults					Tests to be done at 2 location (32 % and 0% of line length) X 2 faults (RN to RYN) x in 2 timings (10 ms and 30 ms) X 2 load direction (from A to B and from B to A) = 16 cases
9	Fault locator function , in case the same is offered as built in feature	Measure fault location for all cases under 1 and 2	Measure fault location for all cases under 1 and 2	Measure fault location for all cases under 1 and 2	Measure fault location for all cases under 2 and 6	Measure fault location for all cases under 2, 7 and 9

SECTION 09- 33 KV AND 11 KV INDOOR SWITCHGEAR

36 KV SWITCHGEAR PANEL

1.1 GENERAL

This specification covers the design, manufacture, assembly, factory test, supply, delivery field test and installation of 36 kV, metal clad, indoor switchgear, complete in all respects with all equipment fittings and accessories for efficient and trouble-free operation as specified herein under. The 33 kV switchgears shall be of single - tier type.

The equipment specified in this Section shall conform to the latest edition of the appropriate IEC specifications and/or other recognized international standards. In particular:

IEC 60056	High-voltage alternating switchgear
IEC 62271	High-voltage alternating switchgear and control gear
IEC 60298	Metal enclosed switchgear and control gear for rated voltage up to 38 kV
IEC 60529	Degree of protection provided by enclosures
IEC 60694	Common specifications for high-voltage switchgear and control gear standards

1.2 EQUIPMENT TO BE FURNISHED

The following complete 36 kV metal clad, cubicle type, indoor switchgears (including all as stated in clause 1.8) shall be furnished:

Single tier:

(a) 33 kV, 2500A indoor VCB switchgears for transformer incomer feeder panel for 33 kV side of 132/33 kV transformer with triple pole operating spring charging mechanism with motor.

(b) 33 kV, 1250A indoor VCB switchgears for transformer feeder panel with triple pole operating spring charging mechanism with motor.

(c) 33 kV, 630A indoor VCB switchgears for outgoing feeder panel with triple pole operating spring charging mechanism with motor.

(d) Special tools and tackle required for operation and maintenance of equipment as specified.

1.3 DESIGN REQUIREMENTS

The switchgear will be used for 33 kV, 3 phases, 50 Hz system.

Circuit breakers shall be installed Indoor for switching Transformer and Line. All equipment and accessories shall be provided with sub-tropical finish to prevent fungus growth.

The maximum temperature rise in any part of the equipment at specified rating shall not exceed the permissible limits as stipulated in relevant standards. The de-rating of the equipment shall be made taking 50 degree Celsius as an ambient temperature of the site, if it is designed for any lower ambient temperature.

The rated peak short circuit current or the rated short time current carried by the equipment shall not cause;

a. Mechanical damage to any part of the equipment

b. Separation of contacts.

c. Insulation damage of "Current Carrying Part"

Technical particulars of the circuit breaker shall be as per specified.

All auxiliary equipment shall be suitable for 3 phase-4 wire, 50 Hz, 400V AC or 1Phase, 230 V AC.

All controls shall be suitable for 220V DC.

The VCB should be Indoor type with minimal maintenance, high reliability and completely free from menace of vermin. It should be designed with adequate clearances; sufficient creepage to suit polluted atmosphere and the communication between the inside of pole unit and the atmosphere is not desirable. Each breaker should have three porcelain enclosed vacuum type interrupters, which is required to provide a high insulation and an excellent breaking capability.

Technical particulars of 36 kV indoor switchgear shall be as per Appendix 2.2-1 enclosed.

1.4 DESIGN REQUIREMENTS

33 kV, Indoor Metal Clad VCB Switchgear with Triple Pole operating, spring charging Mechanism with motor for 33 kV, Incomer and Outgoing feeders.

1.4.1 General Requirement

33 kV cubicle type Indoor Switchgear Panel shall be an air insulated metal clad switchgear with withdraw able vacuum circuit breaker with the fault interrupting capacity of 25 KA at 33 kV solidly grounded system. The switchgear shall be arranged in connection with the existing 33 kV Bus Bar System. The cubicle shall be of modular design provided with space heaters, with the following modules integrated neatly to form dead front type switchgear capable of extension on the both side, forming a single row, single bus bar switchgear panels.

- Breaker compartment.
- Bus bar Compartment
- Cable, C.T. Compartment
- Instrument and Relay Compartment (LV Compartment)
- 33 kV P.T. Compartment.

1.4.2 All Switchgear operation shall be performed behind a close door. Additionally, it shall even be possible to perform all preparations for work inside the cubicle with full degree of protection.

1.4.3 The use of insulation material shall be reduced to minimum; only ripped insulators with high-anti-tracking characteristics shall be used for necessary conductor supports.

1.4.4 Cubicle front shall be covered by a door with inspection windows for mechanical indication for CB ON/OFF position, spring charged and counter indication of CB operation.

1.4.5 The cubicle shall be of modular design consisting of separate modules for Bus bar, circuit breaker, cable and low voltage compartment, and instrument component. Each compartment shall have its own pressure relief flap. High voltage cable termination compartment shall have a steel wire grid mesh fitted inside the back cover so as to prevent accidental contact with the live parts during the routine inspection of the panels. The fixed contact shall be mounted in bushing moved by circuit breaker carriage.

1.4.6 Earthing to cable feeder and Bus bar shall be done via earthing switch manually operated from panel front.

1.4.7 Fixed contacts shall have flat silver plating and contact pressure of male and female contacts during connected position according to the International Standard.

1.4.8 Bus bars and Jumpers shall have made of flat electrolytic bare copper contact with special heat shrinkable sleeves which provide effective insulation between phases or phase to earth, even if bridged by vermin or other conducting body and suitable for rated current not less than 2500 A. Bus bar shall be latched per panel and easy to replace by standard normal material. Flexible insulation shrouds shall cover the Bus bar to Jumper Joints and jumper to stationary contact joints.

1.4.9 Bottom of the cubicle shall be covered with a bottom mica plate through which cables are passed into the panel.

1.4.10 The proposed switchgear panel shall be extendible on both sides.

1.4.11 The proposed switchgear panel shall be suitable for mounting of standard Current and Voltage Transformer according to IEC standard.

1.4.12 The circuit breaker cubicle shall be designed as to be vermin proof to prevent the entry of the vermin, reptiles, mouse etc. inside the compartments of the cubicles

1.5. WITHDRAWABLE PART (CARRIAGE)

i. The chassis shall be made of sheet-steel section and shall carry the switching device, moving mechanism, 4 rolling contact bearings for movement and interlocking mechanism. Movement for carriage shall be done manually and shall be independent from switch room floor.

ii. Moving contacts shall be double flat contact with silver plated contact pieces. The flexible fixing shall allow high tolerance and avoiding overheating.

iii. Connection of auxiliary supply to the fixed part shall be verified via multi-pole plug, which shall be included in the interlocking system. For the easy and assured insert of the plug the hose should come from the fixed part and the plug shall be on with-draw able part.

iv. CB and Isolating Switch Carriage shall have the provision to operate mechanically behind the closed door in Operating and Test Position.

v. Carriage of the same rating shall be exchangeable. It shall be possible to insert CB with higher current in lower rated cubicle but not vice versa. Other Requirements for removable parts:

Removable parts are intended to be used as a disconnector or intended to be removed and replaced more often than only for maintenance purposes, mechanical operation tests shall also be possible as per IEC 62271-102.

The requirement that it shall be possible to know the operating position of the disconnector earthing switch by applying following conditions:

- The isolating distance is visible.
- The position of the withdrawable part, in relation to the fixed part, is clearly visible and the positions corresponding to full connection and full isolation are clearly identified.
- The position of the withdrawable part is indicated by a reliable indicating device.

Any removable part shall be so attached to the fixed part that its contacts will not open inadvertently due to forces which may occur in service, in particular those due to a short circuit.

1.6 33 KV METALCLAD SWITCHGEAR:

i. Main Equipment Characteristics

a. Insulation:

i. 33 kV primary equipment shall be insulated to meet or exceed the following criteria:

- Rated Lightning Impulse Withstand Voltage (kVp): 170
- Rated Power Frequency Withstand Voltage (kVrms): 70

ii. 11kV cubicles shall be designed to provide phase segregation within the enclosures.

b. Clearances:

i. 33 kV Primary Equipment clearances between phases and phase to earth shall not be less than as per IEC, whichever is greater.

ii. The layout of the equipment shall provide for safe access for operation and maintenance whilst the remaining sections equipment are alive.

iii. Minimum clearances in air for the 33 kV 'Indoor' Primary Equipment shall not be less than as per IEC.

iv. The Bus bars shall be insulated by High Grade Phase Insulation. Bus bars partitioning shall be done by means of a bushing plate with Cast-Resin Insulators and Cubicles shall be partitioning with earthed sheet metal barriers.

v. When it is not practicable to disconnect the cable for the dielectric tests from the metal enclosed switchgear and control gear, those parts which remain

connected to the cable shall be capable of withstanding the cable test voltages as stated by the relevant cable standard.

vi. The dimension (especially height) of one termination point of the Trunking Chamber should be matching with the Bus Bar Height of the existing VCB and the height of other termination point of Trunking Chamber should be matching with Bus Bar height of New VCB.

c. Current Carrying Capacity:

i. Switchgear 33 kV Bus bars and Connections thereto shall be designed to carry current corresponding to Maximum Permissible Overload of the connected equipment without exceeding temperature rise specified in the Relevant Standards.

ii. Switchgear 33 kV Bus bar shall be designed to safely withstand with an appropriate margin of the Mechanical and Thermal Effects corresponding to the following short circuit currents:

Symmetrical three-phase

- (Is) (kA)rms: 31.5
- Peak making Current (kA)p: 78.75

1.7 VACUUM CIRCUIT BREAKERS

1.7.1 General

The 11 kV Circuit Breakers shall be Vacuum type, easily withdraw-able and housed in a cubicle. It shall consist of three Vacuum Interrupter, three Supports and the Operating Mechanism. The Operating Mechanism shall have either Motor Charged Spring Operated or Solenoid Operated, with provision of hand operated mechanism. With the breaker in close state, spring energy shall be for a "Trip/Close/Trip" Cycle.

1.7.2 Main Data

Type: Metal enclosed Indoor switchgear cubicle type with vacuum interrupters.

- Nominal Service Voltage (kV): 33
- Rated Voltage (kV): 36
- Rated Frequency (Hz): 50
- Rated Nominal Current for Incomer: 2500A/ 1250A
- Rated Nominal Current for Outgoing feeder: 630 A
- Rated Short-Time Breaking Current (asymmetrical) at Rated Voltage: 31.5 kA (rms)
- Rated Short-Time Making Current at Rated Voltage (kA) p: 78.75 (kA)p
- Rated Operating Mechanism: Motor-spring operated or solenoid operated. : Suitable for Trip/close /Trip cycle.
- Provision for Manual Operation also.

1.7.3 Technical Requirements:

i. The Circuit Breakers shall meet requirements of IEC 56 & IEC 62271.

ii. Vacuum Interrupter:

The Arcing chamber with the two stem connected contacts shall be located between two ceramic insulators. One contact shall be fixed to the housing and the moving contact shall be connected to the housing via vacuum tight bellows. The metal bellows shall enable the moving contact to carry out its strokes. The metal bellows must be able to withstand the movement corresponding to 30,000 make/break operations without failing. The insulators shall be made of metallized aluminum oxide ceramic, which permits them to be brazed to metal so that there is no need to use conventional seals. The Vacuum Interrupter shall remain vacuum tight throughout its working life.

The Contact surfaces should be free of impurities and pollution layers. Materials of high conductivity should be used such that the contact resistance will be very low.

iii. The Operating Mechanism shall have single Trip Coil and be electrically Trip free and anti-pumping.

iv. The Spring Charging Motor, the Closing Coil, the Tripping Coils and all other control devices of all circuit Breakers shall be suitable for 110V dc Operation.

v. A Manually Operated Mechanism for closing and tripping shall be provided in the breaker cubicle for Maintenance and Emergency Operation. This device shall be so interlocked that while it is operative, the breaker cannot be operated remotely.

vi. Each Circuit Breakers shall be equipped with an Operation Counter (to register tripping operations) and position indicator, on the cubicle front.

vii. Provision shall be made for Remote alarm/indication of the following status through a pair of NC+NO contacts:

- Circuit Breaker "Open".
- Circuit Breaker "Closed".
- Circuit Breaker "Trip".
- Trip Circuit Healthy.
- Circuit Breaker "Failure"

viii. The circuit breaker shall be equipped with a local control switch and local remote selector switch auxiliary contacts for remote indication. All contacts shall be wired to terminal block in the breaker cubicle. Control cable and the indicator box shall have at least three numbers of spare cables and the indicators for future use. CT terminal shall be disconnecting type.

ix. Each of the circuit breakers shall be housed in a freestanding indoor type cubicle. This cubicle (and others comprised in the 33 KV metal clad switchgear) shall be of standard construction and shall be suitable for attachment of cable connection as described in relevant cubicles. These cubicles shall be equipped with copper earthing bus bars of not less than 400 Sq.mm.

x. Plugging contact apertures shall be fitted with fully automatic metal safety shutters to close the apertures and prevent access to live part when truck partition is withdrawn and to open when the truck partition is being plugged in. The shutters shall form reasonable dust, drip, fire and insect proof enclosures over the apertures.

xi. Auxiliary Switches shall be provided as required for Indication, Control, Protection and Interlocking. In addition, a minimum of two Normally Open and two Normally Closed Auxiliary Contacts shall be provided as spare contacts. All available contacts of Auxiliary Switch Assembly shall be wired to the Terminal Blocks on the fixed portion of the equipment of the switches and terminals shall be such as to facilitate future extension.

xii. All auxiliary switches shall have contacts with strong wiping action. The switches shall be located in an accessible position and adequate physical protection shall be provided. xiii The Circuit Breakers shall be tested in accordance with IEC56 and IEC60 and shall include the following routine tests:

- Mechanical operating tests
- Power Frequency Voltage withstand tests.
- Tests on auxiliary and control circuits

xiii. The quality assurance of the equipment and their auxiliary shall be of ISO 9001 Standard. An updated copy of its certificate shall be submitted.

xiv. The Minimum Operating Cycle (without maintenance) of Interrupters and Operating Mechanisms shall be suitable for operation over 10Years or 10,000 operations with rated current or 100 operation with rated short circuit current and overall life shall be more than 30,000 operating cycles for bellows.

xv. The Vacuum Circuit Breaker installed in the Switchgear shall move into following position in the Circuit Breaker Components:

- Running Position (Run) Main Circuit and Control Circuit connected to all circuits.
- Test Position (Test)

Main circuit separated from the circuit and only Control Circuits are connected.

- Disconnected Position

As a Control Circuit Connector that would be plugged by hand during the test Position both Main and Control circuits are disconnected from the Circuit.

Special alarms and indications and remote control of 33 kV circuit breakers (off control) shall also be provided for the selected feeders to be controlled from the Load Dispatch Centre (LDC) of NEA as described in related chapter.

EARTHING

i. To ensure personnel protection during maintenance work, all parts of the main circuit to which access is required or provided shall be capable of being earthed prior becoming accessible.

ii. Factory built transport units shall be interconnected during final installation through an earthing conductor. This interconnection between the adjacent transport units shall be capable of carrying the rated short time and peak withstand current for the earthing circuit.

iii. The current density in the earthing conductor, (for copper) shall under the specified earth fault conditions not exceed 200A/mm2 for a rated duration of short circuit of 1 Sec. Its cross section shall not be less than 30mm2.

iv. The enclosure of each functional unit shall be connected to this earthing conductor. All the metallic parts intended to be earthed and not belonging to a main or auxiliary circuit shall also be connected to the earthing conductor directly or through metallic structural parts.

v. The interconnections within the functional unit shall be secured by a technology providing electrical continuity between the frame, covers, doors, partitions or other structural parts. Doors of the high voltage compartments shall be connected to the frame by adequate means.

1.7.4. EARTHING SWITCHES

1.7.4.1 The 33 kV metal clad switchgear shall include earthing switches to facilitate earthing of each cubicle as specified.

The Earthing Switch is operated by means of detachable lever from outside the cable compartment. It shall be mechanically interlocked with the CB so that the earthing switch in close position in section of CB truck into the service position is not possible. The operation of the Earthing Switch shall not be possible as long as the CB is not in isolated position.

1.7.4.2 **Main Data**

Rated Voltage kV:	36 kV
Rated Current for Incomer, Amp:	2500/1250 A
Rated Short-Time Breaking Current (rms) (asymmetrical) at Rated Voltage:	31.5kA
Rated Short-Time Making Current at Rated	78.75 (kA)p

Voltage:

1.7.4.3 **Technical Requirements**:

i. The Earthing Switches shall meet the requirements of IEC129.

ii. Auxiliary Switches shall be provided as specified for the Circuit Breakers.

iii. Provision shall be made for padlocking in the Open and Closed position.

iv. Manual control of the switches and Position indicator external to the cubicle shall be provided.

v. The Earthing Switch shall be interlocked manually with circuit breaker.

1.7.5 INTERLOCKING

The following operation shall be taken place only when the under stated interlocking conditions are fulfilled to ensure Personnel and Operational Safety.

1.7.5.1 Transferring the withdrawable part from the Disconnecting Position to the Service Position:

i. Control Circuit Plug Inserted

ii. High Voltage Compartment Door closed.

iii. Circuit Breaker in OPEN Position.

iv. Earthing Switch in OPEN Position

1.7.5.2 Transferring the Withdrawable part from the Service Position to the Disconnected Position.

Circuit Breaker in OPEN Position.

1.7.5.3 Operating the Circuit breaker

i. Withdrawal part in the Interlocked Final Position (Service or Disconnecting position)

1.7.5.4 Operating the Earth Switch

i. Withdrawal part in the interlocked disconnected position. Windows shall be provided to allow visual inspection.

The Switches shall be tested in accordance with IEC129 and IEC265 and shall include the following routine tests:

- Operating and Mechanical tests
- Measurements of the resistance of the main circuit.

1.8 LOW VOLTAGE COMPARTMENT:

The Low Voltage Compartment of the Switchgear shall be located on the front and on the top front of the Panel and shall be accessible with a separate door and partitioned against high voltage part. Connection of control and Metering cable is by means of a Multi pole plug to the withdrawable part possibly at front face of the breaker. Low voltage devices metering and protection equipment shall be mounted flush in the door or on the mounting plate inside.

Wiring inside the cubicle shall be done by 2.5 Sq. mm insulated stranded copper wires for current circuits and 2.5 Sq. mm for voltage circuits. All power circuit shall be wired with 4 Sq. mm cables.

The following equipment shall be mounted in the low voltage compartment.

- 1 No with A/S Switch.
- 1 No. Voltmeter, Digital Type of 0.5 class, with Voltage Selector switch.

- 1 No. MW Meter, Digital type of 0.5 class
- For Incomer and outgoing feeders - 1 No Energy meter 3Phase 4 wire, Digital, programmable via Optical Port, 3P4W, class 0.5 designation, Current rating 1- 10Amp, Voltage range 0-480 V. The energy meter should have test pulse and calibrating facility. The Energy meters should be from the list of manufacturers.
- **Directional Over current and Earth fault Protection for Incomer**

This protection scheme shall be used as a back-up protection for power transformers low voltage side and as main protection for parallel sub-transmission lines.

(a) Phase over current relay shall:

- have an inverse characteristic with a definite minimum time of 3 secs. at 10 times setting.
- have a variable setting range of 20-200% of rated current.
- have a characteristic angle of 45 degree.
- have a directional controlled low transient over-reach high set instantaneous unit of continuously variable setting range 5-20 times of rated current.
- be of voltage polarized directional controlled type

(b) Directional earth-fault protection

Earth fault over current relay shall:

- be of zero-sequence voltage polarized directional controlled.
- have an inverse characteristic with a definite minimum time of 3 secs. at 10 times setting.
- have an adjustable setting range of 10-80% of rated current.
- have a directional controlled low transient over reach high set instantaneous unit with a continuously variable setting range of 5-20 times of rated current.
- have a characteristics angle of 45 degree.

Non directional over current and Earth fault protection for Outgoing feeders.

- Over current Relay, Numerical Type with Instantaneous tripping for 1A (Secondary Current) and built in Earth fault Relay with Instantaneous Tripping for 1A rating.

  Accuracy Limit → ±5.0%

Over Current Relay:

Setting range 5%-250% in steps of 5% (for Over current element)

Setting range 50% to 2500% in steps of 50% (for High Set Element)

Time Multiplier Setting range 0.025 Sec to 1.00 Sec in steps of 0.025 Sec

Reset Delay 0 to 60 Sec in steps of 1 Sec

Earth fault Relay:

Setting range 5%-250% in steps of 5% (For Earth fault)

Setting range 50% to 2500% in steps of 50% (for High Set Element)

Time Multiplier Setting range 0.025 Sec to 1.00 Sec in steps of 0.025 Sec

Reset Delay 0 to 60 Sec in steps of 1 Sec

Characteristics Selection: SI, EI, VI, LTI, DTL

1.9 CURRENT TRANSFORMERS:

1.9.1. The 11 kV Metal clad Switchgear shall include protection and metering Current Transformers as specified. The Current Transformers shall be Epoxy Resin insulated block type. Current Transformers as follows:

For Incomer Panel Burden	Ratio	Accuracy Class	Burden
-Core 1 (for Metering)	1200-800/1	0.2	15 VA
-Core 2 (for Protection)	1200-800/1	5P20	15 VA
-Core 3 (Differential for Incomer only)	1200-800/1	PS	15 VA

For Outgoing Feeder Panel: Ratio		Accuracy Class	Burden
-Core 1 (for Metering)	400-200/1	0.5	15 VA
-Core 2 (for Protection)	400-200/1	5P20	15 VA
-Core 3	spare		

The current transformer shall comply with the requirements of IEC 185 shall confirm to the specified insulation requirements and shall withstand without damage the applicable short-circuit current specified. Primary ratio taps shall not be accepted.

Maximum temperature rise at rated primary current shall not exceed 50 degree centigrade.

1.9.2 Accuracy classes for the protection and metering shall not be less than 5P20 and 0.5/0.2 respectively. Similarly, Accuracy class for the Differential protection shall not be less than PS. Burden and accuracy class shall be adequate to ensure correct operation of associated protective devices and instruments. Saturation curves shall be provided with CT Characteristics.

1.9.3 Each set of secondary windings shall be wired to suitable terminal blocks and earthed at the first control or relay panel to which they are connected.

1.9.4 Earth Fault Factor should not exceed 1.4 for effectively earthed system.

1.9.5 The continuous thermal current rating shall be 150% of normal current rating.

1.9.6 The Current Transformers shall be tested in accordance with IEC 185 and shall include the following Routine Tests:

i. Verification of terminal markings polarity etc.
ii. Power frequency tests on primary windings.
iii. Partial Discharge Measurement
iv. Power frequency withstand tests on secondary windings.
v. Power Frequency withstand test between sections
vi. Over voltage inter-turn tests.
vii. Determination of ratio error and phase displacement.

1.9.7 Bidders shall submit the flowing Type Test reports conducted by the accredited Test Laboratory.

i. Short Time Current Test.
ii. Temperature Rise Test
iii. Lightening Impulse Test
iv. Determination of Errors
v. Radio Interference Voltage Measurement

All the dielectric Type Test shall be carried out on the same Current Transformer.

1.10. VOLTAGE TRANSFORMERS

1.10.1 The 33 kV Metal clad Switchgear shall include Voltage Transformers in incomer as required by the Single Line Diagram as follows:

i. Type: Epoxy-resin insulated, single pole with 7.3A Primary side fuses
ii. Basic Impulse Level: 170kV
iii. Rated Power Frequency Withstand Voltage: 70 kV
iv. Primary Voltage: 33/√3 kV
v. Secondary Circuit: 110/√3 V
vi. Rated burden: 50 VA
vii. Accuracy classification: 0.2 / 3P Class

1.10.2 The voltage transformers shall comply with the requirements of IEC 186. Accuracy class and burden shall be adequate to ensure the correct operation.

1.10.3 The voltage transformers and their fuses shall meet the specified insulation requirements and have a rated primary voltage of 33 kV with knee of saturation curve not lower than 36 kV and ratios per single line diagram.

1.10.4 The voltage transformer shall be provided with high rupturing capacity (HRC) fuses for primary and secondary circuits. The fuses shall be rated for the short circuit levels specified.

1.10.5 Each set of secondary windings shall be wired to suitable terminal blocks and earthed at the first control or relay panel to which they are connected.

1.10.6 Earth Fault Factor should not exceed 1.4 for effectively earthed system.

1.10.7 Continuous Rated Voltage Factor should be 1.2 and for 8h should be 1.5.

1.10.8 For hermitically sealed Potential Transformer the temperature rise of the oil at the top of the tank or housing shall not exceed 55K.

1.10.9 Power Frequency withstand voltage for the earthed terminal: The terminal of the primary winding intended to be earthed shall, when insulated from the case or frame, be capable of withstanding the rated power frequency short-duration withstand voltage of 3kV (r.m.s.)

1.10.10 The dielectric Dissipation Factor at Um/√3 and ambient should not exceed 0.005.

1.10.11 The rated power frequency-withstand voltage for secondary winding insulation shall be 3kV (rms.)

1.10.12 The Voltage Transformer shall be designed and constructed to withstand without damage, when energized at rated voltage, the mechanical and thermal effects of an external short-circuit for the duration of 1 Sec.

1.10.13 The voltage transformers shall be tested in accordance with IEC 186, and shall include the following routine tests:

i. Verification of terminal markings.
ii. High voltage power frequency withstand test on primary windings.
iii. High voltage power frequency withstand test on secondary windings.
iv. Partial Discharge Measurement.
v. Power Frequency Tests between sections
vi. Determination of Errors

Repeated Power Frequency Tests on Primary windings shall be performed at 80% of the specified test voltage.

1.10.14 Following Types are required to be submitted from the accredited test Laboratory

i. Temperature Rise Test
ii. Short Circuit Withstand Capability Test
iii. Lightening Impulse Test
iv. Switching Impulse Test.
v. Wet Test for Outdoor Type Transformer (N/A)

vi. Determination of Errors

vii. Measurement of the Radio Interference Voltage

All the dielectric Type Test shall be carried out on the same Transformer, unless otherwise specified.

1.10.15 Following Special Tests are required to be done.

i. Measurement of Capacitance & Dielectric Dissipation Factor Test.

1.11. SURGE ARRESTERS FOR INCOMER:

1.11.1 The surge Arresters shall be 30 kV, 10 kA of the gapless Zinc oxide type and suitable for operation under the service conditions specified and be suitable for the protection of Transformer and other substation equipment. The Arresters shall comply with IEC 99-1, IEC99-4.

1.11.2 The surge diverters shall be tested in accordance with IEC 99-4.

1.12 CONTROL PROTECTION AND INSTRUMENTATION:

1.12.1 This covers the detailed requirements for design, manufacture, transport, installation and commissioning of 33 kV Metal clad VCB switchgear.

1.12.2 The substation will normally be attended and operation will be semi-automatic. Normally closing of circuit breakers shall be manual operation and operation of earthing switches will be manual if it is not mentioned.

1.12.3 Local control facilities adjacent to the equipment shall be provided for maintenance, inspection and emergency operation.

1.12.4 The control system shall be designed to permit the following operating modes:

1.12.4.1 Automatic start/stop operation refers to spring-charged motor for operating mechanism of 33 kV VCB.

1.12.4.2 Automatic tripping of 33 kV VCB, LV MCB if faults occur in protected lines equipment or circuits.

1.12.4.3 The control system shall be arranged in such way that it is possible to change between local automatic and local manual control any time.

1.12.4.4 Solid state modular equipment shall be used wherever possible.

1.12.4.5 The designs shall be in general conformity with the single line diagrams and layout drawings accompanying this specification.

1.12.4.6 Under manual control the individual operations shall each be subject to safety interlocks being satisfied.

1.12.4.7 The control scheme shall be operationally simple, safe, easy to maintain and functionally consistent.

1.12.4.8 Each module shall have sufficient test points to felicitate faultfinding. Control circuits shall be brought out to isolating terminals to permit efficient trouble shooting.

1.12.4.9 Each cubicle shall be provided with a sufficient point Annunciation Block to identify an alarm condition, including audible alarm, test, acknowledge and reset push buttons.

1.12.4.10 Control switches for circuit breakers shall be of the discrepancy type. Two independent movements shall be required to initiate an operation.

1.12.4.11 The design shall be such that as to avoid nuisance alarms and shall block those devices, which assume alarm conditions when the equipment is under shutdown. Annunciation Block windows shall be engraved with identification of the alarm condition.

1.12.5 **Annunciators shall have the following sequence**:

Condition	Lamp	Alarm
Normal	Off	Off

Alarm Flashing	On	On
Acknowledge	On	Off
Reset After return:		
Normal	Off	Off
Lamp test	On	Off

1.12.6 REQUIRED SIGNALS / ALARM SYSTEMS:

The switchgear shall have following signalling and alarm system:

- CB Off/On position by green/red lamp
- White lamp for spring charged
- Flag or lamp indication of faults for:

  Over Current Protection, E/F Protection, DC Supply Failure, CB Failure, MCB tripped, AC supply failure.

  All signal lamps shall be LED type.

The design shall avoid nuisance alarms and shall block those devices, which assume alarm conditions when the equipment is under shutdown. Annunciation Block windows shall be engraved with identification of the alarm condition.

1.7.7 The Annunciation Block shall be of solid-state type and suitable for operation at 110 V dc and shall be able to withstand IEC 255 class 3 tests without malfunctioning.

Applicable for Switchgear Panels

1.8 33 kV Switchgear Panel (Incomer and outgoing Feeder) shall consist of metal-clad cubical fitted with:

• Copper Bus bar, 2500A	1 Set
• Fault making earth switch for cable earthing, hand operated with Auxiliary switch	1 set
• Epoxy Resign insulated block type Current Transformer of ratio mentioned above in the clause 1.4.1.	1 set
Withdraw-able module with:	
• Hand operated drive mechanism	1 Set
• Auxiliary block with 4NO+ 4NC contacts for position indication	1 No.
• Multiple Pole lug for control signals	1 No.
• Vacuum circuit breaker with motor operated spring charged Mechanism or solenoid operated mechanism	1 No.
• Close/trip buttons	1 No.
• Trip coil	1 No.
• Closing coil	1 No.
• Counter indicating number of switching operation	1 No.
• Auxiliary block with 11NO + 11NC 1Wi (alarm contact)	1 No.
• Auxiliary switch for spring charged indication	1 No.
In the low voltage compartment the following equipment shall be mounted:	
• 2 pole miniature circuit breakers fitted with auxiliary switch 1NO+1NC	2 No.

• Single Ammeter Cl. 0.5 with A/S switch	
(Range: …. /1A As per CT ratio for Incomer)	
(Range: …. /1A for Feeder Panel)	1 No.
• Voltmeter, Digital Type of 0.5 Accuracy class with voltage selector	
Switch for **Incomer** only	1 No.
• MVA / MW Meter, Digital Type of 0.5 Accuracy Class	
site programmable	1 No.
• kWh meter for 3Phase 4 Wires, accuracy class as specified with Test	
Pulse & Programming Facility	1 No.
• Local/ remote selector switch	1 No.
• Numerical over current relay with Built in Earth fault Relay as	
Specified in 1.3 above	1 No.
• Annunciation Block 2x3 Matrix in Panel	1 No.
• Auxiliary relay and coupling relay	1 No.
• Anti condensation heater in cable compartment	1 No.
Accessories shall consist of:	
• Emergency hand crank for the switch	1No.
• Operation handle for withdrawable module	1No.
• Operation handle for the earthing switch	1No.
• High voltage compartment keys	1No.
• Service Track for removing of withdrawal module	1No.
• Breaker Carriage	1No.

APPENDIX 8 (B): RATING AND FEATURES OF EACH 36 kV SINGLE TIER SWITCHGEAR PANEL COMPLETE

S.No.	Description	Transformer incomer switchgear	Outgoing feeder switchgear
1.	Type	Metal enclosed, cubical indoor type	
2.	Voltage rating: a) Nominal system voltage b) Rated maximum system voltage	 33 kV 36 kV	
3.	Insulation level a) Impulse withstands voltage (crest) b) Power-frequency with stand voltage (1 min.)	 170 kV 70 kV	
4.	Frequency	50 Hz	
5.	Minimum continuous bus-bar rating	2500 A	2500A
6.	Current rating a) Rated continuous current at ambient b) Short circuit breaking current c) Short circuit making current (1 sec)	 2500/1250A 31.5 kA 78.75 kA	 630 A 31.5 kA 78.75 kA
7.	Rated duration of short circuit (tk)	(1 sec)	(1 sec)
8.	Rated capacitive switching currents		
8.1	Rated line charging breaking current	Greater than or equals to 10 kA	
8.2	Rated line charging breaking current	Greater than or equals to 25 kA	
9.	Current transformer a) Current ratio b) Number of cores c) Burden per cores d) Accuracy class	 *1200-800/1 A* 3 15 VA 5P20 /PS/ 0.5	 *400-200/1 A* 3 15 VA 5P20 / 0.5

10.	Potential transformer a) Voltage ratio b) Number per set c) Rated Burden d) Accuracy class e) No. of core	 33000/√3 / 110/√ 3 3 50 VA 3P/0.5 2	
11.	Lightning Arrestor	30 kV	
12.	Metering a) Ammeter scale with selector switch b) Voltmeter scale with selector switch c) Other	 *0– 1200/800A* 0 – 15 kV MVAR	 *0-400/200A* *PF*
13.	Auxiliary supply a) Control circuit and Spring charging motor Space heater and auxiliary equipment.	110 V DC AC, 3 Ph-4 W, 400 V, 50 Hz	
14.	Reclosing duty cycle of Circuit Breaker	O-15 sec-CO	
15.	Total maximum break time	Less than or equals to 60 mS	
16.	Additional auxiliary contacts	6 NO and 6 NC	
17.	Maximum make time	Less than or equals to 100 mS	
18.	First pole to clear actor	1.5	
19.	Degree of protection	IP54	

12 kV SWITCHGEAR PANEL

1.1 GENERAL

This specification covers the design, manufacture, assembly, factory test, supply, delivery field test and installation of 12 kV, metal clad, indoor switchgear, complete in all respects with all equipment fittings and accessories for efficient and trouble-free operation as specified herein under. The 11 kV switchgears shall be of single - tier type.

The equipment specified in this Section shall conform to the latest edition of the appropriate IEC specifications and/or other recognized international standards. In particular:

IEC 60056	High-voltage alternating switchgear
IEC 62271	High-voltage alternating switchgear and control gear
IEC 60298	Metal enclosed switchgear and control gear for rated voltage up to 38 kV
IEC 60529	Degree of protection provided by enclosures
IEC 60694	Common specifications for high-voltage switchgear and control gear standards

1.2 EQUIPMENT TO BE FURNISHED

The following complete 12 kV metal clad, cubicle type, indoor switchgears (including all as stated in clause 1.8) shall be furnished:

Single tier:

(a) 11 kV, 2000A indoor VCB switchgears for incomer feeder panel with triple pole operating spring charging mechanism with motor.

(e) 11 kV, 1250A indoor VCB switchgears for outgoing feeder panel with triple pole operating spring charging mechanism with motor.

(f) Special tools and tackle required for operation and maintenance of equipment as specified.

1.3 DESIGN REQUIREMENTS

The switchgear will be used for 11 kV, 3 phases, 50 Hz system.

Circuit breakers shall be installed Indoor for switching Transformer and Line. All equipment and accessories shall be provided with sub-tropical finish to prevent fungus growth.

The maximum temperature rise in any part of the equipment at specified rating shall not exceed the permissible limits as stipulated in relevant standards. The de-rating of the equipment shall be made taking 50 degree Celsius as an ambient temperature of the site, if it is designed for any lower ambient temperature.

The rated peak short circuit current or the rated short time current carried by the equipment shall not cause;

a. Mechanical damage to any part of the equipment

b. Separation of contacts.

c. Insulation damage of "Current Carrying Part"

Technical particulars of the circuit breaker shall be as per specified.

All auxiliary equipment shall be suitable for 3 phase-4 wire, 50 Hz, 400V AC or 1Phase, 230 V AC.

All controls shall be suitable for 110V DC.

The VCB should be Indoor type with minimal maintenance, high reliability and completely free from menace of vermin. It should be designed with adequate clearances; sufficient creepage to suit polluted atmosphere and the communication between the inside of pole unit and the atmosphere is not desirable. Each breaker should have three porcelain enclosed vacuum type interrupters, which is required to provide a high insulation and an excellent breaking capability.

Technical particulars of 12 kV indoor switchgear shall be as per Appendix 2.2-1 enclosed.

1.4 DESIGN REQUIREMENTS

11 kV, Indoor Metal Clad VCB Switchgear with Triple Pole operating, spring charging Mechanism with motor for 11kV, Incomer and Outgoing feeders.

1.4.1 General Requirement

11kV cubicle type Indoor Switchgear Panel shall be an air insulated metal clad switchgear with withdraw able vacuum circuit breaker with the fault interrupting capacity of 25 KA at 11kV solidly grounded system. The switchgear shall be arranged in connection with the existing 11kV Bus Bar System. The cubicle shall be of modular design provided with space heaters, with the following modules integrated neatly to form dead front type switchgear capable of extension on the both side, forming a single row, single bus bar switchgear panels.

- Breaker compartment.
- Bus bar Compartment
- Cable, C.T. Compartment
- Instrument and Relay Compartment (LV Compartment)
- 11 kV P.T. Compartment.

1.4.2 All Switchgear operation shall be performed behind a close door. Additionally, it shall even be possible to perform all preparations for work inside the cubicle with full degree of protection.

1.4.3 The use of insulation material shall be reduced to minimum; only ripped insulators with high-anti-tracking characteristics shall be used for necessary conductor supports.

1.4.4 Cubicle front shall be covered by a door with inspection windows for mechanical indication for CB ON/OFF position, spring charged and counter indication of CB operation.

1.4.5 The cubicle shall be of modular design consisting of separate modules for Bus bar, circuit breaker, cable and low voltage compartment, and instrument component. Each compartment shall have its own pressure relief flap. High voltage cable termination compartment shall have a steel wire grid mesh fitted inside the back cover so as to prevent accidental contact with the live parts during the routine inspection of the panels. The fixed contact shall be mounted in bushing moved by circuit breaker carriage.

1.4.6 Earthing to cable feeder and Bus bar shall be done via earthing switch manually operated from panel front.

1.4.7 Fixed contacts shall have flat silver plating and contact pressure of male and female contacts during connected position according to the International Standard.

1.4.8 Bus bars and Jumpers shall have made of flat electrolytic bare copper contact with special heat shrinkable sleeves which provide effective insulation between phases or phase to earth, even if bridged by vermin or other conducting body and suitable for rated current not less than 2500 A. Bus bar shall be latched per panel and easy to replace by standard normal material. Flexible insulation shrouds shall cover the Bus bar to Jumper Joints and jumper to stationary contact joints.

1.4.9 Bottom of the cubicle shall be covered with a bottom mica plate through which cables are passed into the panel.

1.4.10 The proposed switchgear panel shall be extendible on both sides.

1.4.11 The proposed switchgear panel shall be suitable for mounting of standard Current and Voltage Transformer according to IEC standard.

1.4.12 The circuit breaker cubicle shall be designed as to be vermin proof to prevent the entry of the vermin, reptiles, mouse etc. inside the compartments of the cubicles

1.5. WITHDRAWABLE PART (CARRIAGE)

vi. The chassis shall be made of sheet-steel section and shall carry the switching device, moving mechanism, 4 rolling contact bearings for movement and interlocking mechanism. Movement for carriage shall be done manually and shall be independent from switch room floor.

vii. Moving contacts shall be double flat contact with silver plated contact pieces. The flexible fixing shall allow high tolerance and avoiding overheating.

viii. Connection of auxiliary supply to the fixed part shall be verified via multi-pole plug, which shall be included in the interlocking system. For the easy and assured insert of the plug the hose should come from the fixed part and the plug shall be on with-draw able part.

ix. CB and Isolating Switch Carriage shall have the provision to operate mechanically behind the closed door in Operating and Test Position.

x. Carriage of the same rating shall be exchangeable. It shall be possible to insert CB with higher current in lower rated cubicle but not vice versa. Other Requirements for removable parts:

Removable parts are intended to be used as a disconnector or intended to be removed and replaced more often than only for maintenance purposes, mechanical operation tests shall also be possible as per IEC 62271-102.

The requirement that it shall be possible to know the operating position of the disconnector earthing switch by applying following conditions:

- The isolating distance is visible.
- The position of the withdrawable part, in relation to the fixed part, is clearly visible and the positions corresponding to full connection and full isolation are clearly identified.
- The position of the withdrawable part is indicated by a reliable indicating device.

Any removable part shall be so attached to the fixed part that its contacts will not open inadvertently due to forces which may occur in service, in particular those due to a short circuit.

1.6 11 KV METALCLAD SWITHGEAR:

i. Main Equipment Characteristics

a. Insulation:

iii. 11kV primary equipment shall be insulated to meet or exceed the following criteria:

- Rated Lightning Impulse Withstand Voltage (kVp): 75
- Rated Power Frequency Withstand Voltage (kVrms): 28

iv. 11kV cubicles shall be designed to provide phase segregation within the enclosures.

b. Clearances:

vii. 11 kV Primary Equipment clearances between phases and phase to earth shall not be less than as per IEC, whichever is greater.

viii. The layout of the equipment shall provide for safe access for operation and maintenance whilst the remaining sections equipment are alive.

ix. Minimum clearances in air for the 11kV 'Indoor' Primary Equipment shall not be less than as per IEC.

x. The Bus bars shall be insulated by High Grade Phase Insulation. Bus bars partitioning shall be done by means of a bushing plate with Cast-Resin Insulators and Cubicles shall be partitioning with earthed sheet metal barriers.

xi. When it is not practicable to disconnect the cable for the dielectric tests from the metal enclosed switchgear and control gear, those parts which remain connected to the cable shall be capable of withstanding the cable test voltages as stated by the relevant cable standard.

xii. The dimension (especially height) of one termination point of the Trunking Chamber should be matching with the Bus Bar Height of the existing VCB and the height of other termination point of Trunking Chamber should be matching with Bus Bar height of New VCB.

c. Current Carrying Capacity:

iii. Switchgear 11kV Bus bars and Connections thereto shall be designed to carry current corresponding to Maximum Permissible Overload of the connected equipment without exceeding temperature rise specified in the Relevant Standards.

iv. Switchgear 11kV Bus bar shall be designed to safely withstand with an appropriate margin of the Mechanical and Thermal Effects corresponding to the following short circuit currents:

Symmetrical three-phase

- (Is) (kA)rms: 25
- Peak making Current (kA)p : 62.5

1.7 VACUUM CIRCUIT BREAKERS

1.7.1 General

The 11 kV Circuit Breakers shall be Vacuum type, easily withdraw-able and housed in a cubicle. It shall consist of three Vacuum Interrupter, three Supports and the Operating Mechanism. The Operating Mechanism shall have either Motor Charged Spring Operated or Solenoid Operated, with provision of hand operated mechanism. With the breaker in close state, spring energy shall be for a "Trip/Close/Trip" Cycle.

1.7.2 Main Data

Type: Metal enclosed Indoor switchgear cubicle type with vacuum interrupters.

- Nominal Service Voltage (kV): 11
- Rated Voltage (kV): 12
- Rated Frequency (Hz): 50
- Rated Nominal Current for Incomer: 2000A
- Rated Nominal Current for Outgoing feeder: 1250A
- Rated Short-Time Breaking Current (asymmetrical) at Rated Voltage: 25 kA (rms)
- Rated Short-Time Making Current at Rated Voltage (kA) p: 62.5(kA)p
- Rated Operating Mechanism: Motor-spring operated or solenoid operated. : Suitable for Trip/close /Trip cycle.
- Provision for Manual Operation also.

1.7.3 Technical Requirements:

xvi. The Circuit Breakers shall meet requirements of IEC 56 & IEC 62271.

xvii. Vacuum Interrupter:

The Arcing chamber with the two stem connected contacts shall be located between two ceramic insulators. One contact shall be fixed to the housing and the moving contact shall be connected to the housing via vacuum tight bellows. The metal bellows

shall enable the moving contact to carry out its strokes. The metal bellows must be able to withstand the movement corresponding to 30,000 make/break operations without failing. The insulators shall be made of metallized aluminum oxide ceramic, which permits them to be brazed to metal so that there is no need to use conventional seals. The Vacuum Interrupter shall remain vacuum tight throughout its working life.

The Contact surfaces should be free of impurities and pollution layers. Materials of high conductivity should be used such that the contact resistance will be very low.

xviii. The Operating Mechanism shall have single Trip Coil and be electrically Trip free and anti-pumping.

xix. The Spring Charging Motor, the Closing Coil, the Tripping Coils and all other control devices of all circuit Breakers shall be suitable for 110V d.c Operation.

xx. A Manually Operated Mechanism for closing and tripping shall be provided in the breaker cubicle for Maintenance and Emergency Operation. This device shall be so interlocked that while it is operative, the breaker cannot be operated remotely.

xxi. Each Circuit Breakers shall be equipped with an Operation Counter (to register tripping operations) and position indicator, on the cubicle front.

xxii. Provision shall be made for Remote alarm/indication of the following status through a pair of NC+NO contacts:

- Circuit Breaker "Open".
- Circuit Breaker "Closed".
- Circuit Breaker "Trip".
- Trip Circuit Healthy.
- Circuit Breaker "Failure"

xxiii. The circuit breaker shall be equipped with a local control switch and local remote selector switch auxiliary contacts for remote indication. All contacts shall be wired to terminal block in the breaker cubicle. Control cable and the indicator box shall have at least three numbers of spare cables and the indicators for future use. CT terminal shall be disconnecting type.

xxiv. Each of the circuit breakers shall be housed in a freestanding indoor type cubicle. This cubicle (and others comprised in the 11KV metal clad switchgear) shall be of standard construction and shall be suitable for attachment of cable connection as described in relevant cubicles. These cubicles shall be equipped with copper earthing bus bars of not less than 200Sq.mm.

xxv. Plugging contact apertures shall be fitted with fully automatic metal safety shutters to close the apertures and prevent access to live part when truck partition is withdrawn and to open when the truck partition is being plugged in. The shutters shall form reasonable dust, drip, fire and insect proof enclosures over the apertures.

xxvi. Auxiliary Switches shall be provided as required for Indication, Control, Protection and Interlocking. In addition, a minimum of two Normally Open and two Normally Closed Auxiliary Contacts shall be provided as spare contacts. All available contacts of Auxiliary Switch Assembly shall be wired to the Terminal Blocks on the fixed portion of the equipment of the switches and terminals shall be such as to facilitate future extension.

xxvii. All auxiliary switches shall have contacts with strong wiping action. The switches shall be located in an accessible position and adequate physical protection shall be provided. xiii The Circuit Breakers shall be tested in accordance with IEC56 and IEC60 and shall include the following routine tests:

- Mechanical operating tests
- Power Frequency Voltage withstand tests.

- Tests on auxiliary and control circuits

xxviii. The quality assurance of the equipment and their auxiliary shall be of ISO 9001 Standard. An updated copy of its certificate shall be submitted.

xxix. The Minimum Operating Cycle (without maintenance) of Interrupters and Operating Mechanisms shall be suitable for operation over 10Years or 10,000 operations with rated current or 100 operation with rated short circuit current and overall life shall be more than 30,000 operating cycles for bellows.

xxx. The Vacuum Circuit Breaker installed in the Switchgear shall move into

Following position in the Circuit Breaker Components:

- Running Position (Run) Main Circuit and Control Circuit connected to all circuits.
- Test Position (Test)

Main circuit separated from the circuit and only Control Circuits are connected.

- Disconnected Position

As a Control Circuit Connector that would be plugged by hand during the test Position both Main and Control circuits are disconnected from the Circuit.

Special alarms and indications and remote control of 11 kV circuit breakers (off control) shall also be provided for the selected feeders to be controlled from the Load Dispatch Centre (LDC) of NEA as described in related chapter.

EARTHING

vi. To ensure personnel protection during maintenance work, all parts of the main circuit to which access is required or provided shall be capable of being earthed prior becoming accessible.

vii. Factory built transport units shall be interconnected during final installation through an earthing conductor. This interconnection between the adjacent transport units shall be capable of carrying the rated short time and peak withstand current for the earthing circuit.

viii. The current density in the earthing conductor, (for copper) shall under the specified earth fault conditions not exceed 200A/mm2 for a rated duration of short circuit of 1 Sec. Its cross section shall not be less than 30mm2.

ix. The enclosure of each functional unit shall be connected to this earthing conductor. All the metallic parts intended to be earthed and not belonging to a main or auxiliary circuit shall also be connected to the earthing conductor directly or through metallic structural parts.

x. The interconnections within the functional unit shall be secured by a technology providing electrical continuity between the frame, covers, doors, partitions or other structural parts. Doors of the high voltage compartments shall be connected to the frame by adequate means.

1.7.4. EARTHING SWITCHES

1.7.4.1 The 11kV metal clad switchgear shall include earthing switches to facilitate earthing of each cubicle as specified.

The Earthing Switch is operated by means of detachable lever from outside the cable compartment. It shall be mechanically interlocked with the CB so that the earthing switch in close position in section of CB truck into the service position is not possible. The operation of the Earthing Switch shall not be possible as long as the CB is not in isolated position.

1.7.4.2 **Main Data**

Rated Voltage kV:	12 kV
Rated Current for Incomer, Amp:	2000 A

Rated Short-Time Breaking Current (rms) (asymmetrical) at Rated Voltage:	25 kA
Rated Short-Time Making Current at Rated Voltage:	62.5 (kA)p

1.7.4.3 **Technical Requirements**:

vi. The Earthing Switches shall meet the requirements of IEC129.

vii. Auxiliary Switches shall be provided as specified for the Circuit Breakers.

viii. Provision shall be made for padlocking in the Open and Closed position.

ix. Manual control of the switches and Position indicator external to the cubicle shall be provided.

x. The Earthing Switch shall be interlocked manually with circuit breaker.

1.7.5 INTERLOCKING

The following operation shall be taken place only when the under stated interlocking conditions are fulfilled to ensure Personnel and Operational Safety.

1.7.5.1 Transferring the withdrawable part from the Disconnecting Position to the Service Position:

v. Control Circuit Plug Inserted

vi. High Voltage Compartment Door closed.

vii. Circuit Breaker in OPEN Position.

viii. Earthing Switch in OPEN Position

1.7.5.2 Transferring the Withdrawable part from the Service Position to the Disconnected Position.

Circuit Breaker in OPEN Position.

1.7.5.3 Operating the Circuit breaker

ii. Withdrawal part in the Interlocked Final Position (Service or Disconnecting position)

1.7.5.4 Operating the Earth Switch

ii. Withdrawal part in the interlocked disconnected position. Windows shall be provided to allow visual inspection.

The Switches shall be tested in accordance with IEC129 and IEC265 and shall include the following routine tests:

- Operating and Mechanical tests
- Measurements of the resistance of the main circuit.

1.8 LOW VOLTAGE COMPARTMENT:

The Low Voltage Compartment of the Switchgear shall be located on the front and on the top front of the Panel and shall be accessible with a separate door and partitioned against high voltage part. Connection of control and Metering cable is by means of a Multi pole plug to the withdrawable part possibly at front face of the breaker. Low voltage devices metering and protection equipment shall be mounted flush in the door or on the mounting plate inside.

Wiring inside the cubicle shall be done by 2.5 Sq. mm insulated stranded copper wires for current circuits and 2.5 Sq. mm for voltage circuits. All power circuit shall be wired with 4 Sq. mm cables.

The following equipment shall be mounted in the low voltage compartment.

- 1 No with A/S Switch.
- 1 No. Voltmeter, Digital Type of 0.5 class, with Voltage Selector switch.
- 1 No. MW Meter, Digital type of 0.5 class
- For Incomer and outgoing feeders - 1 No Energy meter 3Phase 4 wire, Digital, programmable via Optical Port, 3P4W, class 0.5 designation, Current rating 1- 10Amp, Voltage range 0-480 V. The energy meter should have test pulse and calibrating facility. The Energy meters should be from the list of manufacturers.
- **Directional Over current and Earth fault Protection for Incomer**

This protection scheme shall be used as a back-up protection for power transformers low voltage side and as main protection for parallel sub-transmission lines.

(a) Phase over current relay shall:

- have an inverse characteristic with a definite minimum time of 3 secs. at 10 times setting.
- have a variable setting range of 20-200% of rated current.
- have a characteristic angle of 45 degree.
- have a directional controlled low transient over-reach high set instantaneous unit of continuously variable setting range 5-20 times of rated current.
- be of voltage polarized directional controlled type

(b) Directional earth-fault protection

Earth fault over current relay shall:

- be of zero-sequence voltage polarized directional controlled.
- have an inverse characteristic with a definite minimum time of 3 secs. at 10 times setting.
- have an adjustable setting range of 10-80% of rated current.
- have a directional controlled low transient over reach high set instantaneous unit with a continuously variable setting range of 5-20 times of rated current.
- have a characteristics angle of 45 degree.

Non directional over current and Earth fault protection for Outgoing feeders.

- Over current Relay, Numerical Type with Instantaneous tripping for 1A (Secondary Current) and built in Earth fault Relay with Instantaneous Tripping for 1A rating.

  Accuracy Limit → ±5.0%

Over Current Relay:

Setting range 5%-250% in steps of 5% (for Over current element)

Setting range 50% to 2500% in steps of 50% (for High Set Element)

Time Multiplier Setting range 0.025 Sec to 1.00 Sec in steps of 0.025 Sec

Reset Delay 0 to 60 Sec in steps of 1 Sec

Earth fault Relay:

Setting range 5%-250% in steps of 5% (For Earth fault)

Setting range 50% to 2500% in steps of 50% (for High Set Element)

Time Multiplier Setting range 0.025 Sec to 1.00 Sec in steps of 0.025 Sec

Reset Delay 0 to 60 Sec in steps of 1 Sec

Characteristics Selection: SI, EI, VI, LTI, DTL

1.9 CURRENT TRANSFORMERS:

1.9.1. The 11 kV Metal clad Switchgear shall include protection and metering Current Transformers as specified. The Current Transformers shall be Epoxy Resin insulated block type. Current Transformers as follows:

For Incomer Panel Burden	Ratio	Accuracy	Class
-Core 1 (for Metering)	800-400/1	0.5	15 VA
-Core 2 (for Protection)	800-400/1	5P20	15 V
-Core 3 (Differential for Incomer only)	800-400/1	PS	15 VA

For Outgoing Feeder Panel:	Ratio	Accuracy	Class Burden
-Core 1 (for Metering)	400-200/1	0.5	15 VA
-Core 2 (for Protection)	400-200/1	5P20	15 VA

The current transformer shall comply with the requirements of IEC 185 shall confirm to the specified insulation requirements and shall withstand without damage the applicable short-circuit current specified. Primary ratio taps shall not be accepted.

Maximum temperature rise at rated primary current shall not exceed 50 degree centigrade.

1.9.2 Accuracy classes for the protection and metering shall not be less than 5P20 and 0.5 respectively. Similarly, Accuracy class for the Differential protection shall not be less than PS. Burden and accuracy class shall be adequate to ensure correct operation of associated protective devices and instruments. Saturation curves shall be provided with CT Characteristics.

1.9.3 Each set of secondary windings shall be wired to suitable terminal blocks and earthed at the first control or relay panel to which they are connected.

1.9.4 Earth Fault Factor should not exceed 1.4 for effectively earthed system.

1.9.5 The continuous thermal current rating shall be 150% of normal current rating.

1.9.6 The Current Transformers shall be tested in accordance with IEC 185 and shall include the following Routine Tests:

viii. Verification of terminal markings polarity etc.

ix. Power frequency tests on primary windings.

x. Partial Discharge Measurement

xi. Power frequency withstand tests on secondary windings.

xii. Power Frequency withstand test between sections

xiii. Over voltage inter-turn tests.

xiv. Determination of ratio error and phase displacement.

1.9.7 Bidders shall submit the flowing Type Test reports conducted by the accredited Test Laboratory.

vi. Short Time Current Test.

vii. Temperature Rise Test

viii. Lightening Impulse Test

ix. Determination of Errors

x. Radio Interference Voltage Measurement

All the dielectric Type Test shall be carried out on the same Current Transformer.

1.10. VOLTAGE TRANSFORMERS

1.10.1 The 11kV Metal clad Switchgear shall include Voltage Transformers in incomer as required by the Single Line Diagram as follows:

viii. Type: Epoxy-resin insulated, single pole with 7.3A Primary side fuses

ix. Basic Impulse Level: 75kV

x. Rated Power Frequency Withstand Voltage: 28kV

xi. Primary Voltage: 11/√3 kV

xii. Secondary Circuit: 110/√3 V

xiii. Rated burden: 50 VA

xiv. Accuracy classification: 0.5 / 3P Class

1.10.2 The voltage transformers shall comply with the requirements of IEC 186. Accuracy class and burden shall be adequate to ensure the correct operation.

1.10.3 The voltage transformers and their fuses shall meet the specified insulation requirements and have a rated primary voltage of 11kV with knee of saturation curve not lower than 12kV and ratios per single line diagram.

1.10.4 The voltage transformer shall be provided with high rupturing capacity (HRC) fuses for primary and secondary circuits. The fuses shall be rated for the short circuit levels specified.

1.10.5 Each set of secondary windings shall be wired to suitable terminal blocks and earthed at the first control or relay panel to which they are connected.

1.10.6 Earth Fault Factor should not exceed 1.4 for effectively earthed system.

1.10.7 Continuous Rated Voltage Factor should be 1.2 and for 8h should be 1.5.

1.10.8 For hermitically sealed Potential Transformer the temperature rise of the oil at the top of the tank or housing shall not exceed 55K.

1.10.9 Power Frequency withstand voltage for the earthed terminal: The terminal of the primary winding intended to be earthed shall, when insulated from the case or frame, be capable of withstanding the rated power frequency short-duration withstand voltage of 3kV (r.m.s.)

1.10.10 The dielectric Dissipation Factor at Um/√3 and ambient should not exceed 0.005.

1.10.11 The rated power frequency-withstand voltage for secondary winding insulation shall be 3kV (rms.)

1.10.12 The Voltage Transformer shall be designed and constructed to withstand without damage, when energized at rated voltage, the mechanical and thermal effects of an external short-circuit for the duration of 1 Sec.

1.10.13 The voltage transformers shall be tested in accordance with IEC 186, and shall include the following routine tests:

vii. Verification of terminal markings.

viii. High voltage power frequency withstand test on primary windings.

ix. High voltage power frequency withstand test on secondary windings.

x. Partial Discharge Measurement.

xi. Power Frequency Tests between sections

xii. Determination of Errors

Repeated Power Frequency Tests on Primary windings shall be performed at 80% of the specified test voltage.

1.10.14 Following Types are required to be submitted from the accredited test Laboratory

viii. Temperature Rise Test

ix. Short Circuit Withstand Capability Test

x. Lightening Impulse Test

xi. Switching Impulse Test.

xii. Wet Test for Outdoor Type Transformer (N/A)

xiii. Determination of Errors

xiv. Measurement of the Radio Interference Voltage

All the dielectric Type Test shall be carried out on the same Transformer, unless otherwise specified.

1.10.15 Following Special Tests are required to be done.

i. Measurement of Capacitance & Dielectric Dissipation Factor Test.

1.11. SURGE ARRESTERS FOR INCOMER:

1.11.1 The surge Arresters shall be 9kV, 10 kA of the gapless Zinc oxide type and suitable for operation under the service conditions specified and be suitable for the protection of Transformer and other substation equipment. The Arresters shall comply with IEC 99-1, IEC99-4.

1.11.2 The surge diverters shall be tested in accordance with IEC 99-4.

1.12 CONTROL PROTECTION AND INSTRUMENTATION:

1.12.1 This covers the detailed requirements for design, manufacture, transport, installation and commissioning of 11kV Metal clad VCB switchgear.

1.12.2 The substation will normally be attended and operation will be semi-automatic. Normally closing of circuit breakers shall be manual operation and operation of earthing switches will be manual if it is not mentioned.

1.12.3 Local control facilities adjacent to the equipment shall be provided for maintenance, inspection and emergency operation.

1.12.4 The control system shall be designed to permit the following operating modes:

1.12.4.1 Automatic start/stop operation refers to spring-charged motor for operating mechanism of 11kV VCB.

1.12.4.2 Automatic tripping of 11kV VCB, LV MCB if faults occur in protected lines equipment or circuits.

1.12.4.3 The control system shall be arranged in such way that it is possible to change between local automatic and local manual control any time.

1.12.4.4 Solid state modular equipment shall be used wherever possible.

1.12.4.5 The designs shall be in general conformity with the single line diagrams and layout drawings accompanying this specification.

1.12.4.6 Under manual control the individual operations shall each be subject to safety interlocks being satisfied.

1.12.4.7 The control scheme shall be operationally simple, safe, easy to maintain and functionally consistent.

1.12.4.8 Each module shall have sufficient test points to felicitate faultfinding. Control circuits shall be brought out to isolating terminals to permit efficient trouble shooting.

1.12.4.9 Each cubicle shall be provided with a sufficient point Annunciation Block to identify an alarm condition, including audible alarm, test, acknowledge and reset push buttons.

1.12.4.10 Control switches for circuit breakers shall be of the discrepancy type. Two independent movements shall be required to initiate an operation.

1.12.4.11 The design shall be such that as to avoid nuisance alarms and shall block those devices, which assume alarm conditions when the equipment is under shutdown. Annunciation Block windows shall be engraved with identification of the alarm condition.

1.12.5 **Annunciators shall have the following sequence**:

Condition	Lamp	Alarm
Normal	Off	Off
Alarm Flashing	On	On
Acknowledge	On	Off
Reset After return:		
Normal	Off	Off
Lamp test	On	Off

1.12.6 REQUIRED SIGNALS / ALARM SYSTEMS:

The switchgear shall have following signalling and alarm system:

- CB Off/On position by green/red lamp
- White lamp for spring charged
- Flag or lamp indication of faults for:

  Over Current Protection, E/F Protection, DC Supply Failure, CB Failure, MCB tripped, AC supply failure.

  All signal lamps shall be LED type.

The design shall avoid nuisance alarms and shall block those devices, which assume alarm conditions when the equipment is under shutdown. Annunciation Block windows shall be engraved with identification of the alarm condition.

1.7.7 The Annunciation Block shall be of solid-state type and suitable for operation at 110 V dc and shall be able to withstand IEC 255 class 3 tests without malfunctioning.

Applicable for Switchgear Panels

1.8 11 kV Switchgear Panel (Incomer and outgoing Feeder) shall consist of metal-clad cubical fitted with:

• Copper Bus bar, 2500A	1 Set
• Fault making earth switch for cable earthing, hand operated with Auxiliary switch	1 set
• Epoxy Resign insulated block type Current Transformer of ratio mentioned above in the clause 1.4.1.	1 set

Withdraw-able module with:

• Hand operated drive mechanism	1 Set
• Auxiliary block with 4NO+ 4NC contacts for position indication	1 No.
• Multiple Pole lug for control signals	1 No.
• Vacuum circuit breaker with motor operated spring charged Mechanism or solenoid operated mechanism	1 No.
• Close/trip buttons	1 No.
• Trip coil	1 No.
• Closing coil	1 No.
• Counter indicating number of switching operation	1 No.
• Auxiliary block with 11NO + 11NC 1Wi (alarm contact)	1 No.
• Auxiliary switch for spring charged indication	1 No.

In the low voltage compartment the following equipment shall be mounted:

• 2 pole miniature circuit breakers fitted with auxiliary switch 1NO+1NC	2 No.
• Single Ammeter Cl. 0.5 with A/S switch (Range: …. /1A As per CT ratio for Incomer) (Range: …. /1A for Feeder Panel)	1 No.
• Voltmeter, Digital Type of 0.5 Accuracy class with voltage selector Switch for **Incomer** only	1 No.
• MVA / MW Meter, Digital Type of 0.5 Accuracy Class site programmable	1 No.
• kWh meter for 3Phase 4 Wires, accuracy class as specified with Test Pulse & Programming Facility	1 No.
• Local/ remote selector switch	1 No.
• Numerical over current relay with Built in Earth fault Relay as Specified in 1.3 above	1 No.
• Annunciation Block 2x3 Matrix in Panel	1 No.
• Auxiliary relay and coupling relay	1 No.
• Anti condensation heater in cable compartment	1 No.

Accessories shall consist of:

• Emergency hand crank for the switch	1No.
• Operation handle for withdrawable module	1No.
• Operation handle for the earthing switch	1No.
• High voltage compartment keys	1No.
• Service Track for removing of withdrawal module	1No.
• Breaker Carriage	1No.

APPENDIX 8 (B): RATING AND FEATURES OF EACH 12 kV SINGLE TIER SWITCHGEAR PANEL COMPLETE

S.No.	Description	Transformer incomer switchgear	Outgoing feeder switchgear
1.	Type	Metal enclosed, cubical indoor type	
2.	Voltage rating: a) Nominal system voltage b) Rated maximum system voltage	 11 kV 12 kV	
3.	Insulation level a) Impulse withstands voltage (crest) b) Power-frequency with stand voltage (1 min.)	 75 kV 28 kV	
4.	Frequency	50 Hz	
5.	Minimum continuous bus-bar rating	2500 A	2500A
6.	Current rating a) Rated continuous current at ambient b) Short circuit breaking current c) Short circuit making current (1 sec)	 2000A 31.5 kA 62.5 kA	 1250A 31.5 kA 62.5 kA
7.	Rated duration of short circuit (tk)	(1 sec)	(1 sec)
8.	Rated capacitive switching currents		
8.1	Rated line charging breaking current	Greater than or equals to 10 kA	
8.2	Rated line charging breaking current	Greater than or equals to 25 kA	
9.	Current transformer e) Current ratio f) Number of cores g) Burden per cores	 *800-400/1 A* 3 15 VA	 *400-200/1 A* 2 15 VA

	h) Accuracy class	5P20 /PS/ 0.5	5P20 / 0.5
10.	Potential transformer e) Voltage ratio f) Number per set g) Rated Burden h) Accuracy class e) No. of core	 11000/√3 / 110/√3 3 50 VA 3P/0.5 2	
11.	Lightning Arrestor	9 kV	
12.	Metering d) Ammeter scale with selector switch e) Voltmeter scale with selector switch f) Other	 *0– 800/400A* 0 – 15 kV MVAR	 *0-400/200A* *PF*
13.	Auxiliary supply a) Control circuit and Spring charging motor Space heater and auxiliary equipment.	110 V DC AC, 3 Ph-4 W, 400 V, 50 Hz	
14.	Reclosing duty cycle of Circuit Breaker	O-15 sec-CO	
15.	Total maximum break time	Less than or equals to 60 mS	
16.	Additional auxiliary contacts	6 NO and 6 NC	
17.	Maximum make time	Less than or equals to 100 mS	
18.	First pole to clear actor	1.5	
19.	Degree of protection	IP54	

SECTION 10-: LIGHTING SYSTEM

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1.0 LIGHTING SYSTEM

1.1 *LIGHTING SYSTEM FOR SUBSTATION*

The scope of work comprises of design, engineering, testing, supply, installation, testing and commissioning of various lighting fixtures complete with lamps, supports and accessories, ceiling fans complete with electronic regulators, exhaust fans for toilets and pantry & accessories, lighting panels, lighting poles complete with distribution boxes, galvanized rigid steel /rigid PVC conduits, lighting wires, G.I. Earthwire, receptacles, tag block & telephone socket, switchboards, switches, junction boxes, pull out boxes complete with accessories, for control room cum administrative building, switchyard panel room, Auxiliary building/Transit Camp, Fire Fighting pump house, Switchyard and street lighting.

The entire control room building, fire fighting pump house and Transit camp lighting shall be done by LED based low power consumption luminaries to achieve desired lux level specified. The bidder shall quote on lump-sum basis on the basis of design criteria specified for each control room building, Transit Camp and fire fighting pump house.

1.1.1 SYSTEM DESCRIPTION

The lighting system shall comprise of the following:

1.1.2 AC Normal Lighting

AC lights will be connected to AC lighting panels. All the lights connected to the AC lighting system in different areas will be connected to the main lighting distribution boards.

1.1.3 AC Emergency Lighting

This system will be available in control room building, Fire-fighting pump house, & switchyard. AC lighting load will be connected to this system which will be normally 'ON'. The lighting panels of this system will be connected to the Emergency lighting board which is fed from diesel generator during the emergency. 25% of lighting fixtures shall be connected on AC emergency lighting.

1.1.4 D.C. Emergency lighting

A few DC emergency lighting fixtures operated on the DC system will be provided in the strategic locations including staircase, corridors, electrical rooms, Battery charger room, LT switchgear room in control room building, and Firefighting pump house so that the operating personnel can safely find their way even during emergency of a total AC failure. These lights will be normally 'OFF' and will be switched 'ON' automatically when under voltage occurs in the AC main lighting distribution board. GLS lamp down lighters in false ceiling area and Bulkhead fixtures in non-false ceiling area to be used.

1.1.5 Exit Lightings

All Exit lightings in the buildings shall be fed by DC lighting panels. All necessary wiring and its termination shall be in the contractor's scope.

1.1.6 The lighting layout for and around Control Room Cum Administrative Office Building & Fire fighting Pump House indicating the type & BOQ for items shall be prepared and submitted by the contractor for owner's approval during detailed engineering.
The lux levels to be maintained in the switchyard shall be as per following:

Sl No	Area	Average Lux Level
1.	Control Room	**SN.** **Area Average Lux level**

	Building, Firefighting pump house, Transit Camp	**at floor level** i) Control Room & Conference room - 350 Lux ii) Battery room, Passage, Pantry, Toilets, Corridors etc. - 100 Lux iii) All other rooms - 200 Lux
2.	Switchyard	-50 lux on main Equipments (i.e, Transformer, Reactor ISO, CB, CT, CVT, SA) at first level (Equipment connections level.) -20 lux on balance area of switchyard and street / Road at ground level. --10 lux (Area between fence and peripheral roads around the switchyard). The lighting between the fence and the peripheral road around switchyard shall be done by providing the lighting fixtures on lighting pole of suitable height, if required.

The minimum lux level to average lux level ratio should not be less than 0.6 (i.e Emin/Eav>0.6). The maintenance factor for indoor illumination design shall be considered as 0.8. The surface reflectance for ceiling/wall/floor shall be 50/30/10

For achieving the specified lux levels in the switchyard, the contractor can provide luminaries of 1x400 W/1x250 W and 2x400 W/ 2x250 W flood light as per requirement.

The contractor shall submit detailed calculation for reaching the above Lux level. Contractor shall conform the Lux levels at different locations of the switch yard and street lighting by measurement.

In addition to the normal lighting provided in the switchyard area to maintain the desired lux levels, high beam fixtures (Type SF4- 8 nos.) on swivel support shall be provided in strategic locations near equipments for new substations which shall be kept normally OFF and these shall be switched ON in case of maintenance work.

1.1.7 Ceiling fans (1400 mm sweep, AC 230 volts) shall be provided in, fire-fighting pump house and non-AC rooms in the control room building and all the rooms in transit camp building & residential quarters as per the requirements. Wall mounted fans shall be provided in the conference room, control room, shift manager and substation incharge rooms in control room building. Exhaust fans shall be provided in toilets and pantry.

1.1.8 One no. of aluminum ladder of each size shall be supplied by the contractor for maintenance purpose.

1.1.9 The following specific areas are included in the scope of lighting:

(i) Switchyard Area.
(ii) Switchyard Control Room cum Administrative Office Building
(iii) Fire fighting pump house
(iv) Street lighting (peripheral) inside switchyard fencing (Street lighting shall be done using street lighting poles)
v) DG area lighting
vi) LT Transformer area
vii) Transit Camp
viii) Residential quarters
ix) GIS building (including panel rooms)

1.1.10 **For Outdoor Illumination**

The switchyard and street lighting design including lux level calculations, surface illuminance diagram at varying equipment surface levels, detailed drawings showing

the lighting layout and Electrical distribution diagram and BOQ for items shall be prepared by the Contractor and submitted for approval. The above layout drawings will include disposition and location of lighting fixtures, receptacles, etc.

1.1.11 **For Indoor Illumination**

(a) The conduit layout drawing for substation buildings, Electrical distribution diagram for substation buildings, & for substation yard etc. shall be prepared by the Contractor. All wiring including telephone wiring (tinned two pair copper) shall be in concealed conduit. Concealed MS junction boxes for sockets and light points shall be provided in all the rooms of Control Room cum Administrative Office Building and Fire Fighting pump house. In case where false ceiling surface conducting is permissible, all down run conduits will be concealed in wall below the false ceiling.

(b) The scope of work comprises township include of design, engineering, testing, supply, installation, testing and commissioning of 415 V, 400Amp, Main Township Distribution board/Energy meter Boards/Flat DBs etc (single line diagram C/ENGG/TS/STD/COMMON/01 enclosed), Power and Control cables, various lighting fixtures complete with lamps, supports and accessories, ceiling fans complete with electronic regulators, exhaust fans for toilets and pantry & accessories, lighting panels, lighting poles complete with distribution boxes, galvanized rigid steel/PVC conduits, lighting wires, G.I. Earthwire, receptacles, tag block & telephone socket, bells, boxes for telephone/television & Air-conditioners points, switchboards, switches, junction boxes, pull out boxes complete with accessories as outlined in electrical drawings enclosed with tender documents for various type of quarters, parking, pump house, recreation centre and transit camp associated with township.

1.1.12 Each cable run shall be tagged with number that appear in the cable schedules. Cables shall be tagged at their entrance and/or exit from any piece of equipment, junction or pull box, floor opening etc.

1.1.13 The tag shall be made up of aluminum with the number punched on it and securely attached to the cable by not less than two turns of G.I. wire. Cable tags shall be rectangular in shape for power cables and circular shape for control cables.

1.1.14 Location of cables laid directly under ground shall be indicated clearly by cable marker made of galvanised iron plate embedded in concrete block.

1.1.15 The location of under ground cable joints if any, shall be clearly indicated with cable marker with an additional inscription "cable joint".

1.1.16 The marker, which is a concrete block, shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change of direction. It shall also be located on both sides of the road or drain crossing.

2.0 **DESCRIPTION OF ITEMS**

2.1 ***DESCRIPTION OF ITEMS FOR SUBSTATION LIGHTING***

The Contractor shall supply and install the following equipment and accessories in accordance with the specification.

2.1.1 **LIGHTING PANELS**

2.1.1.1 OUTDOOR

400 AC lighting panel with 400V, 63A, 3 phase 4 wire bus and one no. 63A, TPN, MCB with neutral unit as incomer and 20A, SP MCB as outgoing feeders, the details

are as follows.

Type Of Panel	Description	Detail Of Outgoing Feeders
ACP 2	Outdoor	6 nos.- 20 A single pole MCB and 3 No. 32 A Triple pole MCB with Neutral and suitable timer and contactor for automatic switching.
ACP 3	Outdoor Street lighting Panel	3 nos.-32A Triple pole MCB with Neutral with suitable timer and contactor for automatic switching

Note: The number of outgoing feeders indicated above are the minimum.

2.1.1.2 **INDOOR**

400 V indoor AC lighting panel ,63 A 3 phase 4 wire bus and one number 63 amp FP MCB with 300ma 63 A FP RCCB. Flush mounted with per phase isolation and LED indication lamps. The DB will be flush mounted and double door type.

Type Of Panel	Description	Detail Of Outgoing Feeders
ACP 1	Indoor	18 nos. outgoing ,16 Amps SP MCB

220V DC indoor type change over board and 220V DC 32A two wire bus and one 32A contractor backed up by 32A double pole MCB as incomer. The panel shall have local push button controls. Following are the various types of panels required with control timer.

Type Of Panel	Description	Detail Of Outgoing Feeders
DCP	Indoor	6 nos. outgoing ,16 Amps DP MCB

2.1.1.3 **Sub-Lighting Panels**

Type Of Panel	Description	Detail Of Outgoing Feeders
SLP	Outdoor	4 pole 32A Isolator suitable for 400V, 50 cycles AC supply, with LILO facility using 8 nos. terminal blocks suitable for cable upto 16 mm sq cable Enclosure shall be suitable for outdoor use with IP-55 degree of protection as per IEC:60529.

2.1.2 **Lighting Fixtures**

Please Refer Annexure-1

2.1.3 **RECEPTACLES**

	Description	Detail Of Outgoing Feeders
RO	Outdoor	15A, 230V, Receptacle 2 pole, 3- pin type

RP	Outdoor	63A, 400V, Interlocked switch socket, receptacle
RI	Indoor	5/15A, 230V, Receptacle 3-pin type (Modular)

2.1.4 (a) **SWITCH BOARDS**

Modular type switches, 5/15 Amp. Receptacles.

2.1.4 (b) **CONDUITS AND ACCESSORIES**

Galvanized Rigid steel or Rigid PVC conduits of 20/25 /32 mm for Lighting and Telephone wiring

2.1.5 **JUNCTION BOXES -** with 5 Nos. of terminal blocks

2.1.6 **LIGHTING POLES -** (Type A1 poles & Type E1 poles)

2.1.7 **FANS-**1400 mm Sweep with Electronic regulator and 450 mm Wall Mounted fans

2.1.8 **MAINTENANCE EQUIPMENT**

i) A type Aluminium ladder of 3 mtr. vertical height.

ii) Cartwheel mounted aluminium ladder Vertical Extendable from 5.1m to 11m.

2.1.9. **RECEPTACLES**

a) All receptacles shall be of cast steel/aluminium, heavy duty type, suitable for fixing on wall/column and complete with individual switch.

b) In general, the receptacles to be installed are of the following types:

i) **Type RO**-15A, 230V, 2 pole, 3 pin type with third pin grounded, metal clad with gasket having cable gland entry suitable for 2Cx6 sq.mm. PVC/aluminium armoured cable and a metallic cover tied to it with a metallic chain and suitable for installation in moist location and or outdoor. The switch shall be of rotary type. Receptacles shall be housed in an enclosure made out of 2 mm thick GI sheet with hinged doors with padlocking arrangements. Door shall be lined with good quality gasketing. This shall conform to IP-55.

ii) **Type RI-**The 5/15 amp 6 pin receptacles with switches will be of Modular type with flush type switches and electroplated metal enclosures of approved make

iii) **Type RP** - 63A, 400V, 3 phase, 4 pin interlocked plug and switch with earthing contacts. Other requirements shall be same as type RO. The receptacle shall be suitable for 3.5C x 35/3.5Cx70 sq.mm. aluminium conductor cable entry and shall also be suitable for loop-in and loop out connection of cables of identical size. Receptacle shall be suitable for outdoor application. Receptacles shall be housed in a box made out of 2mm thick G.I. sheet, with hinged door with padlocking arrangement. Door shall be lined with good quality gasketing. This shall conform to IP-55.

2.1.10. **LIGHTING PANELS (L.P.)**

2.1.10.1 Each panel shall be provided with one incoming triple pole MCB with neutral link and

outgoing miniature circuit breakers as per clause 2.0. The panels shall conform to IEC: 60439.

2.1.10.2 **Constructional Features**

a) Panels shall be sheet steel enclosed and shall be dust, weather and vermin proof. Sheet steel used shall be of thickness not less than 2.00 mm (cold rolled) smoothly finished, levelled and free from flaws. Stiffners shall be provided wherever necessary. The indoor lighting panels will be ready made DB of minimum 1.6 mm sheet thickness.

b) The panels shall be of single front construction, front hinged and front connected, suitable for either floor mounting on channels, sills or on walls/columns by suitable M.S. brackets. Indoor panels in control room shall be flush mounted.

c) Panels shall have a dead front assembly provided with hinged door(s) and out door panels will be with padlocking arrangement with single key supplied in duplicate.

d) All outdoor panels, removable covers, doors and plates shall be gasket all around with neoprene gaskets.

e) The outdoor panels shall be suitable for cable/conduit entry from the top and bottom. Suitable removable cable gland-plate shall be provided on the top and bottom of panels. Necessary number of double compression cable gland shall be supplied, fitted on to this gland plate. The glands shall be screwed on top and made of tinned brass.

f) The panels shall be so constructed as to permit free access to connection of terminals and easy replacement of parts.

g) Each panel shall have a caution notice fixed on it.

h) Each panel will be provided with directory holder in which printed and laminated as built circuit directory would be kept inside a document holder/pasted at site.

i) Each Outdoor lighting panel shall be provided with one no. 'ON' indicating lamp for each phase along with fuses. For indoor lighting panels din mounted phase indication lamps will be provided, mounted along side of the MCB

j) **Main Bus Bars**

Bus bars shall be of aluminium alloy conforming to IEC: 60114/60105 and shall have adequate cross-section to carry the rated continuous and withstand short circuit currents. Maximum operating temperature of the bus bars shall not exceed 85 deg. C. The bus bars shall be able to withstand a fault level of 9 kA for 1 sec. for AC panels and 4 KA for 1 sec. for DC panels. The Indoor lighting panels shall have copper bus bar

2.1.10.3 **JUNCTION BOXES**

a) The junction boxes shall be concealed type for indoor lighting and suitable for mounting on columns, lighting poles, structures etc., for outdoor lighting.

b) Junction boxes shall be of square/rectangular type of 1.6 mm sheet steel with minimum 6 mm thick pressure die cast aluminum material LM-6 and shall have bolted cover with good quality gasket lining.

c) The junction box and cover of sheet steel construction shall be hot dip galvanized.

d) The junction boxes shall be complete with conduit knockouts/threaded nuts and provided with terminal strips. The junction boxes shall be suitable for termination of Cable glands of dia. 20 mm, 25 mm, 32 mm, 40 mm on all sides. The junction boxes shall be provided with 4 way terminals suitable for two numbers 10 sq. mm. wire & for

street lighting/switchyard lighting suitable for 2 numbers 4C x 16 Sq.mm Al. cable.

e) The junction boxes shall have the following indelible markings

(i) Circuit Nos. on the top.
(ii) Circuit Nos. with ferrules (inside) as per drawings.
(iii) DANGER sign in case of 400 volt junction box.

f) The junction boxes shall be weather proof type with gaskets conforming to IP 55 as per IEC: 60529.

2.1.10.4 **Occupancy Sensors:**

Sufficient number of occupancy sensors shall be provided in the stairs area and corridors of control room cum administrative building. Each occupancy sensor shall be used for indoor use with time delay programmable in the minimum range of 1 sec. to 2 Hour to control the illumination in the area.

2.2 DESCRIPTION OF FCOMMON ITEMS FOR LIGHTING

2.2.1 LIGHTING FIXTURES AND ACCESSORIES

2.2.1.1 General

All lighting fixtures and accessories shall be designed for continuous operation under atmospheric conditions existing at site, without reduction in the life or without any deterioration of materials, internal wiring.

2.2.1.2 Temperature Rise

All lighting fixtures and accessories shall be designed to have a low temperature rise according to the relevant International standard. The design ambient temperature shall be taken as 50 deg.C.

2.2.1.3 Supply Voltage

Lighting fixtures and accessories meant for 230V A.C. operation shall be suitable for operation on 230V A.C. 50Hz, supply voltage variation of ± 10%, frequency variation of ± 2.5% and combined voltage and frequency variation of ± 10%.

Lighting fixture and accessories meant for 220V DC operation shall be suitable for operation on 220V DC with variation between 190 to 230 Volts.

2.2.1.4 Lighting Fixtures

a) The lighting fixtures shall be Philips or equivalent International make except for fixtures type ‘DSM’ & ‘HL’ for which make has been specified elsewhere in this chapter. The different types of lighting fixtures are also indicated elsewhere in this Chapter.

b) All fixtures shall be designed for minimum glare. The finish of the fixtures shall be such that no bright spots are produced either by direct light source or by reflection.

c) All lighting fixtures shall be complete with fluorescent tubes / incandescent lamps/mercury vapour/sodium vapour lamps as specified and shall be suitably wired up.

d) All fluorescent lamp fixture shall be complete with all accessories like ballasts, power factor improvement capacitors, lamps, starters, holders etc.

e) High beam fixtures shall be suitable for pendant mounting and flood lights shall have suitable base plate / frame for mounting on steel structural member. Hook mounted high beam fixtures are not acceptable.

f) Each lighting fixture shall be provided with an earthing terminal suitable for connection to 16 SWG GI earthing conductors.

g) All light reflecting surfaces shall have optimum light reflecting co-efficient such as to ensure the overall light output as specified by the manufacturer.

h) Height of fixtures should be such that it is easy to replace the lamps with normal ladder/stool. In case the ceiling height is very high, the fixtures may be placed on the walls for ground lighting.

2.2.1.5 **ACCESSORIES**

2.2.1.5.1 **Lamp holders and Starter Holders**

(a) Lamp holders/starter holders for fluorescent tubes shall be of the spring loaded, low contact resistance, bi-pin rotor type, resistant to wear and suitable for operation at the specified temperature, without deterioration in insulation value, contact resistance or retention of the lamp/starter. They shall hold the lamp/starter in position under normal condition of shock and vibration.

(b) Lamp holders/starter for incandescent lamps and HPMV/HPSV lamps shall be of screwed type, manufactured in accordance with relevant standard and designed to give long and satisfactory service.

2.2.1.5.2 **Ballasts**

a) All HPSV/HPMV/Metal halide lamp fixtures shall be provided with wire wound ballasts. All fluorescent fixtures shall be provided with high frequency electronic ballasts. The Ballasts shall be designed, manufactured and supplied in accordance with relevant standard and function satisfactorily under site condition specified. The ballasts shall be designed to have a long service life and low power loss.

b) Ballasts shall be mounted using self locking anti-vibration fixing and shall be easy to remove without dismantling the fixtures. They shall be totally enclosed units.

c) The wire-wound ballasts shall be of the inductive, heavy duty type, filled with thermosetting insulating moisture repellent polyester compound filled under pressure or vacuum. The ballast wiring shall be of copper wire. They shall be free from hum. Ballasts which produce humming sound shall be replaced free of cost by the Contractor. Ballasts for high pressure mercury vapour/ HPSV lamps shall be provided with suitable tappings to set the voltage within the range specified. End connections and taps shall be brought out in a suitable terminal block, rigidly fixed to the ballast enclosure.

d) Separate ballast for each lamp shall be provided in case of multi-lamp fixtures.

e) High frequency electronic ballasts shall be capable of satisfactory performance in adverse environment like that of EHV substation. Ballasts shall consist of AC/DC converter, high frequency power oscillator and low pass filter. The ballasts shall be suitable for use of nominal voltage of 230V +/- 10%, 50 Hz supply. The filter circuit shall suppress the feedback of high frequency signals to the mains. The ballast shall be rated for 36/40W fluorescent fixtures. The ballasts shall confirm to IEC 68-2-6FC, IEC 60929 for performance, IEC 60928 for safety and EN 55015, EN 55022A for RFI and EN 61003.

2.2.1.5.3 **Capacitors**

a) The capacitors shall have a constant value of capacitance and shall be connected across the supply of individual lamp circuits.

b) Power factor of fluorescent lamp fixtures with HF electronic ballast shall not be less than 0.90 and that of High pressure Sodium Vapour, Mercury Vapour and Metal Halide lamp fixtures shall not be less than 0.85. The capacitors shall be suitable for operation at supply voltage as specified and shall have a value of capacitance so as to correct the power factors of its corresponding lamp circuit to the extent of 0.98 lag.

c) The capacitors shall be hermetically sealed in a metal enclosure.

2.2.1.5.4 **Lamps**

a) General Lighting Services (GLS) lamps shall be provided with screwed caps and shall be of 'clear' type unless otherwise specified.

b) The Bidder shall furnish typical wiring diagram for Fluorescent, HPMV & HPSV fitting including all accessories. The diagram shall include technical details of accessories i.e. starters, chokes, capacitors etc.

c) Flexible conduits if required, for any fixture shall be deemed to be included in Contractor's scope.

2.2.1.5.5 **SWITCH AND SWITCHBOARD**

(a) All Switch board/boxes, 5/15 Amp Receptacles and electronic fan regulators located in office/building areas shall be modular flush mounted type or brick wall with only the switch knob projecting outside.

(b) Switch boards/boxes shall have conduit knock outs on all the sides.

(c) The exact number of switches including regulator for fans and layout of the same in the switchboard shall be to suit the requirement during installation.

(d) The maximum number of luminaires, controlled by one no 6 amp switch would 4 nos. For DC fixtures there will be no switch and the same shall be directly controlled from DC LP

(e) The luminaires shall be wired in such a fashion that luminaires on each Phase are evenly distributed all over the room.

2.2.1.5.6. **CONDUITS & CONDUIT ACCESSORIES**

a) The conduits shall conform to IEC: 61386 or IEC: 61035 or IEC: 60614 as applicable. All steel conduits shall be seemed by welding, shall be of heavy gauge and shall be hot dip galvanized.

b) Flexible conduits wherever required shall be made with bright, cold rolled annealed and electro-galvanised mild steel strips or PVC/Plastic.

c) All conduits accessories shall conform to relevant IEC and shall be hot dip galvanized or High-quality virgin PVC.

2.2.1.5.7 **TERMINAL BLOCKS**

Each terminal shall be suitable for terminating upto 2 Nos. 10 sq.mm. Stranded Aluminium Conductors without any damage to the conductors or any looseness of connections. Terminal strips provided in street - lighting poles shall be suitable for terminating upto 2 nos. 4C x 16 sq. mm aluminium cables.

2.2.1.5.8 **PULL OUT BOXES**

a) The pull out boxes shall be concealed type for indoor lighting and suitable for

mounting on column, structures etc., for outdoor lighting. The supply of bolts, nuts and screws required for the erection shall be included in the installation rates.

b) The pull out boxes shall be circular of cast iron or 16 SWG sheet steel and shall have cover with good quality gasket lining.

c) The pull out boxes and cover shall be hot dip galvanised.

d) The pull out boxes shall be completed with conduit knock outs/threaded hubs and provided at approximately 3 meters intervals in a conduit run.

2.2.1.5.9 **Residual Current Circuit Breakers (RCCB)**

For indoor panels 63A 4pole 300 ma RCCB conforming IEC 13947 will be provided along with incomer.

2.2.1.5.10 **Miniature Circuit Breaker (MCB)**

a) The miniature circuit breakers shall be suitable for manual closing, opening, automatic tripping under overload and short circuit. The MCBs shall also be trip free. MCB of Type C tripping characteristics as per IEC: 60898 will be used for Switchyard lighting.

b) Single pole as well as three pole versions shall be furnished as required in the Schedule of Lighting Panels.

c) The MCBs and panel MCCB together shall be rated for full fault level. In case the MCB rating is less than the specified fault level the bidder shall co-ordinate these breaker characteristics with the back up MCCB in such a way that if fault current is higher than breaker rating, the MCCB should blow earlier than the breaker. If the fault current is less than MCB breaking capacity, MCB shall operate first and not the incomer MCCB.

d) The MCBs shall be suitable for housing in the lighting panels and shall be suitable for connection with stranded copper wire connection at both the incoming and outgoing side by copper lugs or for bus bar connection on the incoming side.

e) The terminals of the MCBs and the ‘open’ ‘close’ and ‘trip’ conditions shall be clearly and indelibly marked.

f) The tenderer shall check and co-ordinate the ratings of MCBs with respect to starting characteristics of discharge lamps. The vendor has to furnish overload and short circuit curve of MCB as well as starting characteristics curves of lamps for Employer’s approval.

g) The MCB shall generally conform to IEC: 60898.

2.2.1.5.11 **Contactors**

Contactors shall be of the full voltage, direct-on line air break, single throw, electro-magnetic type. They shall be provided with atleast 2-’NC’ and 2’NO’ auxiliary contacts. Contactor shall be provided with the three element, positive acting, ambient temperature compensated time lagged, hand reset type thermal overload relay with adjustable settings to suit the rated current. Hand reset button shall be flush with the front of the cabinet and suitable for resetting with starter compartment door closed. The Contactor shall be suitable for switching on Tungsten filament lamp also. The bidder shall check the adequacy of the Contactors rating wire with respect to lighting load.

2.2.1.5.12 **Push Buttons**

All push buttons shall be of push to actuate type having 2 'NO' and 2 'NC' self reset contacts. They shall be provided with integral escutcheon plates engraved with their functions. Push buttons shall be of reputed make.

2.2.1.5.13 **Labels**

a) The lighting panels shall be provided on the front with panel designation labels on a 3 mm thick plastic plate of approved type. The letter shall be black engraved on white back ground.

b) All incoming and outgoing circuits shall be provided with labels. Labels shall be made of non-rusting metal or 3 ply lamicold. Labels shall have white letters on black or dark blue background.

2.2.1.5.14 **Earthing Terminals**

Panels shall be provided with two separate and distinct earthing terminals suitable to receive the earthing conductors of size 50x6 G.S. Flat.

2.2.1.5.15 Type test reports for following tests on all lighting panels shall be submitted for approval as per clause 9.2 of Chapter 2: GTR.

(i) Wiring continuity test
(ii) High voltage (2.5 KV for 1 minute) and insulation test
(iii) Operational test
(iv) Degree of protection (not less than IP-55 test on outdoor Lighting Panels and IP-52 test on indoor Lighting Panels as per IEC: 60947 (part 1)
(v) Heat run test

2.2.1.5.16. **LIGHTING POLES**

a) The Contractor shall supply, store and install the following types of steel tubular lighting poles required for street lighting.

i) Type A1 Street Lighting Pole - for one fixture

ii) Type E1 Post top lantern pole - for one fixture

b) Street/flood light poles shall conform to the enclosed drawings. In front of control room building, and Fire Fighting Buildings, decorative post top lantern (Type E1) poles and Bollards shall be installed.

c) Lighting poles shall be complete with fixing brackets and junction boxes. Junction boxes should be mounted one meter above ground level.

d) The lighting poles shall be coated with bituminous preservating paint on the inside as well as on the embedded outside surface. Exposed outside surface shall be coated with two coats of metal primer (comprising of red oxide and zinc chromate in a synthetic medium).

e) The galvanized sheet steel junction box for the street lighting poles shall be completely weather proof conforming to IP-55 and provided with a lockable door and HRC fuse mounted on a fuse carrier and fuse base assembly. The fuses & junction box shall be as specified in the specification. However, terminals shall be stud type and suitable for 2 nos. 16 sq.mm. Cable.

f) Wiring from junction box at the bottom of the pole to the fixture at the top of the pole shall be done through 2.5 sq. mm wire.

g) Distance of centre of pole from street edge should be approximately 1000 to 1200 mm.

h) Earthing of the poles should be connected to the switchyard main earth mat wherever it is available and the same should be earthed through 3M long, 20 mm dia., earth electrode.

2.2.1.5.17 **CEILING & WALL MOUNTED FANS AND REGULATORS**

a) The contractor shall supply and install 1400 mm sweep ceiling fans complete with electronic regulator and switch, suspension rod, canopy and accessories. The wall mounted fans shall be of 400 mm sweep

b) The contractor shall supply and install the switch, electronic regulator and board for mounting switch and electronic regulator for celling fans. The regulator will be housed in common switchboard for lighting and shall be of similar make and model as that of modular switches.

c) Winding of the fans and regulators shall be insulated with Class-E insulating material. Winding shall be of copper wire.

d) Electronic regulator with stepped control shall be provided.

2.2.1.5.18 **LIGHTING WIRES**

a) The wiring used for lighting shall be standard products of reputed manufacturers.

b) The wires shall be of 1100 V grade, PVC insulated product of reputed manufacturers.

c) The conductor sizes for wires used for point wiring beyond lighting panels shall be 2.5 sq.mm, 4 sq.mm, 6 sq.mm and 1.5 sq.mm stranded copper wire.

d) The wires used for connection of a lighting fixture from a nearest junction box or for loop-in loop-out connection between two fluorescent fixtures shall be single core copper stranded conductor, 1100V grade flexible PVC insulated cords, unsheathed, conforming to IEC:60502 with nominal conductor cross sectional areas of 2.5 sq. mm.

e) The wires shall be colour coded as follows:

Red for R - Phase
Yellow for Y - Phase
Blue for B - Phase
Black for Neutral
White for DC (Positive)
Grey for DC (Negative)

2.2.1.5.19 **LIGHTING SYSTEM INSTALLATION WORKS**

2.2.1.5.19.1 **General**

In accordance with the specified installation instructions as shown on manufacturer's drawings or as directed by Employer, Contractor shall unload, erect, install, test and put into commercial use all the electrical equipment included in the contract. Equipment shall be installed in a neat, workmanship manner so that it is level, plumbsquare and properly aligned and oriented. Tolerances shall be as established in manufacturers drawing or as stipulated by Purchaser.

All apparatus, connections and cabling shall be designed so as to minimize risk of fire or any damage which will be caused in the event of fire.

2.3.1.5.19.2 **Conduit System**

a) Contractor shall supply, store and install conduits required for the lighting installation as specified. All accessories/fittings required for making the installation complete, including but not limited to pull out boxes (as specified in specification ordinary and

inspection tees and elbow, checknuts, male and female bushings (brass or galvanised steel), caps, square headed make plugs, nipples, gland sealing fittings, pull boxes, conduits terminal boxes, glands, gaskets and box covers, saddle terminal boxes, and all steel supporting work shall be supplied by the Contractor. The conduit fittings shall be of the same material as conduits. The contractor shall also supply 20 mm PVC conduit and accessories for telephone wiring.

b) All unarmoured cables/wires shall run within the conduits from lighting panels to lighting fixtures, receptacles etc.

c) Size of conduit shall be suitably selected by the Contractor.

d) Conduit support shall be provided at an interval of 750 mm for horizontal runs and 1000 mm for vertical runs.

e) Conduit supports shall be clamped on the approved type spacer plates or brackets by saddles or U-bolts. The spacer plates or brackets in turn, shall be securely fixed to the building steel by welding and to concrete or brick work by grouting or by nylon rawl plugs. Wooden plug inserted in the masonary or concrete for conduit support is not acceptable.

f) Where conduits are along with cable trays they shall be clamped to supporting steel at an interval of 600 mm.

g) For directly embedding in soil, the conduits shall be coated with an asphalt-base compound. Concrete pier or anchor shall be provided wherever necessary to support the conduit rigidly and to hold it in place.

h) For long conduit run, pull boxes shall be provided at suitable intervals to facilitate wiring.

i) Conduit shall be securely fastened to junction boxes or cabinets, each with a lock nut inside and outside the box.

j) Conduits joints and connections shall be made through water-tight and rust proof by application of a thread compound which insulates the joints. White lead is suitable for application on embedded conduit and red lead for exposed conduit.

k) The entire metallic/PVC conduit system, shall be embedded, electrically continuous and thoroughly grounded. Where slip joints are used, suitable bounding shall be provided around the joint to ensure a continuous ground circuit.

l) Conduits and fittings shall be properly protected during construction period against mechanical injury. Conduit ends shall be plugged or capped to prevent entry of foreign material.

2.2.1.5.19.3 **Wiring**

a) Wiring shall be generally carried out by PVC insulated wires in conduits. All wires in a conduit shall be drawn simultaneously. No subsequent drawings of wires is permissible.

b) Wires shall not be pulled through more than two equivalent 90 deg. bends in a single conduit run. Where required, suitable junction boxes shall be used.

c) Wiring shall be spliced only at junction boxes with approved type terminal strip.

d) For lighting fixtures, connection shall be teed off through suitable round conduit or junction box, so that the connection can be attended without taking down the fixture.

e) For vertical run of wires in conduit, wires shall be suitably supported by means of wooden/hard rubber plugs at each pull/junction box.

f) Maximum two wires can be terminated to each way of terminal connections.

g) Separate neutral wires are to be provided for each circuit.

h) AC and DC wiring should not run through the same conduit.

2.2.1.5.19.4 **Lighting Panels**

a) The lighting panels shall be erected at the locations to be finalised during detailed engineering.

b) Suitable foundations/supporting structures for all outdoor type lighting panels shall be provided by the Contractor.

2.2.1.5.19.5 **Foundation & civil works**

a) Foundation for street lighting poles, panel foundation and transformer foundation shall be done by the Contractor. The payment towards execution, PCC & RCC shall be made under relevant items of civil work mentioned in Bid Price schedule.

b) All final adjustment of foundation levels, chipping and dressing of foundation surfaces, setting and grouting of anchor bolts, sills, inserts and flastening devices shall be carried out by the Contractor including minor modification of civil works as may be required for erection.

c) Any cutting of masonary / concrete work, which is necessary shall be done by the Contractor at his own cost and shall be made good to match the original work.

ANNEXURE-1

Sl. No.	Type of Lighting Fixture	Description	Philips Catalogue No
1	F1	2x28W T5 type fluorescent lamps in industrial reflector type fixture, complete with accessories and suitable for pendent /surface mounting.	TMS 122/228 HF
2	FF	2x28 T5 energy efficient fluorescent lamps with low glare, mirror optics suitable for recess mounting type lighting fixture.	TBS 088/228 C5 HF
3	FL	2x28W T5 energy efficient fluorescent lamps with low glare mirror optics suitable for pendent/surface mounting with all accessories	TCS 398/228 D6 HF
4	TL	Sleek and Functional electronic decobatten suitable for use with 1x'TLD'36W fluorescent lamp with dual tone end caps. Pre-phosphated & powder coated CRCA steel channel complete with all electrical accessories like electronic ballast, lamp holders all prewired up to a terminal block	TMS500/136 HF
5	IB	60/100w GLS lamp in Bulkhead fixtures with Cast Aluminium alloy body, suitable for column, wall, and ceiling mounting finished stove enameled silver grey outside	NXC101
6	BL	Aesthetic wall/ceiling mounted luminaire suitable for 1x PL-C 13W OR 11W CFL. Low loss O.C. Copper ballast. Built in high gloss anodized reflector. Twin finish UV stabilised SAN diffuser for protection & elimination of lamp glare.	FMC21/113
7	SL	Aesthetic ceiling mounted luminaire for Ecotone crystal/Décor CFL of 2x9W or 1x18W. ABS housing pre-wired with porcelain lampholder. Pre-phospated plated CRCA gear tray.	FL343/118
8	BH	Bulkhead luminaire suitable for use with PL-S 9W CFL. Single piece pressure die-cast aluminium & cover retaining Frame. Opal acrylic cover along with a gasket made of E.P.R..	FXC 101/109
9	BLD	2X9 Or 1x18 watt CFL bollard light for landscape lighting having FRP/LLDPE housing	FGC202 /118
10	DLR	2x18 watt CFL Downlighter with HF ballast suitable for recess mounting	FBH145/218L HF
11	DSM	1X13 WATT surface mounted CFL	FCS100/113
12	IF	Incandescent GLS lamp down light	DN622
13	SF1	1 X 400W HPSV lamps in high flood lighting fixture with integral control gear	SWF 330/1X400
14	SF2	2 X 400W HP sodium Vapour lamps in high flood lighting, non-integral control gear:	RVP302/2x400W

15	SF3	1 X 250W HPSV lamps in high flood lighting fixture with integral control gear:	SWF 330/1X250
16	SF4	150W HP Metal halide MHN-TD lamp in flood lighting fixture with integral control gear.	SWF230/150 MHN-TD
17	SF5	125 HP MV Lamp in weather proof post top lantern for mounting on pole top	HPC-101/125 HPF
18	SC	150W SON-T Tubular Sodium Vapour lamp in street lighting	SRX-51/150

SECTION-11-POWER AND CONTROL CABLE

Table of contents

1. General

This specification covers the design, manufacture, factory test, supply, delivery, installation, field-testing and commissioning of all XLPE Power, Control, and Instrumentation cables required for the entire project.

Manufacturer of power, control, and instrumentation cables shall hold valid ISO 9001 quality certificate.

The equipment and installation works specified in this Section shall conform to the latest edition of the appropriate IEC specifications and/or other recognized international standards

1.1 The equipment to be furnished shall strictly be in accordance with the specifications and the Price Schedule.

1.2 Equipment to be furnished

1.2.1 The following cables shall be furnished in accordance with specification

a) 33 kV XLPE Power Cable, termination equipments and Sealing ends

b) 12 kV XLPE Power Cable and termination equipments

c) 600-volt power cable

d) Control and instrumentation cable

e) Other Miscellaneous materials

1.2.2 The Contractor shall be responsible for estimating and supplying the quantity of various types and sizes of the cables. In course of actual execution, if it is found that additional cross-sections, types or quantities of cables for the transformer are required other than those indicated in his proposal; the same shall be supplied without any additional charge to the employer.

All other materials necessary for proper operation of the Plant and not mentioned in these specifications shall be supplied under the Contract. The prices of such materials shall be deemed to be included in the prices of the miscellaneous materials without any additional cost to the Employer unless stated otherwise in the Price Schedule.

1.3 33 AND 11 KV POWER CABLES, STRAIGHT JOINTS AND SEALING ENDS

1.3.1 DESIGN REQUIREMENTS

1.3.1.1 General

The following 33 & 11 kV power cables, straight through joints and sealing ends shall be supplied and installed according to approved Drawings and the requirements as hereafter specified. Non-erasable Sequential Marking of length shall be provided by embossing on outer sheath of the cable for each meter length. The quality of insulation should be good and insulation should not be deteriorated when exposed to the climatic conditions.

2. Requirement

A) 33kV & 11 kV Power cable

The 33 kV and 11 kV power cables and spare shall be supplied and installed to the following connections;

- 33 kV power cable shall be from 33 kV Gantry to Outside substation area upto distribution feeder point.
- 11 kV power cable as per specification and price schedule.

The 33/11 kV power cable shall be of single-core, cross linked polyethylene (XLPE) insulated, screened and steel tape red, PVC sheathed, copper conductor type and shall have a conductor size as per BOQ. Cable shall conform to BS 6622 & IEC 60502–2.

Operating temperature: - 90°C

Short circuit temperature: - 250°C

Conductor

Annealed Plain Copper Stranded compacted circular conductor conforms to BS 6360 and IEC 60228, class 2

Conductor Screening

Semi-Conducting layer over conductor

IS: 7098 Part 2, IEC: 60502 Part – 2, BS: 6622, BS: 7835.

Insulation

Cross linked Polyethylene to (XLPE)

IS: 7098 Part 2, IEC: 60502 Part – 2, BS: 6622, BS: 7835.

Insulation Screening

Semi-Conducting layer over insulation, in combination with Copper tape.

Bedding

Extruded PVC

Armour

Single Core - Galvanized steel round wire. Non-magnetic

Outer Sheath

Extruded PVC / Special PVC compound such as Flame Retardant (FR), Flame Retardant Low Smoke (FRLS), and Low Smoke Zero Halogen (LSOH) or equivalent compatible with the system can be used for outer sheath to suit a variety of environment and fire risk conditions. Flammability test confirms to IEC 332. For installation where fire and associated problems such as emission of smoke and toxic fumes offer a serious potential threat, special LSF (Low smoke & fumes) compound can be provided. LSF compound is Halogen free (Fluorine, Chlorine, Bromine) when tested as per BS 6425 (Pt 1) & IEC 60754 (Pt 1). The acid gas evolved during combustion is less than 0.5% by weight of material.

The 33 kV power cables shall be rated as follows:

a)	Rated voltage, phase to phase (Uo)	33 kV
b)	Highest voltage of three-phase system (Um)	36 kV
c)	Rated lightning impulse withstand voltage	170 kV
d)	Rated power-frequency short duration withstand voltage for one minute	70 kV
(e)	Maximum short-circuit current	25/31.5 kA
(f)	Maximum time for short-circuit current	3 second

The 33 kV XLPE cables shall be installed in the flexible pipe conduits as per approved Drawing. Flexible pipes shall be provided by Contractor and shall be included in cost of cable. The necessary civil trench works / other works shall be carried accordingly.

At the opening of the civil structures where the power cables are passing through, suitable sealing means shall be provided by the Contractor to keep out rain from the outside.

The method of cable laying shall be designed by the Contractor to ensure higher security and reliability during and after the installation. The cable installation shall be carried out by the Contractor in accordance with the approved procedures.

11 kV power cable

The 11 kV power cables shall be rated as follows:

a)	Rated voltage, phase to phase (Uo)	11 kV
b)	Highest voltage of three-phase system (Um)	12 kV
c)	Rated lightning impulse withstand voltage	75 kV
d)	Rated power-frequency short duration withstand voltage for one minute	17 kV
e)	Maximum short-circuit current	25 kA
f)	Maximum time for short-circuit current	3 second

The 11 kV XLPE cables shall be installed in the flexible pipe conduits. Flexible pipes shall be provided by Contractor and shall be included in cost of cable. The necessary civil works shall be carried accordingly.

At the opening of the civil structures where the power cables are passing through, suitable sealing means shall be provided by the Contractor to keep out rain from the outside.

The method of cable laying shall be designed by the Contractor to ensure higher security and reliability during and after the installation. The cable installation shall be carried out by the Contractor in accordance with the approved procedures.

B) Cable termination/Sealing ends

Outdoor type sealing ends with post insulator support shall be supplied and installed for termination of the 33/11 kV XLPE power cables. Straight through shall be provided as per requirement.

Each sealing end shall be complete with porcelain/Polymer insulator, leading conductor, condenser cone, stress relief cone, insulating compound, shielding cover, protective case, grounding terminal, lower metal with rigid flange and other necessary materials to properly seal the cable terminal.

Thermal expansion and contraction of the cable due to temperature change shall be considered for designing the joint insulation of the sealing end.

Cross bond earthing (or any other) shall be employed so that shielding of both sides of each joint shall be connected to the shielding of the other phase, so as to suppress the induced voltage. Necessary design and materials for such cross-bond earthing shall be provided by the Contractor.

The minimum creepage distance of outdoor sealing-ends shall be as required for heavily polluted atmospheres in line with the IEC 137 standard.

C) Accessories

The following accessories shall be provided with the 33 and 11 kV power cable for each end.

(i) Name plates

(ii) Phase Identification

Phase identification for conductor cables shall be in accordance with the following:

Phase A (R): Red

Phase B (Y): Yellow

Phase C (B): Blue

(i) Voltage Identification

The plastic covering shall be embossed with the name of the manufacturer, number of conductors, the cross sections and type of insulation.

D) Cable Drum

Cable drum shall be non- returnable and shall be made of steel, suitably protected against corrosion for spare length. Drum Schedule shall be finalized after detail layout in substation.

3. Installation Works

Scope of Works

The installation of the transmission materials and substation equipment specified under this subsection shall cover the following works:

Installation works for transmission facilities in:

33 kV Switchgear Busbar to Outside substation area upto feeder termination with overhead line.

33/11 kV transformer to indoor 11 kV Switchgear Busbar

11 kV switchgear Busbar to public road for termination with overhead line.

Any other facility if any as per field requirement.

(a) Installation of 33/11 kV underground cables for single circuit line (three conductors separately) with flexible pipes and civil structure as required including its termination on both ends.

(b) Installation of out door type sealing ends for 33 kV cables with post insulators at out side Public Road or as directed by employer.

(c) Inspection and test.

a) Installation of Underground Lines

The contractor shall lay cables in accordance with approved Drawing by using flexible pipes and necessary civil works.

Termination works for the cables shall be made with utmost care by the skilled workers. Extra loop of approximately 5 m length at cable termination and joint shall be made as far as the space is available. The contractor shall install the steel and/or concrete cable mark as approved by the Employer at 50 m intervals along the cable route.

The cables shall be terminated with sealing ends and post insulators. Each terminal shall be provided with phase identification marks of A-B-C (R-Y-B).

Arrangement of flexible pipes for cable installation is shown in Tender Drawing. Terminations of those pipes shall be properly made so that penetration of water inside the flexible pipes after completion of the works is not allowed.

Prior to pull-through of the cable into the flexible pipes, the Contractor shall calculate the pull-through length of the cable and confirm that the pull-through tension is not more than permissible tension. The shields of the 33 kV power cables shall be grounded in the approved manner at each joint.

b) Installation of Sealing Ends of 33 kV Cable

The 33 kV cable end shall be made as per IEC standard. Necessary additional steel structure with concrete foundation shall be constructed if required for the installation of bushings as well as Lightning arrestors (LA).

c) Inspection and Tests

Through the work execution, various inspections and tests on the progressing works will be ordered to the Contractor by the Employer.

Following inspections and tests will be carried out after completion of the works section by section. The Contractor shall perform all the inspections and tests in accordance with IEC Standard.

Underground Power Cables

a) Visual inspection of the underground cable lines

- Back filling and grade
- Cable and joint marks
- Cable termination and connection

b) Measurement insulation resistance of the lines

3.1 TESTS FOR 33/11 KV POWER CABLES, SEALING ENDS AND ACCESSORIES

Test at works:

The following tests shall be carried out at the manufacturer's premises before shipment as far as applicable for type of conductors and cables:

a) 33/11 kV XLPE power cable

(i) Appearance check

(ii) Conductor resistance measurement

(iii) Capacitance measurement

(iv) Insulation resistance measurement

(v) A.C. withstand voltage

(vi) A.C. long duration withstand voltage

(vii) Impulse withstand voltage

(viii) A.C. long duration breakdown voltage

(ix) Impulse break-down voltage

(x) Dielectric loss tangent

(xi) Temperature-voltage characteristic

(xii) Dimension

- Conductor outermost diameter
- Insulation thickness
- Sheath thickness
- Over-sheath thickness
- Thickness of each tape
- Interval of tape lapping
- Total diameter

(xiii) Bending withstand characteristic

(xiv) Over-sheath, tensile strength

(xv) - do. - , thermal aging

(xvi) - do. - , oil-proof

(xvii) - do. - , non-in flammability

(xviii) - do. - , thermal deformation

(xix) - do. - , hardness

b) Sealing ends

i) Construction

ii) A.C. long duration withstand voltage

iii) Impulse withstand voltage

iv) A.C. long duration breakdown voltage

v) Impulse breakdown voltage

vi) Porcelain or epoxy insulator, construction

vii)- do. - , power frequency flash-over voltage (dry)

viii)- do. - , power frequency flash-over voltage (wet)

ix)- do. - , 50% impulse flash-over voltage

x) - do. - , cantilever strength

xi)- do. - , thermal mechanical performance

(c) Other conductors

i) Construction test

ii) Resistance tests

iii) Withstand voltage test

iv) Insulation resistance test

v) High temperature insulation resistance test

vi) Tensile strength test

vii) Coiling test

viii) Thermal deformation test

ix) Oil proof test

x) Non-inflammability test

xi) Shield conductivity test

xii) Thermal shrinkage test

xiii) A.C. breakdown voltage test

xiv) Impulse breakdown voltage test

xv) Tin plating test

xvi) Acid and alkaline proof test

xvii) Oxygen index measurement

xviii) Chlorine gas measurement

Test on Completion:

After completely installing the 33 kV XLPE power cables, sealing ends and other conductors at site, the following tests shall be carried out by the Contractor.

a) DC High voltage test

Payment:

Payment for Construction and Installation of Contract item for “33/11 kV XLPE HT copper power cable" shall be made at the unit price per running meter of the cable as per bid. Therefore, in the Price schedules, such unit prices shall include full compensation for all costs incurred in furnishing, construction (Cutting of asphalt road, Construction of Cable trench, Man hole, laying of flexible pipe, placing of find sand, laying of power cable, making the road same as it was before digging, placing of route marker) and installing all power cable. In case of the material that are quoted in LS basis in BOQ they are also converted into the run meter and payment is made.

3.2 600 VOLT POWER CABLE

a) General

The low voltage cables shall be 600 V grade polyethylene insulated and PVC sheathed. Low voltage AC power systems will be solidly grounded neutral with phase-to-phase voltage level of 400 V and phase to neutral voltage of 230 V AC system and the DC system with 110 V. The size of the single core conductor shall not be less than 2.5 sq. mm for lighting and 4 sq. mm for power. The main (incomer) cable to AC distribution panel shall be three & half (3.5) core.

Sizing of power cables shall be done by the contractor, keeping in view continuous current, voltage drop & short-circuit consideration of the system. Relevant calculations shall be submitted by bidder during detailed engineering for employer’s approval.

While preparing cable schedules for control/protection purpose following shall be ensured:

- Separate cables shall be used for AC & DC.
- Separate cables shall be used for DC1 & DC2.
- For different cores of CT & CVT separate cable shall be used
- 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.
- For control cabling, including CT/VT circuits, 2.5 sq. mm size copper cables shall be used per connection. However, if required from voltage drop/VA burden consideration additional cores shall be used. Further for potential circuits of energy meters separate connections by 2 cores of 2.5 sq. mm size shall be provided

b) Conductor

Conductor shall consist of stranded annealed copper wires. They shall comply with IEC publication. The cable is intended for use at normal conductor operating temperatures not exceeding 75-degree C.

c) Insulation

The electrically and thermally stable polyethylene insulation shall be extruded onto the conductor so as to prevent contamination and voids in the insulation.

d) Current Rating

The Contractor shall state the maximum continuous current rating and conditions of installation for low voltage power cables.

e) Jacket

The cable core assembly shall be covered with a flame-retardative and moisture resistant PVC jacket, which is free stripping from the insulation. The overall jacket shall be clean, dry, and free of grease and shall be suitable for ink or paint application.

f) Anti-- Termite Covering

Anti-termite protection shall be applied to the cable and shall consist of either a non-magnetic metallic barrier or layer of nylon sheathing

g) Identification

- Each cable shall have a printed legend on the overall jacket with the manufacturer's name, voltage class, the number and size of conductors, type of insulation
- The colours for core identification and colour sequence shall be in accordance with follows
  - Single-core : Black
  - Double-core : Red and black
  - Three-core : Red, yellow and blue
  - Four-core : Red, yellow, blue and black

3.3 CONTROL AND INSTRUMENTATION CABLE

a) General

All control and instrumentation cable shall be 600 V grade as per IEC standard, multi conductor, color-coded, PVC insulated armored cable. Each multicore cable shall have not less than 20 percent or 2 spare cores, whichever is the greater.

b) Conductor

Copper conductor shall be stranded circular non-compacted cross-section of a minimum 2.5 sq. mm. The Contractor shall calculate the load of CT core considering all connected loads and submit to the employer for approval. In case of CT burden constrain, CT circuit cable cross sectional area shall be increased. In this case the Contractor shall supply and install the cable required cross-section area without any additional cost to the Employer.

c) Insulation

The electrically and thermally stable PVC insulation shall be extruded onto the conductor so as to prevent contamination and voids in the insulation.

d) Assembly

1) Multi-core conductor cables shall be assembled in accordance with applicable IEC standards.

2) A flame-retardative binder tape may be used underneath the overall jacket of multi-conductor cables, if required, to achieve the desired flame retardative characteristics. Tapes, if used, shall be non-hygroscopic.

e) Jacket

1) The cable core assembly shall be covered with a flame retardative and resistant jacket, which is free stripping from the insulation.

2) The overall jacket shall be clean, dry, and free of grease and shall be suitable for ink or paint application.

3) Cable jacketing and the interstices within the jacket shall be free of water. Evidence of water shall be the ground for rejection of the cable.

f) Anti- Termite Covering

Anti-termite protection shall be applied to the cable and shall consist of either a non-magnetic metallic barrier or layer of nylon sheathing.

g) Identification

Each cable shall have a printed legend on the overall jacket, with the manufacturer's name, voltage class, the number and size of conductors, and a unique number or code indicating the production run or batch. The identification shall remain legible for the life of the cable

3.4 COMMUNICATION CABLE

a) All cables and wiring shall have copper conductors and PVC insulation and shall comply with IEC standards

b) Each communication cable shall have not less than 20 percent or 4 spare twisted pairs whichever is the greater. Cabling and wiring installations shall be arranged to minimize the risk of fire and damages, which might be caused in the event of fire.

c) For telephone type cables, 2 conductor wires of not less than 0.6 mm dia shall be used. Where twin or quad make up is required in any cable, the cores shall be uniformly twisted and the lays arranged such that cross talk is reduced to a minimum.

d) No conductor smaller than 32/0.2mm ($1mm^2$), or having less than three strands, shall be used for interconnecting the cables except in the case of telephone extensions. All cables shall have insulation, which will withstand the highest temperature to be experienced in service.

e) Each conductor of a multicore cable shall be readily identified by a numbered marker tape or, in the case of telephone type cables, colour coded insulation.

3.5 SPECIAL REQUIREMENTS

3.5.1 The Contractor shall be responsible for estimating and supplying the quantity of various types and sizes of the cables. In course of actual execution, if it is found that additional cross-sections, types or quantities of cables are required for the completion of the specified works the same shall be supplied without any additional charge to the employer.

3.5.2 Small cut piece lengths of cables will not be accepted. Cables up to 500 meters in length or as approved by Employer shall be of one length shipped in a drum of adequate size. For higher quantities, multiple lengths/drums may be shipped subject to the approval of Employer.

3.5.3 DRAWINGS, DATA & MANUALS

The following information shall be furnished along with the bid.

(a) Manufacturer's leaflets giving constructional details, dimensions and characteristics of different cables.

(b) Current rating of cables including derating factor due to grouping, ambient temperature and type of various installation.

3.5.4 TESTS FOR LOW VOLTAGE CONTROL, INSTRUMENT AND COMMUNICATION CABLES

3.6 Routine and Design Tests

Power cable shall be subjected to following routine tests. As far as practical, the procedure of IEC shall be followed:

a) Measurement of the electrical resistance of conductor

b) Partial discharge test

c) Voltage test

The power cable design tests shall include following:

a) Partial discharge test

b) Bending test, followed by a partial discharge test

c) Tan delta measurement

d) Heating cycle test, followed by a partial discharge test

e) Impulse test, followed by voltage test

f) Voltage test for 4 hours.

The Bidder shall submit copy of design test report from recognized testing laboratory for the offered power cable along with the bid.

3.6.1 Field Tests

After installation at Site, cables shall be subjected but not limited to the following tests:

a) Measurement of insulation resistance

b) DC dielectric test

3.6.2 TYPE TESTS

3.6.3 All cables shall conform to all type, routine and acceptance tests listed in the relevant IEC.

3.6.4 XLPE INSULATED POWER CABLES (For working voltages up to and including 1100V): -

3.6.5 Following type tests (on one size in a contract) as per IEC: 60502 (Part 1) including its amendments shall be carried out as a part of acceptance tests on XLPE insulated power cables for working voltages up to and including 1100 V:

a) Physical tests for insulation

i) Hot set test

ii) Shrinkage test

b) Physical tests for outer sheath

i) Shrinkage test

ii) Hot deformation

iii) Heat shock test

iv) Thermal stability

3.6.6 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Chapter 2: GTR for the following tests-

a) Water absorption (gravimetric) test.

b) Ageing in air oven

c) Loss of mass in air oven

d) Short time current test on power cables of sizes 240 sq.mm and above on

i) Conductors.

ii) Armours.

e) Test for armouring wires/strips.

f) Oxygen and Temperature Index test.

g) Flammability test.

3.7 PVC INSULATED POWER & CONTROL CABLES (For working voltages up to and including 1100V)

3.8 Following type tests (on one size in a contract) as per IEC: 60502 (Part 1) including its amendments shall be carried out as a part of acceptance tests on PVC insulated power & control cables for working voltages up to and including 1100 V:

a) Physical tests for insulation and outer sheath

i) Shrinkage test

ii) Hot deformation

iii) Heat shock test

iv) Thermal stability

b) High voltage test.

3.8.1 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Chapter 2: GTR for the following-

a) High voltage test.

b) Ageing in air oven.

c) Loss of mass in air oven.

d) Short time current test on power cables of sizes 240 sq. mm and above on

i) Conductors.

ii) Armours.

e) Test for armouring wires/strips.

f) Oxygen and Temperature Index test.

g) Flammability test.

3.8.2 XLPE INSULATED HV POWER CABLES (For working voltages from 3.3 kV and including 33 kV)-

3.8.3 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Chapter 2: GTR for XLPE insulated HV power cables (as per IEC: 60502 Part-2).

3.8.4 Terminating/jointing accessories as per IEC 60840:1999/ IEC62067

3.9 PERFORMANCE GUARANTEE

The performance figures quoted on schedule of Technical Data shall be guaranteed within the tolerance permitted by relevant standards and shall become part of the Contract. In case of failure of the cables to meet the guarantees, the Employer reserves the right to reject the item. The Contractor shall have to rectify/ replace the defect/ defective part at no extra cost to the Employer and without delaying the commissioning schedule.

The Contractor shall conduct the above-mentioned tests in presence of Employer before dispatch of the Power and control cables (Low voltage up to 1.1 kV). All the cost of tests including cost of travelling, lodging and fooding of two NEA personnel shall be borne by the Contractor. With in seven days after the completion of tests the contractor has to furnish the final three certified copies of report of all tests to the Employer.

SECTION-12: FIRE PROTECTION

Table of contents

1.00.00 **INTENT OF SPECIFICATION**

This section covers the design and performance requirements of the following types of fire protection systems;

a. Hydrant System

b. High Velocity Water (H.V.W) Spray System

c. Fire Detection and alarm System

d. Portable Fire Extinguishers

e. Wheel/ Trolley mounted Fire Extinguishers

1.00.01 It is not the intent to completely specify all details of design and construction. Nevertheless, the system design and equipment shall conform in all respects to high standard of engineering, design and workmanship and shall be capable of performing in continuous commercial operation in a manner acceptable to the Owner. The system design shall also conform to NFPA norms.

1.00.02 The scope of work includes complete earthwork (i.e. excavation, backfilling etc.) for the entire buried piping for the system, valve pits and pipe supports for buried, entrenched and overground piping.

1.00.03 The equipment offered shall comply with the relevant latest International Standards **unless specified otherwise**. The Deluge valves, HVW spray nozzles & quartzoid bulb detectors shall have the approval of any of the following agencies;

a. UL of USA.
b. F M of USA
c. LPCB of UK or
d. VDS of Germany,

1.00.04 Ambient temperature for design of all equipment shall be considered as 50°C.

1.00.05 The piping and instruments diagram for Hydrant and HVW spray system for 400kV switchyard is enclosed at Appendix-I respectively. The successful bidder shall prepare detailed layout and piping drawing based on this drawing and other drawings such as road, drainage, cable trench, switch yard layout, etc. as furnished by the Employer during detailed engineering.

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2.00.00 **DESIGN AND CONSTRUCTION**

2.01.00 **Hydrant System**

Hydrant system of fire protection essentially consists of a large network of pipe, both under ground and over ground which feeds pressurised water to a number of hydrant valves, indoor (if applicable) as well as outdoor. These hydrant valves are located at strategic locations near buildings, Transformers and Reactors. Hose pipes of suitable length and fitted with standard accessories like branch pipes, nozzles etc., are kept in Hose boxes. In case of emergency, these hoses are coupled to the respective hydrant valves through instantaneous couplings and jet of water is directed on the equipment on fire. Hydrant protection shall be provided for the following in all substations of voltage levels 132kV and above (This is not applicable for extension of existing 220kV and 132kV substations where Hydrant system is not available). At least one hydrant post shall be provided for every 60m of external wall measurement of buildings.

a) Control room building

b) L.T. Transformer area.

c) Fire Fighting pump House.

d) Stores

e) Transformers

f) Shunt Reactors/ Bus Reactors.

2.01.01 A warning plate shall be placed near the hydrant points for the transformers and reactors substations to clearly indicate that water shall be sprayed only after ensuring that the power to the transformer/ reactor which is on fire is switched off and there are no live parts within 20metres of distance from the personnel using the hydrant.

2.02.00. **HIGH VELOCITY WATER (H.V.W) SPRAY SYSTEM**

H.V.W. spray type fire protection essentially consists of a network of projectors and an array of heat detectors around the Transformer/Reactor to be protected. On operation of one or more of heat detectors, Water under pressure is directed to the projector network through a Deluge valve from the pipe network laid for this system. This shall be provided for transformers and reactors in all 132kV & above substations (This is not applicable for extension of existing 220kV and 132kV substations where HVWS system is not available). Wet detection initiation system shall be employed for automatic operation.

The system shall be designed in such a way that the same can be extended to protect additional Transformer/ Reactor to be installed in future. However, for the purpose of design it shall be assumed that only one Transformer/ Reactor will be on fire. The main header pipe size in the yard shall be 200mmNB (for 220kV & 132kV switchyard). Branch to the equipment (shall not be more than 20metres length) shall be of the same size as of deluge valve.

2.02.01 The Electrical clearance between the Emulsifier system pipe work and live parts of the protected equipment shall not be less than the values given below:

1.	245 kV bushing	2150 mm
2.	145 kV bushing	1300 mm
3.	52 kV bushing	630 mm
4.	36 kV bushing	320 mm

2.02.02 System shall be designed in such a way that the Water pressure available at any spray nozzle shall be between 3.5bar and 5.0bar and shall be demonstrated through hydraulic calculations. Water shall be applied at a minimum rate of 10.2 LPM/M^2 of the surface area of the transformer / Reactor including radiator, conservator, oil pipes, bushing turrets, etc. (including bottom surface for transformer). The nozzle arrangement shall ensure direct impingement of water on all exterior surfaces of transformer tank, bushing turrets, conservator and oil pipes, except underneath the transformer, where horizontal spray may be provided.

. 2.02.03 **Deluge Valve**

Deluge Valve shall be water pressure operated manual reset type. The Deluge valve shall be closed water tight when water pressure in the heat detector pipe work is healthy and the entire pipe work shall be charged with water under

pressure upto the inlet of the Deluge valve. On fall of water pressure due to opening of one or more heat detectors, the valve shall open and water shall rush to the spray water network through the open Deluge valve. The valves shall be manually reset to initial position after completion of operation. Each Deluge Valve shall be provided with a water motor gong which shall sound an alarm when water after passing through the Deluge valve, is tapped through the water motor.

Each Deluge valve shall be provided with a local panel with provision of opening of Deluge valve from local and remote from control room/ remote centre. In addition to this, each valve shall be provided with local operation latch.

Deluge valves of 100mmNB size shall be used if the flow requirement is ≤ 200m^3/hr and 150mmNB size shall be used for flow requirement >200m^3/hr.

Test valves shall simulate the operation of Deluge valves and shall be of quick opening type. The general construction shall conform to requirements under clause no.7.00.00 for piping, valves and specialities.

2.02.04 **High Velocity Spray Nozzles (Projectors)**

High velocity spray system shall be designed and installed to discharge water in the form of a conical spray consisting of droplets of water travelling at high velocity, which shall strike the burning surface with sufficient impact to ensure the formation of an emulsion. At the same time the spray shall efficiently cut off oxygen supply and provide sufficient cooling.

2.02.05 Minimum set point of the heat detectors used in the HVW spray system shall be 79^{o}C. The optimum rating shall, however, be selected by the Bidder, keeping in mind the maximum and minimum temperature attained at site.

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2.03.00 **Fire Detection and alarm System**

This system shall be provided for control room building and Switchyard panel rooms of substations**.**

2.03.01 Suitable fire detection system using smoke detectors and/or heat detectors shall be provided for the entire building, including corridor and toilets. Fire detectors shall be located at strategic locations in various rooms of the building. Each Switchyard panel room shall be considered a separate zone. Adequate number of extra zones shall be provided for Switchyard panel rooms for future bays identified in Single line diagram of the substation. The operation of any of the fire detectors/ manual call point should result in the following;

1. A visual signal exhibited in the annunciation panels indicating the area where the fire is detected.
2. An audible alarm sounded in the panel, and
3. An external audible alarm sounded in the building, location of which shall be decided during detailed engineering.
4. If the zone comprises of more than one room, a visual signal shall be exhibited on the outer wall of each room.

2.03.02 Each zone shall be provided with two zone cards in the panel so that system will remain healthy even if one of the cards becomes defective.

2.03.03 Coverage area of each smoke detector shall not be more than 80 m^2 and that of heat detectors shall not be more than 40 m^2. Ionisation type smoke detectors shall be provided in all areas except pantry room where heat detectors shall be provided. If a detector is concealed, a remote visual indication of its operation shall be provided. Manual call points (Break glass Alarm Stations) shall be provided at strategic locations in the control room building. All cabling shall be done through concealed conduits.

2.03.04 Cables used should be exclusively for fire detection and alarm system and shall be 2Cx1.5sq.mm Cu. cables. Un-armoured PVC insulated FR cables conforming to latest IEC / International standards shall be used.

2.04.00 Portable and Wheel/ Trolley mounted Fire Extinguishers

2.04.01 Portable Fire Extinguishers

Adequate number of portable fire extinguishers of pressurised water, dry chemical powder, and Carbon dioxide type shall be provided in suitable locations in control room building and FFPH building as indicated in the drawing. In addition to this one (1) CO2 type fire extinguisher of 4.5kg capacity shall be provided for each Switchyard panel room. These extinguishers will be used during the early phases of fire to prevent its spread and costly damage.

The design, construction & testing of portable fire extinguishers shall meet the requirements as per clause 10.00.00.

2.04.02 Wheel/ Trolley mounted Fire Extinguishers

Wheel/Trolley mounted Mechanical foam type fire extinguishers of 50litre capacity, conforming to latest international standards, shall be provided for the protection of the following:

1. Transformers and reactors in 220kV and 132 kV substations where Hydrant/HVWS system is not available. Two (2) nos. for each 220kV or 132kV transformer and reactor.

2. LT transformers in all substations. One (1) no. for each LT transformer.

The design, construction & testing of Mechanical foam type 50 litre capacity shall meet the requirements of relevant International Codes and clause 10.00.00 of this specification.

2.05.00 Water Supply System

For **for 220kV and 132kV** level substations water for hydrant & HVW system shall be supplied by one electrical motor driven pump of rated capacity **273m3/hr**. at 70MWC head, with another pump of same capacity, driven by diesel engine, shall be used as standby. Water storage tank with two compartments of adequate capacity shall be provided. Pumps shall work under positive suction head. Annunciations of the hydrant & HVW spray systems shall be provided in fire water pump house and repeated in control room. Provision for sending data to remote control centre shall also be available.

The outdoor piping for the system in general shall be laid above ground on concrete pedestals with proper supporting arrangement. However, at road/rail crossings, in front/access of buildings, places where movement of cranes/vehicles is expected and at any other place where above ground piping is not advisable, the pipes shall be laid underground. Such locations shall be finalised during detailed engineering.

The whole system will be kept pressurised by providing combination of air vessel and jockey pump of 10.8M^3/hr. capacity at 80MWC. The capacity of air vessel shall not be less than 3m^3. Minor leakage will be met by Jockey pump. One additional jockey pump shall be provided as standby. All pumps shall be of horizontal centrifugal type. Pumps and air vessel with all auxiliary equipment will be located in firewater pump house. A pressure relief valve of suitable rating shall be provided in water header to release excess pressure due to atmospheric temperature variations.

Operation of all the pumps shall be automatic and pumps shall be brought into operation at preset pressure. Fire pumps shall only be stopped manually. Manual start/stop provision shall be provided in local control panel.

2.05.01 The general design of the fire fighting pump sets shall meet the requirements under clauses no.5.00.00 for Horizontal centrifugal pumps, no.6.00.00 for Diesel engines and no.12.00.00 for Electrical motors.

2.05.02 Each pump shall be provided with a nameplate indicating suction lift/delivery head, capacity and number of revolutions per minute.

2.05.03 Design, construction, erection, testing and trial operation of piping, valves, strainers, hydrant valves, hoses, nozzles, branch pipes, hose boxes, expansion joints etc. shall conform to the requirements of clause no. 7.00.00.

2.06.00 **Instrumentation and Control System**

2.06.01 All instruments like pressure indicators, differential pressure indicators, pressure switches, level indicators, level switches, temperature indicators, alarms and all other instruments and panels as indicated in the specification and drawings and those needed for safe and efficient operation of the whole system shall be furnished according to the requirements of clause 11.00.00. Pump running/ fails to start signal shall be taken from the pressure switch immediately after the discharge of the pump.

2.06.02 **Control Panel**

Power feeder for motors will be from switchgear board located in control building but control supply for all local control panels, annunciation panels, battery charger units, space heaters etc. shall be fed from the AC and DC distribution boards located in pump house. These AC & DC distribution boards will be fed from the switchgears and DCDBs located in control building.

a) Panel for motor driven fire water pump

The panel shall be provided with the following:

1.	TPN switch	1 No.
2.	Auto/manual selection facility	
3.	Start/Stop facility with indication lamp	1 Set
4.	DOL starter with thermal O/L relay	1 Set
5.	Indicating lamp showing power ON	1 Set
6.	Indication lamp with drive ON/OF	1 Set
7.	Indication lamp showing Motor Trip	1 No.

Additional provisions shall be made for controlling the following from the remote control centre:

1. Auto/manual selection facility

2. Start/Stop facility

Main power cable from breaker feeder of main switchboard shall be terminated in this panel and another cable shall emanate from this panel which shall be terminated at motor terminals.

b) Panel for Two nos. Jockey Pump 1No.

The panel shall be provided with the following:

1.	Fuse-switch unit for Jockey pumps	1 Set for each pump
2.	Auto/manual selection facility for each pump	
3.	Selector switch for selecting either jockey pump	1 No.
4.	D.O.L. starter with overload relay self-resetting type, for all the drives.	1 No. each
5.	Start/stop push button for Jockey Pump with indication lamp with pad-locking arrangements in stop position	1 Set for each pump
6.	Indication lamp for trip indication	1 No. each for pump

Additional provisions shall be made for controlling the following from the remote control centre:

1. Auto/manual selection facility for each pump**.**

a) Panel for 2 Nos. battery charger & Diesel Engine driven fire water pump 1 No.

The panel shall be provided with the following:

1.	Auto/Manual selection facility for Diesel Engine driven pump	1 No.
2.	Start/Stop facility with indication lamp	1 Set
3.	Indicating lamp showing drive ON/OFF	1 Set
4.	D.C. Voltmeter/Ammeter in the battery charger circuit	1 No. each
5.	Battery charger will be as per specification described	1 Set
6.	Selector switch for selecting either of battery chargers for the battery sets.	1 No.
7.	Selector switch for selecting either set of batteries for Diesel engine starting.	1No.

8. Selector switch for boost charging/Trickle charging of battery set. 1 Set

Additional provisions shall be made for controlling the following from the remote control centre:

1. Manual Start/Stop of Diesel Engine

d) Individual local control panel is to be considered for each transformer/ Reactor deluge system wherever these equipments are envisaged. This panel shall contain push buttons with indicating lamps for spray ON/OFF operation in the valve operation circuit. Push buttons shall be concealed behind glass covers, which shall be broken to operate the buttons. Provision shall be made in the panel for the field signal for the annunciations such as spray ON and fire in the Transformer/Reactor. A signal for spray ON shall also be provided in the control room fire alarm panel for employer's event logger. Remote operation facility to open the Deluge valve from control room/ remote centre shall also be provided.

2.06.03 **Annunciation Panels**

a) Location: Fire Water Pump House

i) Indicating lamps showing power supply "ON".

ii) Annunciation windows complete with buttons. Details are as follows:

Sl.No.	Description	Number
1.	Electric motor driven fire water pump running	1
2.	Electric motor driven fire water pump fails to start	1
3.	Diesel engine driven fire water pump running.	1
4.	Diesel engine driven water pump fails to start	1
5.	Jockey pump-1 running	1
6.	Jockey pump-1 fails to start	1
7.	Jockey pump-2 running	1
8.	Jockey pump-2 fails to start	1
9.	Fire in Transformer/ Reactor	1 for each equipment
10.	Deluge system operating for Transformer/Reactor	1 for each equipment
11.	Header pressure low	1
12.	Fire in smoke detection system zone (Common Fire Signal)	1
13.	Water storage tank water level low	2

14.	High speed diesel tank level low	1
15.	Spare	10

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b) **Location: Substation Control Room**

i) Indication lamp showing power supply 'ON'

ii) Provision shall be made in the panel for a signal for spray ON for each Transformer/Reactor for owner's use for event logger.

iii) Each Switchyard panel room shall be considered as separate zone for fire detection and alarm system.

iv) Following annunciations shall be provided.

Sl.No.	Description	Number
1.	Fire in Transformer/ Reactor	1 for each equipment
2.	Diesel engine driven fire water pump in operation	1
3.	Motor driven fire water pump in operation	1
4.	Jockey pump in operation	1
5.	Fire fighting Water storage tank level Low	2
6.	Fire/Fault (zone alarm module)	1+1(duplicate) For each zone as applicable
7.	Spare windows complete in all respect, with relays	10
8.	Spare zone alarm modules	Number of future A/c Kiosks required for the bays identified as per SLD

c) Each annunciation panel shall be provided with a hooter**.** A hooter in parallel to the hooter in fire panel shall be provided in the security room of substation for alert in case of fire.

d) Indication for fault in respective areas shall also be provided. Each zone alarm module shall exhibit 'FIRE' and 'FAULT' conditions separately.

e) **Provision for sending data to Remote Control Unit for the following**

(i) Fire in Switchyard Panel Room (Switchyard Panel room shall be considered as separate zone for fire detection and alarm system).

(ii) Fire in Transformer/Reactor (1 for each equipment)

(iii) Diesel engine driven fire water pump in operation.

(iv) Motor driven fire water pump in operation

(v) Fire/Fault in Control Room.

(vi) Water Storage tank level (low and very low for each storage tank).

(vii) High Speed Diesel tank level (low & very low)

(viii) AC Mains Supply Healthy/Fail for Main Pump & Jockey Pump

(ix) DC Control Supply Healthy/Fail for Main Pump & Jockey Pump

(x) DC Control Supply Healthy/Fail for Diesel Engine driven pump.

2.06.04 The control and interlock system for the fire protection system shall meet the following requirements:

1. **Electric Motor Driven Fire Water Pump**

Pump should start automatically when the System header pressure is low.

Pump should be stopped manually only. Pump should also be started manually if required from local control panel.

2. **Diesel Engine Driven Standby Pump**

The pump should automatically start under any of the following conditions:

a) System Header pressure low.

b) Electric motor operated fire water pump fails to start.

Pump should be stopped manually only. Pump should also be started manually if required from the local control panel. The battery set which is connected for starting of Diesel engine shall not be subjected to boost charge.

3. **Jockey Pump**

It shall be possible to select any one of the Jockey pumps as main and the other as standby. Main Jockey pump shall start automatically when water pressure in header falls below the set value. If the main jockey pump fails to start then the standby should start. Jockey pump shall stop automatically when the pressure is restored to its normal value.

Manual starting/stopping shall be possible from the local control panel.

3.00.00 **TESTS**

3.01.00 **Shop Tests**

3.01.01 Shop tests of all major equipment centrifugal pumps, diesel engines, electrical drive motors, piping, valves and specialties, pressure and storage vessels, MCC, electrical panels, controls, instrumentation etc. shall be conducted as specified in various clauses and as per applicable standards/codes.

3.01.02 Shop tests shall include all tests to be carried out at Contractor's works, works of his sub-contractor and at works where raw materials supplied for manufacture of

equipment are fabricated. The tests to be carried out shall include but not be limited to the tests described as follows:

a) Materials analysis and testing.

b) Hydrostatic pressure test of all pressure parts, piping, etc.

c) Dimensional and visual check.

d) Balancing test of rotating components.

e) Response of heat/smoke detectors.

f) Performance characteristics of HVW spray nozzles (projectors).

g) Flow rate and operational test on Flow control valves.

h) Operational test of alarm valve (water-motor gang).

i) Calibration tests on instruments and tests on control panel.

j) Destruction/burst tests on 2% or minimum one (1) no. of hoses and portable type fire extinguishers for each type as applicable. Any fraction number shall be counted as next higher integer.

k) Performance test on fire extinguishers as required in the code.

3.01.03 In the absence of any Code/Standard, equipment shall be tested as per mutually agreed procedure between the supplier and the Employer.

3.01.04 A comprehensive visual and functional check for panels would be conducted and will include a thorough check up of panel dimensions, material of construction, panel finish, compliance with tubing and wiring specifications, quality of workmanship, proper tagging & locations of instruments/accessories. The wiring check shall be complete point to point ring out and check for agreement with installation drawings and equipment vendor prints of the complete system and an inspection of all field connection terminals and levelling.

3.01.05 All test certificates and reports shall be submitted to the Employer for approval.

3.01.06 The Employer's representative shall be given full access to all tests. The manufacturer shall inform the Employer allowing adequate time so that, if the Employer so desires, his representatives can witness the test.

3.02.00 **Pre-commissioning Tests**

3.02.01 **General**

a) All piping and valves, after installation will be tested hydraulically at a pressure of 16kg/cm^2 for a period of 30 minutes to check against leak tightness.

b) All manually operated valves/gates shall be operated throughout 100% of the travel and these should function without any trouble whatsoever, to the satisfaction of the Employer.

c) All pumps shall be run with the specified fluid from shut off condition to valve wide open condition. Head developed will be checked from the discharge pressure gauge reading. During the test, the pumps and drives shall run smoothly without any undue vibration, leakage through gland, temperature rise in the bearing parts, noise, flow pulsation etc.

d) All pressure vessels should be tested hydraulically at the specified test pressure, singly or in the system.

e) Painting shall be checked by dry type thickness gauges.

f) Visual check on all structural components, welding, painting etc. and if doubt arises, these will be tested again.

g) All test instruments and equipment shall be furnished by the Contractor to the satisfaction of the Employer.

h) Automatic starting of all the fire pumps by operating the test valves.

i) Automatic operation of the Jockey pump

j) Operation of the Deluge valve by breaking a detector as well as manual and remote operation of the deluge valve.

k) Operation of entire annunciation system.

Replacement of fused/damaged quartzoid bulb detectors during the test shall be responsibility of contractor.

3.02.02 After erection at site, the complete HVW spray protection and hydrant system shall be subject to tests to show satisfactory performance for which detailed procedure shall be submitted for Employer's approval.

Full flow tests with water shall be done for the system piping as a means of checking the nozzle layout, discharge pattern and coverage, any obstructions and determination of relation between design criteria and actual performance, also to ensure against clogging of the smaller piping and the discharge devices by foreign matter carried by the water.

Rigidity of pipe supports shall also be checked during the water flow.

3.02.03 All the detectors installed shall be tested for actuation by bringing a suitable source of heat/smoke near the detector and creating a stream of hot air/ smoke over the detector. The exact procedure of this test shall be detailed out by the Employer to the successful Bidder.

4.00.00 **SPARE PARTS**

The Contractor shall indicate in his scope of supply all the mandatory spares in the relevant schedules. The list of mandatory spares is indicated in ‘Section - Projects’.

5.00.00 **HORIZONTAL CENTRIFUGAL PUMPS**

This clause covers the design, performance, manufacturing, construction features and testing of horizontal centrifugal pumps used for the purpose of fire fighting.

5.01.00 The materials of the various components shall conform to the applicable BS/ASTM/DIN Standards.

5.01.01 In case of any contradiction with the aforesaid standards and the stipulations as per the technical specification as specified hereinafter, the stipulations of the technical specification shall prevail.

5.02.00 **General Performance Requirements**

5.02.01 The pump set shall be suitable for continuous operation at any point within the "Range of operation".

5.02.02 Pumps shall have a continuously rising head capacity characteristics from the

specified duty point towards shut off point, the maximum being at shut off.

5.02.03 Pumps shall be capable of furnishing not less than 150% of rated capacity at a head of not less than 65% of the rated head. The shut off head shall not exceed 120% of rated head. Range of operation shall be 20% of rated flow to 150% of rated flow.

5.02.04 The pump-motor set shall be designed in such a way that there is no damage due to the reverse flow through the pump which may occur due to any mal-operation of the system.

5.02.05 **Drive Rating**

The drive rating shall not be less than the maximum power requirement at any point within the "Range of Operation" specified.

During starting under reverse flow condition, the motor shall be capable of bringing the pump to rated speed at normal direction with 90% rated voltage at motor terminals.

5.02.06 Pump set along with its drive shall run smooth without undue noise and vibration. Acceptable peak to peak vibration limits shall guided by applicable standards.

5.02.07 The Contractor under this specification shall assume full responsibility in the operation of the pump and drive as one unit.

5.03.00 **Design & Construction**

5.03.01 Pump casing may be axially or radially split. The casing shall be designed to withstand the maximum pressure developed by the pump at the pumping temperature.

5.03.02 Pump casing shall be provided with adequate number of vent and priming connections with valves, unless the pump is made self-venting & priming. Casing drain, as required, shall be provided complete with drain valves.

5.03.03 Under certain conditions, the pump casing nozzles will be subjected to reactions from external piping. Pump design must ensure that the nozzles are capable of withstanding external reactions not less than those specified in API-610.

5.03.04 Pump shall preferably be of such construction that it is possible to service the internals of the pump without disturbing suction and discharge piping connections.

5.03.05 **Impeller**

The impeller shall be secured to the shaft and shall be retained against circumferential movement by keying, pinning or lock rings. On pumps with overhung shaft impellers shall be secured to the shaft by an additional locknut or cap screw. All screwed fasteners shall tighten in the direction of normal rotation.

5.03.06 **Wearing Rings**

Replaceable type wearing rings shall be furnished to prevent damage to impeller and casing. Suitable method of locking the wearing ring shall be used.

5.03.07 **Shaft**

Shaft size selected shall take into consideration the critical speed, which shall be at least 20% away from the operating speed. The critical speed shall also be atleast 10% away from runaway speed.

5.03.08 **Shaft Sleeves**

Renewable type fine finished shaft sleeves shall be provided at the stuffing boxes/mechanical seals. Length of the shaft sleeves must extend beyond the outer faces of gland packing or seal and plate so as to distinguish between the leakage between shaft & shaft sleeve and that past the seals/gland.

5.03.09 Shaft sleeves shall be securely fastened to the shaft to prevent any leakage or loosening. Shaft and shaft sleeve assembly should ensure concentric rotation.

5.03.10 **Bearings**

Bearings of adequate design shall be furnished for taking the entire pump load arising from all probable conditions of continuous operation throughout its "Range of Operation" and also at the shut-off condition. The bearing shall be designed on the basis of 20,000 working hours minimum for the load corresponding to the duty point.

Bearings shall be easily accessible without disturbing the pump assembly. A drain plug shall be provided at the bottom of each bearing housing.

5.03.11 **Stuffing Boxes**

Stuffing box design shall permit replacement of packing without removing any part other than the gland. Stuffing boxes shall be sealed/cooled by the fluid being pumped and necessary piping, fittings, valves, instruments, etc. shall form an integral part of the pump assembly.

5.03.12 **Shaft Couplings**

All shafts shall be connected with adequately sized flexible couplings of suitable design. Necessary guards shall be provided for the couplings.

5.03.13 **Base Plates & Sole Plate**

A common base plate mounting both for the pump and drive shall be furnished.

The base plate shall be of rigid construction, suitably ribbed and reinforced. Base plate and pump support shall be so constructed and the pumping unit so mounted as to minimise misalignment caused by mechanical forces such as normal piping strain, hydraulic piping thrust etc. Suitable drain taps and drip lip shall be provided.

5.03.14 Material of Construction

All materials used for pump construction shall be of tested quality. Material of construction of the major parts of the pumps shall be as given below or superior as per relevant latest International standards:

a)	Casing	Casting Grade 17 of BS 1452
b)	Impeller	Bronze Grade LG2-C of BS1400
c)	Wearing ring	Bronze Grade LG2-C of BS1400
d)	Shaft	Mild Steel.
e)	Shaft sleeve	Bronze Grade LG2-C of BS1400
f)	Stuffing box	2.5% Nickel CI Grade 17 of BS 1452
g)	Gland	--- do ---

5.03.15 **Balancing**

All rotating components shall be statically and dynamically balanced at shop.

5.03.16 All the components of pumps of identical parameters supplied under this specification shall be interchangeable.

5.04.00 **Tests and Inspection**

5.04.01 The manufacturer shall conduct all routine tests required to ensure that the

equipment furnished conform to the requirements of this specification and are in compliance with the requirements of applicable Codes and Standards. The particulars of the proposed tests and the procedures for the tests shall be submitted to the Employer/Engineer for approval before conducting the tests.

5.04.02 Where stage inspection is to be witnessed by Employer, in addition to above, the Bidder shall submit to the Employer/Engineer at the beginning of the contract, the detailed PERT-Chart showing the manufacturing programme and indicating the period where Employer or his authorised inspecting agency are required at the shop.

5.04.03 **Material of Construction**

All materials used for pump construction shall be of tested quality. Materials shall be tested as per the relevant standards and test certificates shall be made available to the Employer/Engineer.

5.04.04 Where stage inspection is to be witnessed by Employer, all material test certificates shall be correlated and verified with the actual material used for construction before starting fabrication, by Employer's Inspector who shall stamp the material. In case mill test certificates for the material are not available, the Contractor shall carry out physical and chemical tests at his own cost from a testing agency approved by the Employer, as per the requirements of specified material standard. The samples for physical and chemical tests shall be drawn up in presence of Employer's inspector who shall also witness the tests.

5.04.05 Shaft shall be subjected to 100% ultrasonic test and machined portion of the impeller shall be subject to 100% DP test. On finished shaft DP test will also be carried out.

5.04.06 **Hydraulic test at shop**

All pressure parts shall be subjected to hydraulic testing at a pressure of 150% of maximum pressure generated by the pump at rated speed or 200% of total dynamic head whichever is higher, for a period not less than one (1) hour.

5.04.07 **Performance test at shop**

Pumps shall be subjected to routine tests to determine the performance of the pumps. These tests shall be conducted in presence of Employer/Engineer's representative as per the requirements of the ASME Power Test Code PTC 8.2/BS-599/I.S.S., latest edition. Routine tests shall be done on all the pumps.

5.04.08 Performance tests shall be conducted to cover the entire range of operation of the pumps. These shall be carried out to span 150% of rated capacity upto pump shut-off condition. A minimum of five combinations of head and capacity are to be achieved during testing to establish the performance curves, including the design capacity point and the two extremities of the Range of operation specified.

5.04.09 Tests shall preferably be conducted along with the actual drives being supplied.

5.04.10 The Bidders shall submit in his proposal the facilities available at his works to conduct performance testing. If because of limitations of available facilities, a reduced speed test or model test has to be resorted to establish pump performance, the same has to be highlighted in the offer.

5.04.11 In case of model testing, the stipulations of latest edition of applicable standards shall be binding. Prototype or model tests, however, shall be conducted with the suction condition identical to the field conditions i.e. sigma values of prototype and model is to be kept same.

5.04.12 Prior to conducting model testing, calculations establishing model parameters, sizes and test procedure will be submitted to Employer/Engineer for approval.

5.04.13 All rotating components of the pumps shall be subjected to static and dynamic balancing tests.

5.04.14 The Employer or his authorised representative shall have full access to all tests.

Prior to performance tests, the Contractor shall intimate the Employer allowing adequate time so that if the Employer so desires, his representative can witness the test.

5.04.15 Report and test certificates of the above tests shall be submitted to the Employer/Engineer for approval.

5.04.16 **Pre-commissioning tests.**

After installation, pumps offered may be subjected to testing at field also by Employer. If the performances at field are not found to meet the requirement, then the equipment shall be rectified by the Contractor without any extra cost. Prior to performance testing, the procedure for such tests will be mutually agreed between Employer and Contractor. The Contractor shall furnish all necessary instruments, accessories and personnel for testing. Prior to testing, the calibration curves of all instruments and permissible tolerance limit of instruments shall be mutually agreed upon.

6.00.00 **DIESEL ENGINES**

This Clause covers the design, performance, manufacturing construction features and testing of compression ignition diesel engines, used primarily for driving centrifugal pumps, used for the purpose of fire fighting.

6.01.00 **Design and Construction**

General

6.01.01 The diesel engine shall be of multicylinder type four-stroke cycle with mechanical (airless) injection, cold starting type.

6.01.02 The continuous engine brake horse power rating (after accounting for all auxiliary power consumption) at the site conditions shall be atleast 20% greater than the requirement at the duty point of pump at rated RPM and in no case, less than the maximum power requirement at any condition of operation of pump.

6.01.03 Reference conditions for rated output of engine shall be as per ISO: 3046, part I.

6.01.04 The engine shall be designed with regard to ease of maintenance, repair, cleaning and inspection.

6.01.05 All parts subjected to substantial temperature changes shall be designed and supported to permit free expansion and contraction without resulting in leakage, harmful distortion or misalignment.

6.01.06 **Starting**

The engine shall be capable of both automatic and manual start. The normal mode of starting is automatic but in the event of failure of automatic start or at the discretion of the operator, the engine can be started manually from the LCP.

Since the fire pumping unit driven by the diesel engine is not required to run continuously for long periods and the operation will not be frequent, special features shall be built into the engine to allow it to start within a very short period against full load even if it has remained idle for a considerable period.

6.01.07 If provision for manual start (cranking) is provided, all controls/ mechanisms, which have to be operated during the starting process, shall be within easy reach of the operator.

6.01.08 Automatic cranking shall be affected by a D.C. motor having high starting torque to overcome full engine compression. Starting power will be supplied from either of the two (2) sets of storage batteries. The automatic starting arrangement shall include a 'Repeat Start' feature for 3 attempts. The battery capacity shall be adequate for 3 (three) consecutive starts without recharging with a cold engine under full compression.

6.01.09 The batteries shall be used exclusively for starting the diesel engine and be kept fully charged all the time in position. Arrangement for both trickle and booster charge shall be provided.

Diesel engine shall be provided with two (2) battery charger units of air-cooled design. The charger unit shall be capable of charging one (1) set of battery at a time. Provision shall, however, be made so that any one of the charger units can be utilised for charging either of the two (2) batteries.

6.01.10 For detail design of battery and battery charger, sub- section Electrical may be referred to.

6.01.11 **Governing System:**

The engine shall be fitted with a speed control device, which will control the speed under all conditions of load.

6.01.12 The governor shall offer following features:

a) Engine should be provided with an adjustable governor capable of regulating engine speed within 5% of its rated speed under any condition of load between shut-off and maximum load conditions of the pumps. The governor shall be set to maintain rated pump speed at maximum pump load.

b) Engine shall be provided with an over speed shut- down device. It shall be arranged to shut-down the engine at a speed approximately 20% above rated engine speed and for manual reset, such that the automatic engine controller will continue to show an over speed signal until the device is manually reset to normal operating position (Vol.II, NFPA, 1978).

6.01.13 The governor shall be suitable for operation without external power supply.

6.01.14 **Fuel System**

The diesel engine will run-on High-Speed Diesel.

6.01.15 The engine shall be provided with fuel oil tank of 250 litres capacity. The fuel oil tank shall preferably be mounted near the engine. No fuel oil tank will be provided by the Employer.

6.01.16 The fuel oil tank shall be of welded steel constructed to relevant standards for mild steel drums. The outlet of the tank shall be above the inlet of fuel injection pump of the diesel engine to ensure adequate pressure at suction of injection pump.

6.01.17 The fuel oil tank shall be designed in such a way that the sludge and sediment settles down to the tank bottom and is not carried to the injection pump. A small sump shall be provided and fitted with drain plug to take out sludge/sediment and to drain oil. Adequate hand holes (greater than 80 mm size) shall be provided to facilitate maintenance.

6.01.18 Pipeline carrying fuel oil shall be gradually sloped from the tank to the injection pump. Any valve in the fuel feed pipe between the fuel tank and the engine shall be placed adjacent to the tank and it shall be locked in the open position. A filter shall be incorporated in this pipeline, in addition to other filters in the fuel oil system. Pipe joints shall not be soldered and plastic tubing shall not be used. Reinforced flexible pipes may also be used.

6.01.19 The complete fuel oil system shall be designed to avoid any air pocket in any part of the pipe work, fuel pump, sprayers/injectors, filter system etc. No air relief cock is permitted. However, where air relief is essential, plugs may be used.

6.01.20 A manual fuel pump shall be provided for priming and releasing of air from the fuel pipelines.

6.01.21 **Lubricating Oil System**

Automatic pressure lubrication shall be provided by a pump driven by the crank

shaft, taking suction from a sump and delivering pressurised oil through cooler and fine mesh filters to a main supply header fitted in the bed plate casing. High pressure oil shall be supplied to the main and big end bearings, cam-shaft bearings, cam-shaft chain and gear drives, governor, auxiliary drive gears etc. Valve gear shall be lubricated at reduced pressure through a reducing valve and the cams by an oil bath.

6.01.22 **Cooling Water System**

Direct cooling or heat exchanger type cooling system shall be employed for the diesel engine. Water shall be tapped from the fire pump discharge. This water shall be led through duplex strainer, pressure breakdown orifice and then after passing through the engine, the water at the outlet shall be taken directly to the sump through an elevated funnel.

6.02.00 **Testing & Inspection**

6.02.01 The manufacturer shall conduct all tests required, to ensure that the equipment furnished conforms to the requirement of this sub-section and in compliance with requirements of applicable codes. The particulars of the proposed tests and the procedure for the tests shall be submitted to the Employer for approval before conducting the tests.

6.02.02 At manufacturer's works, tests shall be carried out during and after completion of manufacture of different component/parts and the assembly as applicable. Following tests shall be conducted.

6.02.03 Material analysis and testing.

6.02.04 Hydrostatic pressure testing of all pressure parts.

6.02.05 Static and dynamic balance tests of rotating parts at applicable over-speed and determination of vibration level.

6.02.06 MPI/DPT on machined parts of piston and cylinder.

6.02.07 Ultrasonic testing of crankshaft and connecting rod after heat treatment.

6.02.08 Dimensional check of close tolerance components like piston, cylinder bore etc.

6.02.09 Calibration tests of all fuel pumps, injectors, standard orifices, nozzles, instruments etc.

6.02.10 Over speed test of the assembly at 120% of rated speed.

6.02.11 Power run test.

6.02.12 Performance test of the diesel engine to determine its torque, power and specific fuel consumption as function of shaft speed. Performance test of the engine shall be carried for 12 hours out of which 1 hour at full load and one hour at 110% overload.

6.02.13 Measurement of vibration & noise.

(i) Measurement of vibration

The vibration shall be measured during full load test as well as during the overload test and limit shall be 100 microns.

(ii) Measurement of noise level

The equivalent 'A' weighted sound level measured at a distance of 1.5 M above floor level in elevation and 1.0 M horizontally from the base of the equipment, expressed in dB to a reference of 0.0002 microbar shall not exceed 93 dBA.

Above tests for vibration shall be repeated at site as pre-commissioning tests.

6.02.14 Adjustment of speed governor as per BS: 5514.

6.02.15 Diesel engine shall be subjected to routine tests as per BS: 5514.

7.00.00 **PIPING, VALVES AND SPECIALITIES**

This clause covers the design, manufacture, shop testing, erection, testing and commissioning of piping, valves and specialities.

7.02.00 **Scope**

The piping system which shall include but not be limited to the following:

7.02.01 Plain run of piping, bends, elbows, tees, branches, laterals, crosses, reducing unions, couplings, caps, expansion joints, flanges, blank flanges, thrust blocks, anchors, hangers, supports, saddles, shoes, vibration dampeners, sampling connections, hume pipes etc.

7.02.02 Gaskets, ring joints, backing rings, jointing material etc. as required. Also, all welding electrodes and welding consumables including special ones, if any.

7.02.03 Instrument tapping connections, stubs etc.

7.02.04 Gate and globe valves to start/stop and regulate flow and swing check valves for one directional flow.

7.02.05 Basket strainers and Y-type strainers

7.02.06 Bolts, nuts, fasteners as required for interconnecting piping, valves and fittings as well as for terminal points. For pipe connections into Owner's R.C.C. works, Bidder will furnish all inserts.

7.02.07 Painting, anti-corrosive coatings etc. of pipes and equipment.

Adequate number of air release valves shall be provided at the highest points in the piping system to vent any trapped air in the system.

7.03.00 **Design**

7.03.01 Material of construction of various pipes shall be as follows:

(a) **Buried Pipes**

Mild steel black pipes as per ASTM A53 medium grade suitably lagged on the outside to prevent soil corrosion, as specified elsewhere.

(b) **Overground Pipes normally full of water**

Mild steel black pipes as per ASTM A53 medium grade.

(c) Overground pipes normally empty, but periodic charge of water and for detector line for HVW System**.**

Mild steel galvanised pipes as per ASTM A53 medium grade.

7.03.02 All fittings to be used in connection with steel pipe lines upto a size of 80 mm shall be as per ASTM A53 Mild steel tubular and other wrought steel pipe fittings, Heavy grade. Fittings with sizes above 80 mm upto 150 mm shall be fabricated from ASTM A53 Heavy grade pipes or steel plates having thickness not less than those of ASTM A53 Heavy grade pipes. Fittings with sizes above 150 mm shall be fabricated as per ASTM A53 standard. All fitting used in GI piping shall be threaded type. Welding shall not be permitted on GI piping.

7.03.03 Pipe sizes shall not be less than the sizes indicated in the attached drawings.

7.03.04 For steel pipeline, welded construction should be adopted unless specified otherwise.

7.03.06 All piping system shall be capable of withstanding the maximum pressure arising from any condition of operation and testing including water hammer effects.

7.03.09 Gate/sluice valve shall be used for isolation of flow in pipe lines and **construction** shall be as per BS 5150. Valves shall be of rising spindle type and of PN 1.6 class

7.03.10 Gate Valves shall be provided with the following:

(a) Hand wheel.

(b) Position indicator.

(c) Locking facility (where necessary).

7.03.11 Gate valves shall be provided with back seating bush to facilitate gland removal during full open condition.

7.03.12 Globe valves shall be provided with contoured plug to facilitate regulation and control of flow. All other requirements should generally follow those of gate valve.

7.03.13 Non-return valves shall be swing check type. Valves will have a permanent "arrow" inscription on its body to indicate direction of flow of the fluid.

7.03.14 Whenever any valve is found to be so located that it cannot be approached manually from the nearest floor/gallery/platform hand wheel with floor stand or chain operator shall be provided for the same.

7.03.15 Valves below 50 mm size shall have screwed ends while those of 50 mm and higher sizes shall have flanged connections.

7.03.14 **Basket Strainer**

a) Basket strainers shall be of 30mesh and have the following materials of construction:

Body: Fabricated mild steel (Tested Quality). Strainer Wires: stainless steel (AISI: 316), 30 SWG, suitably reinforced.

b) Inside of basket body shall be protected by two (2) coats of heavy duty bitumastic paint.

c) Strainers shall be Simplex design. Suitable vent and drain connections with valves shall be provided.

d) Screen open area shall be at least 4 times pipe cross sectional area at inlet.

e) Pressure drop across strainer in clean condition shall not exceed 1.5 MWC at 410M3/hr (for 765kV/400kV substations) and 1 MWC at 273M3/hr flow (for 220kV & 132kV substations). Pressure drop test report of strainer of same design shall be furnished.

7.03.15 **Y-type On-line Strainer**

Body shall be constructed of mild steel (tested quality). Strainer wires shall be of stainless steel AISI: 316, 30 SWG, 30 mesh.

Blowing arrangement shall be provided with removable plug at the outlet. Screen open area shall be atleast 4 times pipe cross-sectional area at inlet.

Pressure drop test report of strainer of same design shall be furnished.

7.03.16 **Hydrant Valve (Outdoor) and Indoor Hydrant Valves (Internal Landing Valves).**

The general arrangement of outdoor stand post assembly, consisting of a column pipe and a hydrant valve with a quick coupling end shall be as per TAC requirement.

Materials of construction shall be as follows or superior:

a)	Column pipe	M.S. ASTM A53 med. grade.
b)	Hydrant Valve	
i)	Body	Stainless steel.
ii)	Trim	Leaded tin bronze.
iii)	Hand Wheel	Cast Iron.
iv)	Washer, gasket, etc.	Rubber.
v)	Quick coupling connection	Leaded tin bronze
vi)	Spring	Phosphor Bronze.
vii)	Cap and chain	Leaded tin bronze

The general design of hydrant valve shall conform to relevant latest international standards.

7.03.17 **Hoses, Nozzles, Branch pipes and Hose boxes**

(a) Hose pipes shall be of reinforced rubber-lined canvas construction with nominal size of 63 MM (2 1/2") and lengths of 15 metre or 7.5 metre, as indicated elsewhere.

(b) Hosepipes shall be capable of withstanding an internal water pressure of not less than 35**.7** kg/cm^2 without bursting. It must also withstand a working pressure of 8.5 kg/cm^2 without undue leakage or sweating.

(c) Each hose shall be fitted with instantaneous spring lock type couplings at both ends. Hose shall be fixed to the coupling ends by copper rivets and the joint shall be reinforced by 1.5 mm galvanised mild steel wires and leather bands.

(d) Branch pipes shall be constructed of copper and have rings of leaded tin bronze at both ends. One end of the branch pipe will receive the quick coupling while the nozzles will be fixed to the other end.

(e) Nozzles shall be constructed of leaded tin bronze.

(f) Suitable spanners of approved design shall be provided in adequate numbers for easy assembly and dismantling of various components like branch pipes, nozzles, quick coupling ends etc.

(g) Hose pipes fitted with quick coupling ends, branch pipes, nozzles spanner etc. will be kept in a hose box, which will be located near point of use.

(h) All instantaneous couplings, as mentioned under clause Nos.3.03.19, 3.03.20 and 3.03.21 above shall be of identical design (both male and female) so that any one can be interchanged with another. One male, female combination shall get locked in by mere pushing of the two halves together but will provide leak tightness at a pressure of 8 kg/cm^2 of water. Designs employing screwing or turning to have engagement shall not be accepted.

7.04.00 **Fabrication & Erection**

7.04.01 The contractor shall fabricate all the pipe work strictly in accordance with the related approved drawings.

7.04.02 **End Preparation**

(a) For steel pipes, end preparation for butt welding shall be done by machining.

(b) Socket weld end preparation shall be sawing/machining.

(c) For tees, laterals, mitre bends, and other irregular details cutting templates shall be used for accurate cut.

7.04.03 **Pipe Joints**

(a) In general, pipes having sizes over 25 mm shall be joined by butt welding. Pipes having 25 mm size or less shall be joined by socket welding/screwed connections. Galvanised pipes of all sizes shall have screwed joints. No welding shall be permitted on GI pipes. Screwed joints shall have tapered threads and shall be assured of leak tightness without using any sealing compound.

(b) Flanged joints shall be used for connections to vessels, equipment, flanged valves and also on suitable straight lengths of pipe line of strategic points to facilitate erection and subsequent maintenance work.

7.04.04 **Overground Piping**

(a) Piping to be laid overground shall be supported on pipe rack/supports. Rack/supports details shall have to be approved by Employer/Engineer.

(b) Surface of overground pipes shall be thoroughly cleaned of mill scale, rust etc. by wire brushing. Thereafter one (1) coat of **red oxide primer** shall be applied. Finally, two (2) coats of synthetic enamel paint of approved colour shall be applied.

7.04.05 **Buried Pipe Lines**

(a) Pipes to be buried underground shall be provided with protection against soil corrosion by coating and wrapping with two coats of coal tar hot enamel paint and two wraps of reinforced fibre glass tissue. The total thickness of coating and wrapping shall not be less than 3 mm. Alternatively, corrosion resistant tapes can also be used for protection of pipes against corrosion.

(b) For Coating and wrapping, holiday testing to be performed in line with latest ASTM standards.

(c) Buried pipelines shall be laid with the top of pipe one meter below ground level.

(d) At site, during erection, all coated and wrapped pipes shall be tested with an approved Holiday detector equipment with a positive signalling device to indicate any fault hole breaks or conductive particle in the protective coating.

7.05.00 **General Instruction for Piping Design and Construction**

7.05.01 While erecting field run pipes, the contractor shall check, the accessibility of valves, instrument tapping points, and maintain minimum headroom requirement and other necessary clearance from the adjoining work areas.

7.05.02 Modification of prefabricated pipes, if any, shall have to be carried out by the contractor at no extra charge to the Employer.

7.05.03 **Welding**

(i) Welding shall be done by qualified welders only.

(ii) Before welding, the ends shall be cleaned by wire brushing, filing or machine grinding. Each weld-run shall be cleaned of slag before the next run is deposited.

(iii) Welding at any joint shall be completed uninterrupted. If this cannot be followed for some reason, the weld shall be insulated for slow and uniform cooling.

(iv) Welding shall be done by manual oxyacetylene or manual shielded metal arc process. Automatic or semi-automatic welding processes may be done only with the specific approval of Employer/ Consultant.

(v) As far as possible welding shall be carried out in flat position. If not possible, welding shall be done in a position as close to flat position as possible.

(vi) No backing ring shall be used for circumferential butt welds.

(vii) Welding carried out in ambient temperature of 5°C or below shall be heat-treated.

(viii) Tack welding for the alignment of pipe joints shall be done only by qualified welders. Since tack welds form part of final welding, they shall be executed carefully and shall be free from defects. Defective welds shall be removed prior to the welding of joints.

Electrodes size for tack welding shall be selected depending upon the root opening.

(ix) Tacks should be equally spaced as follows**:**

for 65 NB and smaller pipes : 2 tacks

for 80 NB to 300 NB pipes : 4 tacks

for 350 NB and larger pipes : 6 tacks

(x) Root run shall be made with respective electrodes/filler wires. The size of the electrodes/filler wires. The size of the electrodes shall not be greater than 3.25 mm (10 SWG) and should preferably be 2.3 mm (12 SWG). Welding shall be done with direct current values recommended by the electrode manufacturers.

(xi) Upward technique shall be adopted for welding pipes in horizontally fixed position. For pipes with wall thickness less than 3 mm, oxyacetylene welding is recommended.

(xii) The root run of butt joints shall be such as to achieve full penetration with the complete fusion of root edges. The weld projection shall not exceed 3 mm inside the pipe.

(xiii) On completion of each run craters, weld irregularities, slag etc. shall be removed by grinding or chipping.

(xiv) Fillet welds shall be made by shielded metal arc process regardless of thickness and class of piping. Electrode size shall not exceed 10 SWG. (3.25 mm). At least two runs shall be made on socket weld joints.

7.06.00 **Tests at Works**

7.06.01 **Pipes**

(i) Mechanical and chemical tests shall be performed as required in the codes/standards.

(ii) All pipes shall be subjected to hydrostatic tests as required in the codes/standards.

(iii) 10% spot Radiography test on welds of buried pipes shall be carried out as per ASME VIII.

7.06.02 **Valves**

(i) Mechanical and chemical tests shall be conducted on materials of the valve as required in the codes/standards.

(ii) All valves shall be tested hydrostatically for the seat as well as required in the code/standards for a period of ten minutes.

(iii) Air test shall be conducted to detect seat leakage.

(iv) Visual check on the valve and simple operational test in which the valve will be operated thrice from full open to full close condition.

(v) No repair work on CI valve body, bonnet or wedge shall be allowed.

7.06.03 **Strainers**

(i) Mechanical and chemical tests shall be conducted on materials of the strainer.

(ii) Strainers shall be subjected to a hydrostatic test pressure of 1.5 times the design pressure or 10 kg/cm2g whichever is higher for a period of one hour.

7.06.04 **Hydrant valves and Indoor Hydrant Valves (Internal Landing Valves)**

(i) The stand post assembly along with the hydrant valve (valve being open and outlet closed) shall be pressure tested at a hydrostatic pressure of 21 kg/cm2g to detect any leakage through defects of casting.

(ii) Flow test shall be conducted on the hydrant valves at a pressure of 7 kg/cm2g and the flow through the valve shall not be less than 900 litres/min.

(iii) Leak tightness test of the valve seat shall be conducted at a hydrostatic test pressure of 14 kg/cm2g.

7.06.05 **Hoses, Nozzles, Branch Pipes and Hose Boxes**

Reinforced rubber-lined canvas hoses shall be tested hydrostatically. Following tests shall be included as per relevant latest International standard.

a) Hydrostatic proof pressure test at 21.4 kgf/cm2g

b) Internal diameter

The branch pipe, coupling and nozzles shall be subjected to a hydrostatic test pressure of 21 kg/cm2g for a period of $2^1/_2$ minutes and shall not show any sign of leakage or sweating.

Dimensional checks shall be made on the hose boxes and nozzle spanners.

8.00.00 **AIR VESSELS**

8.01.00 Air vessels shall be designed and fabricated of mild steel as class-II vessels as per BS 5500 for a pressure of 14kg/cm^2 and shall be minimum 3 m^3 capacity.

8.02.00 Inside surface of the tank shall be protected by anti-corrosive paints/coatings/linings as required.

8.03.00 Outside surfaces of the vessels shall be provided with one (1) coat of red lead primer with two (2) coats of synthetic enamel paint of approved colour and characteristics.

8.04.00 **Tests & Inspection**

8.04.01 Air vessels shall be hydraulically tested at 21kg/cm2 for a period not less than one (1) hour.

8.04.02 All materials used for fabrication shall be of tested quality and test certificates shall

be made available to the Owner.

8.04.03 Welding procedure and Welder's qualification tests will be carried out as per relevant International Standard.

8.04.04 NDE tests, which will include 100% Radiography on longitudinal seams and spot Radiography for circumferential seams, for pressure vessel will be carried out.

9.00.00 **HEAT DETECTORS/FIRE DETECTORS AND SPRAY NOZZLES**

9.00.01 **Intent of Specification**

This specification lays down the requirements of the smoke detectors, heat detectors and spray nozzles for use in various sub-systems of the fire protection system.

9.00.02 **Codes and Standards**

All equipment supplied shall conform to internationally accepted codes and standards.

9.01.00 **Heat Detectors**, **Quartzoid bulb type.** (Used in HVW spray system)

a) Heat detectors shall be of any approved and tested type. Fusible chemical pellet type heat detectors are however not acceptable.

b) Temperature rating of the heat detector shall be selected by the Bidder taking into consideration the environment in which the detectors shall operate. Minimum set point shall, however, be 79^{o}C.

c) Heat detectors shall be guaranteed to function properly without any maintenance work for a period of not less than twenty five (25) years.

d) The heat detectors shall be mounted on a pipe network charged with water at suitable pressure. On receipt of heat from fire, the heat detector will release the water pressure from the network. This drop in water pressure will actuate the Deluge valve.

9.02.00 **HVW Spray Nozzles (Projectors)**

High velocity water spray system shall be designed and installed to discharge water in the form of a conical spray consisting of droplets of water travelling at high velocity which shall strike the burning surface with sufficient impact to ensure the formation of an emulsion. At the same time the spray shall efficiently cut off oxygen supply and provide sufficient cooling. Integral non-ferrous strainers shall be provided in the projectors ahead of the orifice to arrest higher size particle, which are not allowed to pass through the projectors.

9.03.00 **Fire Detectors (Used in fire detection and alarm system)**

9.03.01 Fire detectors shall be approved by FOC-London or similar international authorities.

9.03.02 Both smoke and heat type fire detectors shall be used. Bidder shall clearly indicate the mode of operation of detectors in his proposal.

9.03.03 The set point shall be selected after giving due consideration for ventilating air velocity and cable insulation.

9.03.04 Fire detectors shall be equipped with an integral L.E.D. so that it shall be possible to know which of the detectors has been operated. The detectors, which are to be placed in the space above the false ceiling or in the floor void shall not have the response indicators on the body but shall be provided with remote response indicators.

9.03.05 Approval from competent authority shall be made available for ionisation type smoke detectors. All required accessories shall also be included in the scope of supply.

9.03.06 Fire detectors shall be guaranteed to function properly without any maintenance work for a period of not less than ten (10) years.

10.00.00 **PORTABLE AND WHEEL/ TROLLEY MOUNTED FIRE EXTINGUISHERS**

10.00.01 This specification lays down the requirement regarding fire extinguishers of following types:

Portable fire extinguishers.

a) Pressurised water type.

b) Dry chemical powder type

c) Carbon Dioxide type

Wheel/ Trolley mounted fire extinguishers.

a) Mechanical foam type

10.00.02 All the extinguishers offered by the Bidder shall be of reputed make.

10.01.00 **Design and Construction**

10.01.01 All the portable extinguishers shall be of freestanding type and shall be capable of discharging freely and completely in upright position.

10.01.02 Each extinguisher shall have the instructions for operating the extinguishers on its body itself.

10.01.03 All extinguishers shall be supplied with initial charge and accessories as required.

10.01.04 Portable type extinguishers shall be provided with suitable clamps for mounting on walls or columns.

10.01.05 All extinguishers shall be painted with durable enamel paint of fire red colour conforming to relevant International Standards.

10.01.06 Pressurisation of water type fire extinguishers shall either be done by compressed air or by using gas cartridge. Both constant air pressure and the gas pressure type shall conform to their latest relevant International standards.

10.01.07 Dry chemical powder type portable extinguisher shall conform to its latest relevant International standards.

10.01.08 Carbon Dioxide type portable extinguisher and Carbon Dioxide type trolley mounted extinguisher shall conform to their latest relevant International standards.

10.01.09 Wheel/ trolley mounted fire extinguishers of 50 litre capacity Mechanical foam type shall conform to its **latest relevant International standards.**

10.02.00 **Tests and Inspection**

10.02.01 A performance demonstration test at site of five (5) percent or one (1) number whichever is higher, of the extinguishers shall be carried out by the Contractor. All consumable and replaceable items require for this test would be supplied by the Contractor without any extra cost to Employer.

10.02.02 Performance testing of extinguisher shall be in line of applicable International Standards. In case where no International Standard is applicable for a particular type of extinguisher, the method of testing shall be mutually discussed and agreed to before placement of order for the extinguishers.

10.03.00 **Painting**

Each fire extinguisher shall be painted with durable enamel paint of fire red colour conforming to relevant International Standards.

11.00.00 **INSTRUMENTS**

11.00.01 **Intent of Specification**

The requirements given in the sub-section shall be applicable to all the instruments being furnished under this specification.

11.00.02 All field mounted instruments shall be weather and dust tight, suitable for use under ambient conditions prevalent in the subject plant. All field mounted instruments shall be mounted in suitable locations where maximum accessibility for maintenance can be achieved.

11.01.00 **Local Instruments**

Pressure/ Differential Gauges & Switches.

11.01.01 The pressure sensing elements shall be continuous 'C' bourdon type.

11.01.02 The sensing elements for all gauges/switches shall be properly aged and factory tested to remove all residual stresses. They shall be able to withstand atleast twice the full scale pressure/vacuum without any damage or permanent deformation.

11.01.03 For all instruments, connection between the pressure sensing element and socket shall be braced or hard soldered.

11.01.04 Gauges shall be of 150 mm diameter dial with die-cast aluminium, stoved enamel black finish case, aluminium screwed ring and clear plastic crystal cover glass. Upper range pointer limit stop for all gauges shall be provided.

11.01.05 All gauges shall be with stainless steel bourdon having rotary geared stainless steel movements.

11.01.06 Weather-proof type construction shall be provided for all gauges. This type of construction shall be fully dust tight, drip tight, weather resistant and splash proof with anti-corrosive painting conforming to NEMA- 4.

11.01.07 All gauges shall have micrometer type zero adjuster.

11.01.08 Neoprene safety diaphragm shall be provided on the back of the instruments casing for pressure gauges of ranges 0-10 Kg/cm^2 and above.

11.01.09 Scales shall be concentric, white with black lettering and shall be in metric units.

11.01.10 Accuracy shall be $\pm$ 1.0 percent of full range or better.

11.01.11 Scale range shall be selected so that normal process pressure is approximately 75 percent of full scale reading. For pressure gauges and pressure switches, the range shall not be less than 0 -16 Kg/cm^2

11.01.12 All gauges shall have 1/2 inch NPT bottom connection.

11.01.13 All instruments shall conform to their **latest relevant International standards.**

11.01.14 All instruments shall be provided with 3 way gauge isolation valve or cock. Union nut, nipple and tail pipe shall be provided wherever required.

11.01.15 Switch element contact shall have two (2) NO and two (2) NC contacts rated for 240 Volts, 10 Amperes A.C. or 220 Volts, 5 Amperes D.C. Actuation set point shall be adjustable throughout the range. ON-OFF differential (difference between switch actuation and de-actuation pressures) shall be adjustable. Adjustable range shall be suitable for switch application.

11.01.16 Switches shall be sealed diaphragm, piston actuated type with snap action switch

element. Diaphragm shall be of 316 SS.

11.01.18 Necessary accessories shall be furnished.

11.02.00 **Timers**

11.02.01 The timers shall be electro-mechanical type with adjustable delay on pick-up or reset as required.

11.02.02 Each timer shall have two pairs of contacts in required combination of NO and NC.

11.03.00 **Level Gauges/Indicator/Switches**

11.03.01 **Level Gauges**

i) Gauge glasses shall be used for local level indication wherever shown in the flow diagram.

ii) Gauge glasses, in general, shall be flag glass type with bolted cover. Body and cover material shall be of carbon steel with rubber lining.

iii) Level coverage shall be in accordance with operating requirements. Maximum length of a single gauge glass shall not exceed 1.4 M. Should a larger gauge glass be required, multiple gauges of preferably equal length shall be used with 50 mm overlap in visibility.

iv) Reflex type gauge glasses shall be used for colourless liquids and transparent type gauge glasses shall be used for all liquids having colour.

v) Each gauge glass shall be complete with a pair of offset valves. Valves shall have union bonnet, female union level connection, flanged tank connection, and vent and drain plug.

vi) Offset valves shall have corrosion resistant ball-check to prevent fluid loss in the event of gauge glass breakage. Valve body shall have a working pressure of 200 percent of the maximum static pressure at the maximum process fluid temperature. Valve body materials shall be of carbon steel with rubber lining.

11.03.02 **Level Indicators**

i) Float type mechanical level gauges with linear scale type indicator shall be offered for measuring level of tanks wherever shown in the flow diagram.

ii) AISI-316 stainless steel float, guide rope and tape shall be used. Housing shall be of mild steel painted with anti-corrosive painting.

iii) The scale indicator shall be provided at a suitable height for ease of reading.

iv) Accuracy shall be + 1% of scale range or better.

11.03.03 **Level Switches**

i) Level switches shall be of ball float operated magnetic type complete with cage.

ii) Materials of construction shall be suitable for process and ambient conditions. The float material shall be AISI-316 stainless steel.

iii) Actuating switches shall be either hermetically sealed mercury type or snap acting micro-switches. Actuation set point shall be adjustable. ON-OFF differential (difference between switch actuation and de-actuation levels) shall be adjustable. Adjustable range shall be suitable for switch application. All switches shall be repeatable within + 1.0 percent of liquid level change required to activate switch. Contacts shall be rated for 50 watts resistive at 240 V A.C. Number of contacts shall be two NO and two NC for each level switch.

11.04.00 **Solenoid Valves**

11.04.01 The body of the valves shall be Forged brass or stainless steel.

11.04.02 The coil shall be continuous duty, epoxy moulded type Class-F, suitable for high temperature operation.

11.04.03 The enclosure shall be watertight, dust-tight and shall conform to NEMA-4 Standard.

11.04.04 The valves shall be suitable for mounting in any position.

11.05.00 **Switches, Lamps, Meters Etc.**

All electrical components on the panel namely push buttons, switches, lamps, meters etc. shall meet the requirements of sub-section Electrical enclosed with the specification.

11.06.00 All local instruments shall be inspected by Employer/Consultant as per the agreed quality plan.

11.07.00 Makes of control panel and local instruments, accessories shall be as per Employer's approval.

12.00.00 **ELECTRIC MOTORS**

12.01.00 **General**

12.01.01 This clause covers the requirements of three phase squirrel cage induction motors and single-phase induction motors.

12.01.02 The motors to be furnished, erected and commissioned as covered under this specification shall be engineered, designed, manufactured, erected, tested as per the requirements specified herein. These requirements shall however be read along with the requirements of the respective driven equipment being supplied under the specification of which this specification forms a part.

12.01.03 The motor supplied under this specification shall conform to the standards specified in GTR.

12.01.04 Terminal point for all motors supplied under this specification shall be at the respective terminal boxes.

12.01.05 Materials and components not specifically stated in this specification but are necessary for satisfactory operation of the motor shall be deemed to be included in the scope of supply of this specification.

12.01.06 Notwithstanding anything stated in this motor specification, the motor has to satisfy the requirement of the mechanical system during normal and abnormal conditions. For this the motor manufacturer has to co-ordinate with the mechanical equipment supplier and shall ensure that the motor being offered meets the requirements.

12.02.00 **Codes & Standards**

12.02.21 The design, manufacture, installation and performance of motors shall conform to the provisions of latest Electricity Act and Electricity Rules. Nothing in these specifications shall be construed to relieve the Contractor of his responsibility.

12.02.22 In case of contradiction between this specifications and IEC, the stipulations of this specification shall be treated as applicable.

12.02.23 National Electrical code for hazardous location and relevant NEMA standard shall also be applicable for motors located in hazardous location.

12.03.00 **Design Features**

12.03.01 **Rating and type**

(i) The induction motors shall be of squirrel cage type unless specified otherwise.

(ii) The motors shall be suitable for continuous duty in the specified ambient temperature.

(iii) The MCR KW rating of the motors for 50ºC ambient shall not be less than the power requirement imposed at the motor shaft by the driven equipment under the most onerous operation conditions as defined elsewhere, when the supply frequency is 51.5 Hz (and the motor is running at 103% of its rated speed).

(iv) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously in the system having the following particulars:

a) Rated terminal voltage

From 0.2 to 200 KW	400V (3 Phase, solidly earthed)
Below 0.2 KW	230 V (1 Phase, solidly earthed)
Variation in voltage	± 6%.

b) Frequency 50 Hz ± 3%.

c) Any combination of (a) & (b)

12.03.02 Enclosure

Motors to be installed outdoor and semi-outdoor shall have hose proof enclosure equivalent to IP-55. For motors to be installed indoor, the enclosure shall be dust proof equivalent to IP-54.

12.03.03 **Cooling method**

Motors shall be TEFC (totally enclosed fan cooled) type.

12.03.04 **Starting requirements**

(i) **Induction motor**

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

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

c) The starting current of the motor at rated voltage shall not exceed six (6) times the rated full load current subject to tolerance as given in IEC 60034.

d) Motors when started with the driven equipment imposing full starting torque under the supply voltage condition specified under Clause 12.03.01 (iv) (a) shall be capable of withstanding at least two successive starts with coasting to rest between starts and motor initially at the rated load operating temperature. The motors shall also be suitable for three equally spread starts per hour, the motor initially at a temperature not exceeding the rated operating temperature.

e) The locked rotor withstand time under hot condition at 110% of rated voltage shall be more than the starting time with the driven equipment at minimum permissible voltage (clause 12.03.04 (i) (a) by at least two

seconds or 15% of the accelerating time whichever is greater. In case it is not possible to meet the above requirements, the Bidder shall offer centrifugal type speed switch mounted on the motor shaft which shall remain closed for speeds lower than 20% and open for speeds above 20% of the rated speed. The speed switch shall be capable of withstanding 120% of the rated speed in either direction of rotation.

12.03.05 **Running Requirements**

(i) When the motors are operating at extreme condition of voltage and frequency given under clause no.12.03.01 (iv) the maximum permissible temperature rise over the ambient temperature of 50ºC shall be within the limits specified in IEC 60034 after adjustment due to increase ambient temperature specified herein.

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

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

(iv) Induction motors shall be so designed as to be capable of withstanding the voltage and torque stresses developed due to the difference between the motor residual voltage and incoming supply voltage during fast changeover of buses. The necessary feature incorporated in the design to comply with this requirement shall be clearly indicated in the proposal.

(v) Motors shall be capable of developing the rated full load torque even when the supply voltage drops to 70% of rated voltage. Such operation is envisaged for a period of one second. The pull out torque of the induction motors to meet this requirement shall not be less than 205% of full load torque.

(vi) The motors shall be capable of withstanding for 10 seconds without stalling or abrupt change in speed (under gradual increase of torque) an excess torque of 60 percent of their rated torque, the voltage and frequency being maintained at their rated value.

(vii) Guaranteed performance of the motors shall be met with tolerances specified in respective standards.

12.04.00 **Construction Features**

12.04.01 **Stator**

(i) **Stator frame**

The stator frames and all external parts of the motors shall be rigid fabricated steel or of casting. They shall be suitably annealed to eliminate any residual stresses introduced during the process of fabrication and machining.

(ii) **Stator core**

The stator laminations shall be made from suitable grade magnetic sheet steel varnished on both sides. They shall be pressed and clamped adequately to reduce the core and teeth vibration to minimum.

(iii) **Insulation and winding**

All insulated winding conductor shall be of copper. The overall motor winding insulation for all 400 volts motors shall be of epoxy thermosetting type i.e., class 'F' but limited to class-B operating from temperature rise consideration. Other motors may be of conventional class-B type. The windings shall be suitable for successful operation in hot, humid, tropical climate with the ambient temperature of 50ºC.

12.04.02 **Rotor**

(i) Rotors shall be so designed as to keep the combined critical speed with the driven equipment away from the running speed by atleast 20%.

(ii) Rotors shall also be designed to withstand 120% of the rated speed for 2 minutes in either direction of rotation.

12.04.03 **Terminal box leads**

(i) For motors of 400 Volts and below a single terminal box may be provided for power and accessories leads.

(ii) Terminal boxes shall be of weatherproof construction designed for outdoor service. To eliminate entry of dust and water, gaskets of neoprene or approved equivalent shall be provided at cover joints and between box and motor frame.

(iii) Terminal box shall be suitable for top and bottom entry of cables.

(iv) Unless otherwise approved, the terminal box shall be capable of being turned through 360o in steps in 90o.

(v) The terminals shall be complete with all accessories for connecting external cables. They shall be designed for the current carrying capacity and shall ensure ample phase to phase to ground clearances.

(vi) Suitable tinned brass compression type cable glands and cable lugs shall be supplied by the Contractor to match Employer's cable.

(vii) Terminal box for single core cable shall be of non- magnetic material.

(viii) Marking of all terminals shall be in accordance with IEC/ International Standard.

12.04.04 **Rating Plates**

(i) Rating plates shall be provided for all motors giving the details as called for in IEC 60034 (for three phase squirrel cage induction motors).

(ii) In addition to above, the rating plate shall indicate the following:

a) Temperature rise in °C under normal working conditions.

b) Phase sequence corresponding to the direction of rotation for the application.

c) Bearing identification number (in case of ball/ roller bearing) and recommended lubricants.

12.04.05 **Other Constructional Features**

(i) Two independent earthing points shall be provided on opposite sides of the motor for bolted connection of Employer's earthing conductor to be specified to the successful Bidder.

(ii) Motor weighing more than 25 kg shall be provided with eyebolts, lugs or other means to facilitate lifting.

12.05.00 **Paint and Finish**

12.05.01 Motor external parts shall be finished and painted to produce a neat and durable surface, which would prevent rusting and corrosion. The equipment shall be thoroughly degreased, all sharp edges and scales removed and treated with one coat of primer and two coats of grey enamel paint.

12.05.02 Motor fans shall also be painted to withstand corrosion.

12.05.03 All fasteners used in the construction of the equipment shall be either of corrosion resistant material or heavy cadmium plated.

12.05.04 Current carrying fasteners shall be either of stainless steel or high tensile brass.

12.06.00 **Tests at Manufacturers Works**

12.06.01 Motors shall be subject to routine tests in accordance with IEC 60034.

12.06.02 In addition, the following tests shall also be carried out:

a) 20% over speed test for 2 minutes on all rotors.

b) Measurement of vibration.

c) Measurement of noise level.

d) Phase sequence and polarity checks relative to mechanical rotation.

12.06.03 **Tests after installation at site**

(i) After installation and commissioning at site, the motors along with the driven equipment shall be subject to tests to ascertain their conformity with the requirement of this specification and those of the driven equipment specification and the performance data quoted by the Bidder.

(ii) In case of non-conformity of the motor with these specifications and performance requirement, the Engineer may at his discretion reject or ask for necessary rectification/replacement as detailed in general Terms and Conditions of Contract (GCC) Volume-I.

13.00.00 **BATTERY & BATTERY CHARGERS**

This clause covers the design, performance, manufacturing, construction features and testing of Battery and Battery charger used primarily for starting the diesel engine driving the fire water pumps. Battery Chargers shall be housed in Diesel Engine Panel.

13.01.00 **General Information**

13.01.01 The equipment specified hereinafter are required for starting the diesel engines and other operation of the plant as required.

13.01.02 For each diesel engine there shall be two (2) sets of Battery and two (2) sets of Battery Charger.

13.01.03 The D.C. voltage shall be obtained normally after necessary rectification by battery charger. The Battery Charging system shall be capable of meeting the following requirements:

13.01.04 Float charging the Battery.

13.01.05 Boost Charging the Battery.

13.01.06 The battery shall be large enough to crank the engine **3** times without charging in between and without getting drained to an extent which will affect its life.

13.01.07 The Bidder shall indicate the battery voltage and battery capacity in Ampere- Hour at ten (10) hour discharge rate. The battery voltage at any time during operation shall not be less than the minimum voltage required for operation of the D.C. loads.

13.02.00 **General Design**

The Battery shall be located indoor

13.02.01 **Battery**

(i) The cells shall be lead-acid type. The Battery shall be automotive type.

(ii) The cells shall be sealed in type with anti-splash type vent plug.

(iii) The cell terminal posts shall be provided with connector bolts and nuts, effectively coated with lead to prevent corrosion. Lead or lead coated copper connectors shall be furnished to connect up cells of battery set.

(iv) Positive and Negative terminal posts shall be clearly and indelibly marked for easy identification.

(v) The electrolyte shall be of battery grade Sulphuric Acid. Water for storage batteries conforming to relevant standards shall be used in the preparation of the electrolyte.

13.02.02 **Battery Charger**

(i) The Bidder shall furnish the battery charging scheme complete with all necessary accessories such as transformers, switches, fuses, starters, contactors, diodes, ammeters, voltmeters and other devices as required for trouble free operation. All devices and equipment shall conform to relevant International Standard or shall be Superior to it.

(ii) The scheme of the battery charger shall be such that the battery can be charged automatically as well as manually.

(iii) The boost charger shall have sufficient capacity to restore a fully discharged Battery to a state of full charge in eight (8) hours with some spare margin over maximum charging rate. Suitable provision shall be kept so that, for a particular engine, any of the two (2) charger units can be used for charging any of the two (2) batteries.

(iv) The instruments, switches and lamps shall be flush/semi-flush mounted on the front panel. Name plate of approved type shall be provided for each of these equipments.

(v) The panel shall be complete with internal wiring and input-output terminal block. Terminal blocks shall be clip on type of suitable rating. All equipment and wire terminals shall be identified by symbols corresponding to applicable schematic/wiring diagram.

(vi) Space heaters of adequate capacity shall be provided to prevent moisture condensation in the panel.

13.03.00 **Testing**

13.03.01 The Battery Charger shall also be subjected to the following tests at manufacturer's works as per IEC 60146.

13.03.02 Insulation test.

13.03.03 Connection checking.

13.03.04 Measurement of voltage regulation.

13.03.05 Auxiliary of devices.

13.03.06 Alternating current measurement.

13.03.07 Performance test.

13.03.08 Temperature rise test.

13.03.09 Following acceptance tests shall be carried out in batteries as per IEC/International standard.

a) Marking and packing

b) Verification of dimensions

c) Test for capacity

d) Test for voltage during discharge

Battery and battery charger shall be checked for auto charging and providing sufficient power for three consecutive starting kicks to diesel engine within five minutes with A.C. supply switched off.

14.00.00 CONTROL & ANNUNCIATION PANELS

14.01.00 Intent of Specification

The following requirement shall be applicable to the control and annunciation panels furnished under these specifications.

14.02.00 General Information

14.02.01 The equipment specified herein are required for controlling, metering, monitoring and indication of electrical systems of the plant offered.

14.02.02 The selection and design of all the equipment shall be so as to ensure reliable and safe operation of the plant and shall be subjected to approval by the Employer.

14.02.03 The reference ambient temperature outside the panel shall be taken as 50^{o}C and relative humidity 100%.

14.03.00 Equipment to be Furnished

Control & annunciation panels shall be furnished complete with all accessories and wiring for safe and trouble free operation of the plant. Details are included in sub-section General.

14.04.00 Constructional Details

14.04.01 The panel frames shall be fabricated using suitable mild steel structural sections or pressed and shaped cold-rolled sheet steel of thickness not less than 2.5 mm. Frames shall be enclosed in cold-rolled sheet steel of thickness not less than 1.6 mm. Stiffeners shall be provided wherever necessary.

14.04.02 Panels shall be of free standing type and shall be provided with hinged door with locking arrangement. The access doors, cutest and covers shall be equipped with neoprene/synthetic rubber gaskets (conforming to IEC 60149) all around and the latches sufficiently strong to hold them in alignment when closed. The panels to be installed outdoor or semi outdoor shall have a degree of protection of IP: 55 and those installed indoor shall have a degree of protection of IP: 52 as per IEC 60947.

14.04.03 If a panel consists of a number of panels, each panel should be mounted side by side and bolted together to form a compact unit, when two panels meet, the joints shall be smooth, close fittings and un-obstructive.

14.04.04 Removable eye bolt or lifting lugs shall be provided on all panels to facilitate easy lifting.

14.04.05 The heights of all operating equipment on the panel shall be between 800 mm to 1600 mm from the finished floor level. The proper supporting arrangement shall be provided by the Contractor.

14.04.06 Cable entries to the panel may be from bottom or top. The cable entry required will be intimated to the successful Bidder. A suitable removable gland plate of 3 mm thick shall be mounted not less than 200 mm above the floor level.

14.04.07 All equipment mounted on the front face of the panels shall be flush or semi-flush type. All equipment shall be so located that their terminal and adjustment are readily accessible for inspection or maintenance and their removal and replacement can be done without interruption of service to other equipment. The contractor shall submit the panel general arrangement drawings clearly bringing out internal mounting details, dimensions of equipment, clearance between the equipment and the edges of the panel, for approval.

14.05.00 **Name Plates and Labels**

14.05.01 Each panel shall be provided with prominent, engraved identification plates for all front mounted equipment. Panel identification name plate shall be provided at front and rear as required.

14.05.02 All name plates shall be of non-rusting metal or 3 ply lamicold, with white engraved lettering on black background. Inscription and lettering sizes shall be subjected to Employer's approval.

14.05.03 Suitable plastic sticker labels shall be provided for easy identification of all equipment located inside the panel. These labels shall be positioned so as to be clearly visible and shall give the device number, as mentioned in the wiring drawings.

14.06.00 **AC/DC Power Supply**

14.06.02 The Employer will provide one feeder each for AC and DC to the panel. The Contractor shall make for his own arrangements for providing these power supplies to different panels.

14.06.02 The Contractor shall provide suitable isolating switch fuse unit in the control panel for receiving the above incoming AC and DC supplies. Fuse and link shall be provided for isolating of individual circuit without disturbing other circuits.

14.07.00 **Wiring**

14.07.01 All inter panel wiring and connections between panels (if there is group of panels) including all bus wiring for AC & DC supplies shall be provided by the Contractor.

14.07.02 All internal wiring shall be carried out with 1100 V grade, single core, 1.5 square mm or larger stranded copper wires having colour-coded PVC insulation. CT circuits shall be wired with 2.5 square mm copper wires, otherwise similar to the above.

14.07.03 Extra-flexible wire shall be used for wiring to devices mounted on moving parts such as doors.

14.07.04 Spare contacts of auxiliary relays, timers and switches shall be wired out to the terminal blocks as required by the Employer/Engineer at the time of detailed engineering.

14.08.00 **Terminal Blocks**

14.08.01 Terminal Blocks shall be of 650V grade, rated for 10 Amps and in one-piece moulding. It shall be complete with insulating barriers, clip-on-type terminals, and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring diagrams. It shall be similar to 'Elmex-Standard' type terminals.

14.08.02 Terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal blocks.

14.08.03 The terminal blocks shall have at least 20% spare terminals.

14.09.00 **Grounding**

A continuous copper bus 25 x 3 mm size shall be provided along the bottom of the panel structure. It shall run continuously throughout the length of the panel and shall have provision at both ends for connection to the station grounding grid (25 x

6 mm MS Flat).

14.10.00 **Space Heater and Lighting**

14.10.01 Space heaters shall be provided in the panels for preventing harmful moisture condensation.

14.10.02 The space heaters shall be suitable for continuous operation on 230V AC, 50 Hz, single phase supply and shall be automatically controlled by thermostat. Necessary isolating switches and fuses shall also be provided.

14.10.03 Free standing panel shall have a 230V AC, plug point and a fluorescent light operated by door switch.

14.11.00 **Control and Selector Switches**

14.11.01 Control and selector switches shall be of rotary type, with escutcheon plates clearly marked to show the function and positions.

14.11.02 Control/selector switches shall be spring return or stay put type as per the requirements. Handles of control/selector switches shall be black in colour. Shape and type of handles shall be to the approval of the Employer.

14.11.03 The contact ratings shall be at least the following:

i)	Make and carry continuously	10 Amp.
ii)	Breaking current at 240V DC	1Amp. (Inductive)
iii)	Breaking current at 240V DC	5 Amp. at 0.3 p.f. lagging

14.12.00 **Push Buttons**

14.12.01 Push buttons shall be spring return, push to actuate type and rated to continuously carry and break 10A at 230V AC and 0.5A (Inductive) at 220V DC. The push buttons shall have at least 1 NO and 1 NC contact. All contact faces shall be of silver or silver alloy.

14.12.02 All push buttons shall be provided with integral escutcheon plates marked with its function.

14.12.03 The colour of buttons shall be as follows:

Green	For motor START, Breaker CLOSE, Valve/ damper OPEN.
Red	For motor TRIP, Breaker OPEN, Valve/ damper CLOSE.
Black	For all annunciation functions, overload reset and miscellaneous.

14.12.04 Red push buttons shall always be located to the left of green push buttons. In case of clinker grinder etc. the push buttons would be black-red-green from left to right.

14.13.00 **Indicating Lamps**

14.13.01 Indicating lamps shall be of the panel mounting, filament type and of low-watt consumption. Lamps shall be provided with series resistors preferably built-in- the lamps assembly. The lamps shall have escutcheon plates marked with its function, wherever necessary.

14.13.02 Lamp shall have translucent lamp covers of the following colours:

Red	for motor OFF, Valve/damper OPEN, Breaker CLOSED.
Green	for motor ON, Valve/damper CLOSED, Breaker OPEN.
White	for motor AUTO-TRIP.

Blue for all healthy conditions (e.g. control supply, lube oil pressure and also for spring charged).

Amber for all ALARM conditions (e.g. pressure low, over load and also for 'service' and 'Test' position indication).

14.13.03 Bulbs and lamps covers shall be easily replaceable from the front of the panel.

14.13.04 Indicating lamps should be located directly above the associated push button/control switches. Red lamps shall variably be located to the right of the green lamp. In case a white lamp is also provided, it shall be placed between the red and green lamps. Blue and amber lamps should normally be located above the red and green lamps.

14.14.00 **Fuses**

14.14.01 All fuses shall be of HRC cartridge plug-in-type and shall be of suitable rating, depending upon circuit requirements.

14.14.02 All fuses shall be mounted on fuse carriers, which shall be mounted on fuse-bases.

14.15.00 **Contactors**

14.15.01 Contactors shall be of air break, electromagnetic type rated as per requirement.

14.15.02 Operating coils of AC contactors shall be of 230V AC or 220V DC as required. AC contactors shall operate satisfactorily between 85% and 110% of the rated voltage. The Contactor shall not drop out at 70% of the rated voltage.

14.15.03 DC contactors shall have a coil voltage of 220V DC and shall be suitable for satisfactory continuous operation at 80% to 110% of the rated voltage.

14.16.00 **Relays and Timers**

14.16.01 All auxiliary relays & timers shall be of proven design and of reputed make. Contacts of relays and timers shall be of solid silver or silver cadmium oxide or solid silver faced. Timers shall have the provision to adjust the delay on pick-up or reset as required.

14.16.02 All relays and timers shall have at least two NO and two NC contacts.

14.16.03 All relays and timers shall be suitable for 230V AC and 220V DC as required. DC relays shall operate satisfactorily between 70% and 110% and AC relays shall be suitable for voltage variation between 80% and 110%.

14.17.00 **Indication Instruments**

14.17.01 All indicating and integrating meters shall be flush mounted on panel front. The instruments shall be of at least 96 mm square size with 90-degree scales and shall have an accuracy class of 2.0 or better. The covers and cases of instruments and meters shall provide a dust and vermin proof construction.

14.17.02 All instruments shall be compensated for temperature errors and factory calibrated to directly read the primary quantities. Means shall be provided for zero adjustment removing or dismantling the instruments.

14.17.03 All instruments shall have white dials with black numerals and lettering. Black knife edge pointer with parallax free dials will be preferred.

14.17.04 Ammeters provided on motor feeders shall have a compressed scale at the upper current region to cover the starting current.

14.18.00 **Annunciation System**

14.18.01 The annunciation system shall be complete with all necessary relays, flashers and other accessories required for the proper operation of the equipment and shall be

completely solid state. The control circuit shall be mounted on plug-in type glass epoxy printed circuit boards. Audible alarms for the system shall be mounted inside the panel. One set of acknowledge, test and reset push buttons shall be mounted on the panel.

14.18.02 Indications shall be engraved on Acrylic inscription plate window and shall be visible clearly when the indication lamp is lighted (black letters on white background). Each window shall be provided with two lamps.

14.18.03 Audible hooter shall sound when a trouble contacts operates and shall continue to sound until the acknowledge button is pressed. In addition to the hooters provided on annunciation panels, a hooter shall be provided outside FFPH which shall sound in any fire alarm condition.

14.18.04 Indication lamps shall flash when trouble contact operates and shall continue flashing until acknowledge button is pressed.

14.18.05 After acknowledge button is pressed, the hooter and flashing shall stop but the indication lamp shall remain lighted.

14.18.06 After trouble is cleared indication lamps shall be ready and shall go off only when reset.

14.18.07 Silencing the hooter in conjunction with one trouble contact shall not stop and hooter sounding if another trouble contact operates.

14.18.08 When test button is pressed, all lamps shall flash and hooter shall sound.

14.18.09 Annunciator systems shall operate on 220V DC Systems.

14.18.10 The annunciation system shall include alarm for AC control system failure (working on DC supply), DC supply failure (working on AC supply) and test facilities for these alarms.

14.18.11 List of annunciations required on the panels has been listed elsewhere. The Contractor shall also provide additional annunciations if desired by the Employer/Engineer during Vendor drawing review stage and for such additional annunciations no extra charges shall be claimed by the Contractor, if the number of such additions are within 10% of the number stipulated in this specification.

14.18.12 20% spare windows shall be provided on the panel.

14.19.00 **Painting**

14.19.01 **Painting procedure adopted shall conform to requirements given in GTR**. The paint thickness shall not be less than **60** microns. Finished parts shall be coated by peelable compound by spraying method to protect the finished surface from scratches, grease, dirt and oily spots during testing, transportation handling and erection.

14.20.00 **Tests**

14.20.01 Following tests/inspection shall be carried out by the Contractor in the presence of Employer's representative:

(A) Factory Tests

1. Compliance with approved drawings, data and specification.

2. Visual check for workmanship.

3. Wiring continuity and functional checks.

4. Calibration of instruments, relays and metres wherever required by inspector.

5. HV test

6. Insulation resistance measurement before and after HV test.

(B) Inspection/Testing at site:

1. IR test before and after HV test

2. HV Test

3. Functional Testing.

(C)

1. The Fire detection and annunciation panel shall be subjected to functional tests.

2. The Annunciation System shall be routine tested

SECTION-13: AIR CONDITIONING SYSTEM

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1 GENERAL

1.1 This specification covers supply, installation, testing and commissioning and handing over to NEA of Air conditioning system for the control room building and switch-yard panel rooms.

1.2 Air conditioning units for control room building shall be set to maintain the inside DBT at 24 ° C ± 2°C and the air conditioning system for switch-yard panel rooms shall be set to maintain DBT inside switch-yard panel rooms below 24°C.

1.3 Controllers shall be provided in Control room and Battery room for controlling and monitoring the AC units in these rooms as detailed in clause no.2.3.4.

1.4 Each switch-yard panel room shall be provided with temperature transducer to monitor the temperature of the panel room. The Temperature transducer shall have the following specification:

Sensor	:	Air temperature sensor (indoor use)
Output	:	4 to 20mA
Temperature range	:	-5°C to 60°C
Resolution	:	0.1°C
Accuracy	:	0.5°C or better.

2 AIR CONDITIONING SYSTEM FOR CONTROL ROOM BUILDING.

2.1 Air conditioning requirement of control room building shall be met using a combination of following types Air Conditioning units as required.

a) Ductable Split unit of 8.5TR.
b) Cassette type split AC units of 3TR.
c) High wall type split AC units of 2TR.

2.2 **Scope**

The scope of the equipment to be furnished and services to be provided under the contract are outlined hereinafter and the same is to be read in conjunction with the provision contained in other sections/ clauses. The scope of the work under the contract shall be deemed to include all such items, which although are not specifically mentioned in the bid documents and/or in Bidder's proposal, but are required to make the equipment/system complete for its safe, efficient, reliable and trouble free operation.

2.2.1 Required number of Ductable split type AC units of 8.5 TR capacity with air cooled outdoor condensing unit with semi hermetic/hermetic compressors including refrigerant pipes, controls, thermostats, filters, outlet dampers, etc.

2.2.2 Required number of Cassette type split AC units of 3TR capacity each complete with air cooled outdoor condensing unit having hermetically sealed compressor unit with cordless remote controller.

2.2.3 Required number of High wall type split AC units of 2TR capacity each complete with air cooled outdoor condensing unit having hermetically sealed compressor and high wall type indoor evaporator unit with cordless remote controller.

2.2.4 Copper refrigerant piping complete with insulation between the indoor and outdoor

units as required.

2.2.5 First charge of refrigerant and oil shall be supplied with the unit.

2.2.6 GSS/Aluminium sheet air distribution ducting for distributing conditioned dehumidified air along with supply air diffusers and return air grilles with volume control dampers and necessary splitters etc., suitable fixtures for grilles/diffusers and supports for ducting complete with insulation.

2.2.7 Local start/stop facility for local starting/ stopping of all electrical equipment/ drives.

2.2.8 All instruments and local control panels along with controls and interlock arrangements and accessories as required for safe and trouble free operation of the units.

2.2.9 PVC drain piping from the indoor units upto the nearest drain point.

2.2.10 Supply and erection of Power and control cable and earthing.

2.2.11 MS Brackets for outdoor condensing units, condensers as required.

2.3 **Technical specifications.**

2.3.1 **Ductable split type AC units.**

2.3.1.1 Each Split Air conditioner shall have an indoor unit and an outdoor unit, designed to provide free delivery of conditioned air to the conditioned space. The indoor unit shall be suitable for mounting on the ceiling concealed above the false ceiling. Outdoor unit can be placed on the roof. Each unit shall include a primary source of refrigeration for cooling and dehumidification, means for circulation and cleaning air.

2.3.1.2 Cabinet

The cabinets housing the components of indoor units & outdoor units shall be of heavy gauge sheet steel and suitable for floor mounting/mounting from ceiling. The access panels shall be of easily removable type. The entire casing shall be lined with 25mm thick insulation of totally flame proof type. Suitable drain connection shall be provided for removal of condensate collected inside a tray under cooling coil.

2.3.1.3 Compressor

The compressor shall be Semi hermetically/hermetically sealed type and complete with drive motor. The compressor shall be mounted on spring inside the lower most section of the unit so that it is easily accessible for servicing.

2.3.1.4 Condenser

Air cooled condenser of adequate surface area shall be offered. The air cooled condenser shall be made of copper tubes with external fins.

2.3.1.5 Air Handling Fan

The air handling fan shall be centrifugal type complete with belt drive and electric motor.

2.3.1.6 Filter

Pre-filter at the suctions to remove dust particles down to 10 micron size with 90% efficiency and fine filters to remove dust particles down to 5 micron size with 99% efficiency at the outlet. All filters shall be of panel type.

2.3.1.7 Cooling Coil

Cooling coils shall be of direct expansion type and made of heavy gauge copper with aluminium fins. Rows shall be staggered in the direction of air flow. Separate tubings from the distributor shall feed refrigerant uniformly to different sections of the coil.

2.3.1.8 Refrigerant Piping

Refrigerant piping shall be of heavy gauge copper, heavy class seamless M.S. pipe complete with thermostatic expansion valve, liquid strainer, dehydrator, liquid line shut off valve, high and low pressure gauges.

2.3.1.9 Condensate Trays

An adequate method of condensate removal shall be provided. Condensate tray of adequate size, made of corrosion-resistant material or suitably treated with corrosion-resistant coating shall be provided. The tray shall be adequately insulated to avoid condensation over its external surface.

2.3.1.10 Refrigerant Strainer

A refrigerant strainer shall be provided in the liquid line immediately before the expansion device.

2.3.1.11 Vibration Isolator

A minimum of six 25 thick neoprene rubber pads shall be supplied for each unit.

2.3.1.12 Cooling capacity of 8.5TR unit shall not be less than 102000 btu/hr.

2.3.2 **Cassette type split AC units**.

The Cassette type AC units shall be complete with indoor evaporator unit, outdoor condensing units and cordless remote control units.

2.3.2.1 Outdoor unit shall comprise of hermetically/ semi hermetically sealed compressors mounted on vibration isolators, fans and copper tube aluminium finned coils all assembled in a sheet metal casing. The casing and the total unit shall be properly treated and shall be weatherproof type. They shall be compact in size and shall have horizontal discharge of air.

2.3.2.2 Indoor units shall be of 4-way, ceiling mounted cassette type. The indoor unit shall be compact and shall have elegant appearance. They shall have low noise centrifugal blowers driven by suitable motors and copper tube aluminium finned cooling coils. Removable and washable polypropylene filters shall be provided. They shall be complete with multi function cordless remote control unit with special features like programmable timer, sleep mode etc.

2.3.2.3 Cooling capacity of 3TR AC units shall not be less than 36000btu/hr. and their EER shall not be less than 2.7.

2.3.3 **High wall type split AC units**

2.3.3.1 The split AC units shall be complete with indoor evaporator unit, outdoor condensing units and cordless remote control units.

2.3.3.2 Outdoor unit shall comprise of hermetically/semi hermetically sealed compressors mounted on vibration isolators, propeller type axial flow fans and copper tube aluminium finned coils all assembled in a sheet metal casing. The casing and the total unit shall be properly treated and shall be weatherproof type. They shall be compact in size and shall have horizontal discharge of air.

2.3.3.3 The indoor units shall be high wall type. The indoor unit shall be compact and shall have elegant appearance. They shall have low noise centrifugal blowers driven by suitable motors and copper tube aluminium finned cooling coils. Removable and washable polypropylene filters shall be provided. They shall be complete with multi function cordless remote control unit with special features like programmable timer, sleep mode and soft dry mode etc.

2.3.3.4 Cooling capacity of 2TR AC units shall not be less than 22000btu/hr. and shall have energy efficiency rating of 3star or above.

2.3.4 Controllers shall be provided in Control room and Battery room, one controller for each room, to control and monitoring of AC units and shall have the following facilities;

- Standby units shall come in to operation automatically when the running main unit fails
- Main and standby units shall be changed over periodically which shall be finalised during detailed engineering.
- Following alarms shall be provided:

  a. Compressor On/OFF condition of each unit
  b. Compressor failure of each unit
  c. Power OFF to AC unit
  d. High temperature in room.

2.4 **Warranty**

All compressors shall have minimum 5 years Warranty from the date of commissioning.

3 AIR CONDITIONING SYSTEM FOR SWITCHYARD PANEL ROOMS.

3.1 Air conditioning system shall be provided in the switchyard panel rooms used for

housing control and protection panels. These panel rooms will be located in the switchyard area and generally unmanned. Therefore, the air-conditioning system shall be rugged, reliable, maintenance free and designed for long life.

3.2 Air conditioning system is required for maintaining the temperature below 24°C for sub-station control and protection panels. This shall be achieved using Packaged AC units with free cooling arrangement as per clause 3.4. The system shall be designed for 24 Hours, 365 Days of the year operation to maintain the inside Switchyard panel rooms temperature for proper operation of the critical equipment.

3.3 Number and rating of the units for each panel room shall be as follows:

i. For panel room of length not more than 6 metres: 2 nos. (1 working + 1 standby) AC units of 2TR capacity each.
ii. For panel room of length more than 6 metres: 2 nos. (1 working + 1 standby) AC units of 3TR capacity each.

3.4 **Technical specification for Packaged AC units with Free Cooling.**

3.4.1 Each AC unit shall be complete with air cooled condensing unit with scroll compressor, direct expansion type evaporating unit and microprocessor controller. AC units shall be provided with free cooling arrangement. In free cooling mode, the refrigerant cycle of AC unit shall be switched off and outside air (after filtration) shall be circulated inside the conditioned space through the operation of dampers provided with suitable sensors. This mode shall come into operation in the following conditions;

i. When the ambient temperature is below a preset value, which is to be decided during detailed engineering.
ii. In case of failure of refrigeration system of both the units.

3.4.2 One of the air-conditioners shall be running at a time and shall maintain the required temperature. On failure of the running air-conditioner, the other air-conditioner shall start automatically. To ensure longer life of the system and to keep the AC units healthy, change over of the standby unit shall be done periodically through the controller. Further, if inside temperature of the room reaches 35°C due to any emergency condition, the standby air-conditioner shall also start running to maintain the temperature less than 24°C and system shall generate an alarm for such a situation. After achieving this temperature, the standby unit shall again shut off. However, any hunting situation shall be reported. No heating or humidification is envisaged for the air conditioning system inside the Switchyard panel rooms.

3.4.3 Packaged AC units with free cooling shall be designed for highly sensitive cooling with sensible heat factor of 90% or above.

3.4.4 Each air conditioner shall be completely self-contained. All components of the units shall be enclosed in a powder coated cabinet. The unit shall be assembled, wired, piped, charged with refrigerant and fully factory tested as a system to ensure trouble free installation and start up. Suitable isolation or other by-passing arrangement shall be provided such that any unit/component could be maintained/ repaired without affecting the running standby unit.

3.4.5 The AC units shall be mounted on the wall and the maintenance of unit shall be possible from outside the Switchyard panel room.

3.4.6 Required Features of Various Components

The compressor shall be very reliable, trouble free and long life i.e. hermetically sealed Scroll type of reputed make suitable for continuous operation. Compressor should be installed on vibration isolated mountings or manufacturers recommended approved mounting. Valve shall be provided for charging/topping up of refrigerant. The bidder shall furnish details of their compressor indicating the MTBF, life of compressor and continuous run time of compressor without failure. The contractor shall also furnish details of all accessories i.e. refrigeration system, evaporator coil, condenser coil, evaporator blower, filter, cabinet, indoor supply and return grill etc. during detailed engineering.

3.5 **Warranty**

All compressors shall have minimum 5 years Warranty from the date of commissioning

3.6 For owner's remote monitoring purposes, necessary digital inputs shall be provided for 'ON' and 'OFF' condition of each compressor.

SECTION 14: DIESEL GENERATOR SET

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1.1 SCOPE OF SUPPLY

1.1.1. The scope covers supply of. Diesel Generator set of stationary type having a net electrical output of 160 kVA/100kVA (as applicable) capacity at specified site conditions of 50^{o} C ambient temperature and 100% relative humidity on FOR site basis. DG set shall be equipped with:

(i) Diesel engine complete with all accessories.
(ii) An alternator directly coupled to the engine through coupling, complete with all accessories.
(iii) Automatic voltage regulator.
(iv) Complete starting arrangement, including two nos. batteries & chargers.
(v) Base frame, foundation bolts etc.
(vi) Day tank of 990 Litre capacity.
(vii) Engine Cooling and lubrication system.
(viii) Engine air filtering system.
(ix) Exhaust silencer package.
(x) Set of GI pipes, valves, strainers, unloading hose pipes as required for fuel transfer system from storage area to fuel tank including electrically driven fuel pump.
(xi) All lubricants, consumable, touch up paints etc. for first filing, testing & commissioning at site. The fuel oil for first commissioning will also be provided by the contractor.
(xii) AMF panel for control, metering and alarm.
(xiii) Enclosure for silent type D.G. Set

1.2. SCOPE OF SERVICE

1.2.1. The Contractor shall provide following services:

a) Design, manufacture, shop testing including assembly test.
b) Despatch, transportation to site.
c) Erection, testing & commissioning with all equipments/materials required for the purpose.
d) Drawings, data, design calculations and printed erection, operation & maintenance manual.
e) Certification and compliance for meeting noise level & emission parameters and other requirements in accordance with latest Notification of MOEF.

1.3. TECHNICAL REQUIREMENTS

1.3.1. The rating of DG sets are as follows:

DG set net output after considering deration for engine and alternator separately due to temperature rise in side the enclosure and on account of power reduction due to auxiliaries shall be 160 kVA/100kVA (as applicable), 1500 RPM, 0.8Pf, 400V, 3 phase, 50Hz. The above ratings are the minimum requirements.

1.3.1.1. DG sets shall also be rated for 110% of full load for 1 hour in every twelve hrs of continuous running.

1.3.2. The output voltage, frequency and limits of variation from open circuit to full load shall be as follows:

a)	Voltage variation	$\pm$10% of the set value provision shall exist to adjust the set value between 90% to 110% of nominal Generator voltage of 400V.
b)	Frequency	50Hz, $\pm$2.5%

1.3.3. The Diesel Generator and other auxiliary motor shall be of H class with temperature rise limited to Class-F for temperature rise consideration.

1.3.4. NOISE LEVEL & EMISSION PARAMETERS: These shall be as per latest Notification of MOEF

1.4. PLANT DESIGN

1.4.1. DIESEL ENGINE

1.4.1.1. The engine shall comply with the BS 5514/ISO 3046; latest edition

1.4.1.2. Diesel engine shall be turbo charged multicylinder V-type in line type with mechanical fuel injection system.

1.4.1.3. The engine with all accessories shall be enclosed in an enclosure to make it work silently (within permissible noise level) without any degradation in its performance.

1.4.1.4. The Diesel Engines shall be directly water cooled. Cooling of water through radiator and fan as envisaged.

1.4.1.5. The fuel used shall be High Speed Diesel oil (HSD) or Light Diesel Oil (LDO).

1.4.2. AIR SUCTION & FILTRATION

1.4.2.1. Suction of air shall be from indoor for ventilation and exhaust flue gasses will be let out to outside atmosphere, Condensate traps shall be provided on the exhaust pipe.

1.4.2.2. Filter shall be dry type air filter with replaceable elements.

1.4.3. FUEL AND LUBRICATING OIL SYSTEM

1.4.3.1. The engine shall have closed loop lubricating system. No moving parts shall require lubrication by hand prior to the start of engine or while it is in operation.

1.4.4. ENGINE STARTING SYSTEM

1.4.4.1. Automatic electric starting by DC starter motor shall be provided.

1.4.5. FUEL INJECTION AND REGULATOR

1.4.5.1. The engine shall be fitted with electronic governor.

1.4.5.2. The engine shall be fitted with a heavy, dynamically balanced fly wheel suitable for constant speed governor duty.

1.4.6. ALTERNATOR

1.4.6.1. The alternator shall comply with IEC 60034; latest edition.

1.4.6.2. The alternator shall be of continuously rated duty, suitable for 400 V, 3 phase, 50 Hz. Power development having brush-less, synchronous, self-excited, self-regulating system.

1.4.6.3. The alternator shall be drip-proof, screen protected as per IP-23 degree of Protection.

1.4.6.4. The rotor shall be dynamically balanced to minimize vibration.

1.4.6.5. The alternator shall be fitted with shaft mounted centrifugal fan.

1.4.6.6. It shall have the winding of class H but limited to Class-F for temperature rise consideration.

1.4.6.7. The Alternator regulator shall be directly coupled to the engine and shall be complete with the excitation system, automatic voltage regulation of +/- 1%, voltage adjusting potentiometer and under/over speed protection.

1.4.6.8. **TERMINAL BOX**

1.4.6.8.1. Six (6) output terminals shall be provided in alternator terminal box. Terminals shall be Suitable for 1 No. of single core, 630 mm^2 XLPE cables per phase for 250kVA DG set and 3½Core 300 mm^2 XLPE cable for 100kVA DG set. The neutral shall be formed in AMF panel. The generator terminal box shall be suitable to house necessary cables and should be made of non-magnetic material.

1.4.6.9. The alternator with all accessories shall be enclosed in a enclosure to make it work Silently (within permissible noise level)

1.4.7. **COUPLING**

1.4.7.1. The engine and alternator shall be directly coupled by means of self-aligning flexible flange coupling to avoid misalignment.

1.4.7.2. The coupling shall be provided with a protecting guard to avoid accidental contract.

1.4.8. **MOUNTING ARRANGEMENT**

1.4.8.1. The engine and alternator shall be mounted on a common heavy duty, rigid fabricated steel base frame constructed from ISMC of suitable sections.

1.4.8.2. Adequate number of anti-vibrations mounting pads shall be fixed on the common base frame on which the engine and the alternator shall be mounted to isolate the vibration from passing on to the common base frame or the foundation of the D.G. Set.

1.4.9. **PERIPHERALS**

1.4.9.1. **FUEL TANK**

1.4.9.1.1. The Fuel tank of 990 Litre capacity shall be provided on a suitably fabricated steel platform. The tank shall be complete with level indicator marked in litres, filling inlet with removable screen, an outlet, a drain plug, an air vent, an air breather and necessary piping. The tank shall be painted with oil resistant paint and shall be erected in accordance with **Nepal Explosive Act.** Fuel tank shall be kept outside of enclosure. The fuel piping shall be carried out to connect the D.G set kept inside.

1.4.9.1.2. For transferring fuel to Fuel tank transfer pump is envisaged. The capacity of transfer pump shall be adequate to fill the day tank in about 30 minutes. Fuel pump shall be electrically driven.

1.4.9.2. **BATTERY AND BATTERY CHARGER**

1.4.9.2.1. Two nos. 24V batteries complete with all leads, terminals and stand shall be provided. Each battery shall have sufficient capacity to give 10 nos. successive starting impulse to the diesel engine.

1.4.9.2.2. The battery charger shall be complete with transformer, suitable rating (400 V, 3 Ph., 50 Hz. /230V, 1Ph., 50 Hz) rectifier circuit, charge rate selector switch for “trickle”/’boost’ charge, D.C. ammeter & voltmeter, annunciation panel for battery charge indication / loading / failures.

1.4.9.2.3. The charger shall float and Boost Charge the battery as per recommendation of manufacturer of battery. The charger shall be able to charge a fully discharged battery to a state of full charge in 8 Hrs. with 25% spare capacity.

1.4.9.2.4. Manual control for coarse and fine voltage variation shall be provided. Float charger shall have built-in load limiting features.

1.4.9.2.5. Ripple shall not be more than 1 % (r.m.s) to get smooth DC voltage shall be provided.

1.4.9.2.6. Charger shall be provided with Out-put Voltmeter & Ammeter.

1.4.9.2.7. Changeover scheme for selecting battery and battery charger by changeover switch should be provided.

1.5. **CONTROL AND INSTRUMENTATION**

1.5.1. Each D.G. Set shall be provided with suitable instruments, interlock and protection arrangement, suitable annunciation and indications etc. for proper start up, control, monitoring and safe operation of the unit. One local AMF control panel alongwith each D.G. set shall be provided by the Supplier to accommodate these instruments, protective relays, indication lamps etc. The AMF Panel shall have IP-52 degree of Protection as per IEC: 60529.

1.5.2. The D.G. sets shall be provided with automatic start facility to make it possible to take full load within 30 seconds of Power Supply failure.

1.5.3. Testing facility for automatic operation of D.G. Set shall be provided in AMF panel.

1.5.4. A three-attempt starting facility using two impulse timers and summation timer for engine shall be proved and if the voltage fails to develop within 40 sec. from receiving the first impulse, the set shall block and alarm to this effect shall be provided in the AMF panel.

1.5.5. Following instruments shall be provided with Diesel Engine
a) Lube oil pressure gauge
b) Water temperature thermometers
c) Engine tachometer/HR
d) Any other instruments necessary for DG Set operation shall be provided.

1.5.6. DG set shall be capable of being started/ stopped manually from remote as well as local. (Remote START/STOP push button shall be provided in 400V ACDB). However, interlock shall be provided to prevent shutting down operation as long as D.G. Circuit breaker is closed.

1.5.7. The diesel generator shall commence a shutdown sequence whenever any of the following conditions appear in the system:
a) Overspeed
b) Overload
c) High temperature of engine and cooling water.
d) High temperature inside enclosure
e) Low lube oil pressure
f) Generator differential protection
g) Short circuit protection
h) Under voltage
i) Over voltage
j) Further interlocking of breaker shall be provided to prevent parallel operation of DG set with normal station supply.

1.5.8. Following indication lamps for purposes mentioned as under shall be provided in AMF panel:

1.5.8.1. Pilot indicating lamp for the following:
a) Mains ON

b) Alternator ON
c) Charger ON/OFF
d) Breaker ON/OFF
e) Main LT Supply ON/OFF

1.5.8.2. Visual annunciation shall be provided for set shut down due to:
a) engine overheating
b) low oil pressure
c) lack of fuel
d) Set failed to start in 30 sec. after receiving the first start impulse
e) high cooling water temperature
f) Low level in daily service fuel tank
g) Overspeed trip
h) Audio & visual Annunciation for alternator fault.

1.5.9. Thermostatically controlled space heaters and cubicle illumination operated by Door Switch shall be provided in AMF panel. Necessary isolating switches and fuses shall also be provided.

1.5.10. AMF panel shall have facility for adjustment of speed and voltage including fine adjustments in remote as well as in local mode.

Following shall also be provided in AMF panel:
a) Frequency meter

b) 3 Nos. single phase CT's for metering

c) 3 Nos. (Provided by LT swgr manufacturer) single phase CT's with KPV 300V & RCT 0.25 ohm for differential protection of DG Set on neutral side only for 160 kVA/100kVA.
d) One (1) DC Ammeter (0-40A)

e) One (1) DC Voltmeter (0-30V)

f) One (1) Voltmeter Selector switch

g) One (1) AC Ammeter

h) One (1) AC Voltmeter

i) Three (3) Timers (24V DC)

j) Two (2) Auto/Manual Selector Switch

k) Two (2) Auto/test/Manual Selector Switch

l) Eleven (11) Aux. Contactors suitable for 24V DC

m) One (1) Motorised potentiometer for voltage adjustment

n) Two (2) Set Battery charger as specified in Technical Specification

o) One (1) Set Phase & Neutral busbars.

p) Any other item required for completion of Control scheme shall be deemed to be included.

1.6. D.G. SET ENCLOSURE

1.6.1. General requirements

1.6.1.1. Diesel engine, alternator, AMF panel, Batteries and Chargers shall be installed outdoor in a suitable weather-proof enclosure which shall be provided for protection from rain, sun, dust etc. Further, in addition to the weather proofing, acoustic enclosures shall also be provided such that the noise level of acoustic enclosure DG set shall meet the requirement of MOEF the diesel generator sets should also conform to Nepal Environment (Protection) Rules. An exhaust fan with louvers shall be installed in the enclosure for temperature control inside the enclosure. The enclosure shall allow sufficient ventilation to the enclosed D.G. Set so that the body temperature is limit to 50°C. The air flow of the exhaust fan shall be from inside to the outside the shelter. The exhaust fan shall be powered from the DG set supply output so that it starts with the starting of the DG set and stops with the stopping of the DG set. The enclosure shall have suitable viewing glass to view the local parameters on the engine.

1.6.1.2. Fresh air intake for the Engine shall be available abundantly; without making the Engine to gasp for air intake. A chicken mess shall be provided for air inlet at suitable location in enclosure which shall be finalised during detailed engineering.

1.6.1.3. The Enclosure shall be designed and the layout of the equipment inside it shall be such that there is easy access to all the serviceable parts.

1.6.1.4. Engine and Alternator used inside the Enclosure shall carry their manufacturer's Warranty for their respective Models and this shall not degrade their performance.

1.6.1.5. Exhaust from the Engine shall be let off through Silencer arrangement to keep the noise level within desired limits. Interconnection between silencer and engine should be through stainless steel flexible hose/ pipe.

1.6.2. All the Controls for Operation of the D.G. Set shall be easily assessable. There should be provision for emergency shut down from outside the enclosure.

1.6.3. Arrangement shall be made for housing the Battery set in a tray inside the Enclosure.

1.6.4. CONSTRUCTION FEATURES:

1.6.4.1. The enclosure shall be fabricated from at least 14 Gauge CRCA sheet steel and of Modular construction for easy assembling and dismantling. The sheet metal components shall be pre-treated by Seven Tank Process and Powder coated (PURO Polyester based) both-in side and out side – for long life. The hard-ware and accessories shall be high tensile grade. Enclosure shall be given a lasting anti-rust treatment and finished with pleasant environment friendly paint. All the hardware and fixtures shall be rust proof and able to withstand the weather conditions.

1.6.4.2. Doors shall be large sized for easy access and provided with long lasting gasket to make the enclosure sound proof. All the door handles shall be lockable type.

1.6.4.3. The Enclosure shall be provided with anti-vibration pads (suitable for the loads and vibration they are required to carry) with minimum vibration transmitted to the surface the set is resting on.

1.6.4.4. High quality rock wool of required density and thickness shall be used with fire retardant thermo – setting resin to make the Enclosure sound proof.

1.6.5. Provision for Neutral/Body Earthing

1.6.5.1. Points shall be available at two side of the enclosure with the help of flexible copper wires from alternator neutral, and electrical panel body respectively. The earthing point shall be isolated through insulator mounted on enclosure.

1.7. INSTALLATION ARRANGEMENT

1.7.1. DG set enclosed in enclosure shall be installed on Concrete Pedestal 300mm above FGL.

1.8. DOCUMENTS

1.8.1. Following drawings and data sheet shall be submitted for approval:

(i) Data sheet for Engine, Alternator, Battery, AMF panel and Enclosure
(ii) GA drawing of DG set
(iii) Layout of DG set in the enclosure along with sections
(iv) GA and schematic of AMF panel
(v) Arrangement of inclined roof and pedestal.

1.8.2. The D G Set shall be supplied with

(i) D G Set test certificate
(ii) Engine Operation & maintenance Manual.
(iii) Engine Parts Catalogue.
(iv) Alternator Operation, maintenance & Spare parts Manual.
(v) Alternator test certificate.

1.9. TESTS

a) The Diesel generator sets shall be tested for routine and acceptance tests as per the relevant IEC standards.

1.10. COMMISSIONING CHECKS

In addition to the checks and test recommended by the manufacturer, the Contractor shall carryout the following commissioning tests to be carried out at site.

1. Load Test

The engine shall be given test run for a period of atleast 6 hours. The set shall be subjected to the maximum achievable load as decided by Purchaser without exceeding the specified DG Set rating:

During the load test, half hourly records of the following shall be taken:

a) Ambient temperature.
b) Exhaust temperature if exhaust thermometer is fitted.
c) Cooling water temperature at a convenient point adjacent to the water output from the engine jacket.
d) Lubricating oil temperature where oil cooler fitted.
e) Lubricating oil pressure.
f) Colour of exhaust gas
g) Speed
h) Voltage, wattage and current output.
i) Oil tank level

The necessary load to carryout the test shall be provided by the purchaser.

2. Insulation Resistance Test for Alternator

Insulation resistance in mega-ohms between the coils and the frame of the alternator when tested with a 500V megger shall not be less than IR=2 x (rated voltage in KV) +1

3. Check of Fuel Consumption

   A check of the fuel consumption shall be made during the load run test. This test shall be conducted for the purpose of proper tuning of the engine.

4. Insulation Resistance of Wiring

   Insulation resistance of control panel wiring shall be checked by 500V Megger. The IR shall not be less than one mega ohm.

5. Functional Tests

   a) Functional tests on control panel.
   b) Functional test on starting provision on the engine.
   c) Functional tests on all Field devices.
   d) Functional tests on AVR and speed governor.

6. Measurement of Vibration

   The vibration shall be measured at load as close to maximum achievable load and shall not exceed 250microns.

7. Noise Level shall be less than 75 dBA at a distance of one meter.

8. The tests shall be carried out with the DG set operating at rated speed and at maximum achievable load. Necessary correction for Test environment condition & background noise will be applied as per applicable IEC/International Standards.

SECTION 15: SWITCHYARD ERECTION

Table of contents

1.0 GENERAL

The detailed scope of work includes design, engineering, manufacture, testing at works, supply on FOR destination site basis, insurance, handling, storage, erection testing and commissioning of various items and works as detailed herein.

This Chapter covers the description of the following items.

A. Supply of

- String insulators and hardware
- AAC / ACSR conductor
- Galvanised Steel Earthwire
- Aluminium Tubular Bus Bars
- Spacers
- Bus post insulators
- Earthing & Earthing materials
- Lightning protection materials
- Cabling material
- Other items

B. Erection Of all items

1.1 String Insulators & Hardware

The insulators for suspension and tension strings shall conform to IEC-60383 and long rod insulators shall conform to IEC-60433. Insulator hardware shall conform to equivalent international standard. Composite long rod insulator shall conform to IEC: 61109.

1.1.1 Construction Features

1.1.1.1 For porcelain insulators

a) Suspension and tension insulators shall be wet process porcelain with ball and socket connection. Insulators shall be interchangeable and shall be suitable for forming either suspension or tension strings. Each insulator shall have rated strength markings on porcelain printed and applied before firing.

b) Porcelain used in insulator manufacture shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

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

1.1.1.2 For glass insulators

It shall be made of toughened glass. Glass used for the shells shall be sound, free from defects, flows bubbles, inclusions e.t.c and be of uniform toughness over its entire surface. All exposed glass surfaces shall be smooth.

1.1.1.3 When operating at normal rated voltage there shall be no electric discharge between conductor and insulator which would cause corrosion or injury to conductors or insulators by the formation of substances due to chemical action. No radio interference shall be caused when operating at normal rated voltage.

1.1.1.4 The design of the insulator shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. All ferrous parts shall be hot dip galvanized. The zinc used for galvanizing shall be of grade Zn-99.95. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains bulky white deposits and blisters.

1.1.1.5 Bidder shall make available data on all the essential features of design including the method of assembly of discs and metal parts, number of discs per insulator string insulators, the manner in which mechanical stresses are transmitted through discs to adjacent parts, provision for meeting expansion stresses, results of corona and thermal shock tests, recommended working strength and any special design or arrangement employed to increase life under service conditions.

1.1.1.6 Clamps for insulator strings and Corona Control rings shall be of aluminium alloy as stipulated for clamps and connectors.

1.1.1.7 Insulator hardware shall be of forged steel. Malleable cast iron shall not be accepted except for insulator disc cap. The surface of hardware must be clean, smooth, without cuts, abrasion or projections. No part shall be subjected to excessive localized pressure. The metal parts shall not produce any noise generating corona under operating conditions.

1.1.1.8 The tension Insulator hardware assembly shall be designed for minimum 12000 kg tensile load for below 765kV. Earth wire tension clamp shall be designed for minimum 1000 kg tensile load with a factor of safety of two (2).

1.1.1.9 The tension string assemblies shall be supplied alongwith suitable turn buckle. Sag compensation springs if required may also be provided.

1.1.1.10 All hardware shall be bolted type.

1.2 Long Rod Porcelain Insulators

1.2.1 As an alternative to disc insulator, Bidder can offer long rod porcelain insulators strings, with suitable hardware. The combination should be suitable for application specified and should offer the identical/equivalent parameters as would be available from insulator string comprising disc insulators and hardware combination.

1.2.2 All constructional features specified at Clause 1.1.1 of this Chapter shall also apply to the long rod insulator string.

1.3 **Tests**

In accordance with the stipulations of the specification, the suspension and tension strings, insulator and hardware shall be subjected to the following type tests, acceptance tests and routine tests:

1.3.1 **Type Tests on Insulator Strings:** The test reports for following type tests shall be submitted for approval as per clause 9.0 of Chapter 2 - GTR.

a) Power frequency voltage withstand test with corona control rings under wet condition as per IEC- 60383.

b) Lightning Impulse voltage withstand test with corona control rings under dry condition as per IEC-60383

c) Voltage distribution test (Dry)

The voltage across each insulator unit shall be measured by sphere gap method. The result obtained shall be converted into percentage. The voltage across any disc shall not exceed 13% for 220KV suspension and tension insulator strings, 20% and 22% for 132KV suspension and tension insulator strings respectively.

e) Corona Extinction Voltage test (Dry): - (As per Annexure – C)

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 156kV (rms) for 220kV line to ground under dry condition. There shall be no evidence of Corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC 60383.

f) RIV Test (Dry)

Under the conditions as specified under (e) above the insulator string along with complete hardware fittings shall have a radio interference voltage level below 1000 microvolts at 1 MHz when subjected to 50 Hz AC line to ground voltage of 156kV for 220kV string under dry conditions. The test procedure shall be in accordance with IEC 60437.

g) Mechanical strength test

The complete insulator string along with its hardware fitting excluding arcing horn, corona control ring, grading ring, tension/suspension clamps shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to dismantle them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.3.2 **Type Tests on Insulators**

Type test report for Thermal Mechanical Performance tests as per IEC - 60575, Clause 3 / IEC: 61109, clause 5.1 (for composite long rod insulators) shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

1.3.3 **Acceptance Tests for Insulators:**

a) Visual examination as per IEC-60383/ IEC-61109 clause no. 7.2 (for composite long rod insulators).

b) Verification of Dimensions as per IEC- 60383.

c) Temperature cycle test as per IEC- 60383.

d) Puncture Test as per IEC-60383 (Applicable only for porcelain insulators).

e) Galvanizing Test as per IEC- 60383.

f) Mechanical performance test as per IEC-60575 Cl. 4 / IEC-61109 clause no. 7.2 (for composite long rod insulators).

g) Test on locking device for ball and socket coupling as per IEC-60372(2).

h) Porosity test as per IEC- 60383 (Applicable only for porcelain insulators).

i) Thermal shock test as per IEC-60383 (Applicable only for glass insulators)

1.3.4 **Acceptance Test on Hardware Fitting**

a) Visual Examination as per Cl. 5.10 of IS: 2486 (Part-I).

b) Verification of Dimensions as per Cl. 5.8 of IS: 2486 (Part-I)

c) Galvanising/Electroplating tests as per Cl. 5.9 of IS: 2486 (Part-I).

d) Slip strength test as per Cl 5.4 of IS-2486 (part-I)

e) Shore hardness test for the Elastometer (if applicable as per the value guaranteed by the Bidder).

f) Mechanical strength test for each component (including corona control rings and arcing horns). The load shall be so applied that the component is stressed in the same way as it would be in actual service and the procedure as given in 1.2.13.1 (g) above should be followed.

g) Test on locking devices for ball and socket coupling as per IEC -60372(2).

1.3.5 **Routine Test on Insulator**

a) Visual Inspection as per IEC-60383

b) Mechanical Routine Test as per IEC-60383

c) Electrical Routine Test as per IEC-60383

1.3.6 **Routine Test on hardware Fittings**

a) Visual examination as per IEC-61109 (for composite long rod insulators).

b) Mechanical strength Test as per IEC-61109 (for composite long rod insulators).

1.3.7 **Test during manufacture on all Components as applicable on insulator**

a) Chemical analysis of zinc used for galvanising:

Samples taken from the zinc ingot shall be chemically analyzed. The purity of zinc shall not be less than 99.95%.

b) Chemical Analysis, mechanical hardness tests and magnetic particle inspection for malleable casting:

The chemical analysis, hardness tests and magnetic particle inspection for malleable casting will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding tests will be as discussed and mutually agreed to by the Contractor and Owner in Quality Assurance Program.

1.3.8 Test during manufacture on all components as applicable on hardware fittings:

a) Chemical analysis of zinc used for galvanising:

Samples taken from the zinc ingot shall be chemically analyzed. The purity of zinc shall not be less than 99.95%

b) Chemical analysis, hardness tests and magnetic particle for forgings:

The chemical analysis, hardness tests and magnetic particle inspection for forgings will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding tests will be as discussed and mutually agreed to by the Contractor and Owner in Quality Assurance Programme.

c) Chemical analysis and mechanical hardness tests and magnetic particle inspection for fabricated hardware:

The chemical analysis, hardness tests and magnetic particle inspection for fabricated hardware will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding tests will be as discussed and mutually agreed to by the Contractor and Owner in Quality Assurance programme.

1.4 Parameters

1.4.1 Disc Insulators

Sl. No.	Description	For 220/132kV
a)	Type of insulators	Anti-Fog type
b)	Size of insulator units (mm)	255x145 or 280x145
c)	Electro mechanical strength	120 kN
d)	Creepage distance of individual insulator units (minimum and as required to meet total creepage distance)	430 mm
e)	Markings	
i)	For Porcelain insulators	Markings on porcelain
ii)	For toughened glass insulators	Markings shall be done on initial parts
f)	Power frequency puncture withstand voltage	1.3 times the actual wet flashover voltage

1.4.2 INSULATOR STRING

Sl. No.	Description	220kV	132kV
a)	Power frequency withstand voltage of the complete string with corona control ring (wet) – KV rms	460	275
b)	Lightning impulse withstand Voltage of string with corona control rings (dry) - kVp	± 1050	± 650
c)	Switching surge withstand voltage of string with corona control rings (wet) - kVp	NA	NA
d)	Minimum corona extinction voltage level of string with Corona Control rings (dry) - kV rms	156	NA
e)	Maximum RIV level in micro volts of string with Corona Control rings at 508 kV (rms) for 765 kV, 320 kV (rms) for 400 kV string and 156 kV for 220 kV string across300 Ohms resistor at 1 MHz	1000	NA

f)	Minimum total creepage distance of the insulator string (mm)	6125	3625
g)	Total no. of discs per strings	15	10

For tension application, double insulator strings for 220 KV and single insulator strings for 132 kV system shall be used. For suspension purpose single suspension insulator string shall be used for 220 KV & 132 kV system.

1.4.2.1 **INSULATOR STRING (33 KV)**

a) Power frequency withstand voltage of the complete string with Corona Control ring (wet) - kV rms : 75

b) Lightning impulse withstand Voltage of string with corona control rings (dry) – kVp : ±170

c) Power frequency puncture with-stand voltage for a string insulator : 1.3 times actual wet flashover voltage of the unit

d) Total creepage distance of the complete insulator string (mm) : 900

f) Total no. of discs per strings : 5 (S/T & S/S)

1.5 ***COMPOSITE LONG ROD INSULATOR***

As an alternative to disc insulator/long rod porcelain, Bidder can also offer composite long rod insulators with suitable hardware.

1.5.1 ***Details of Composite Long Rod Insulators***

1.5.1.1 Contractor shall offer such composite insulators which have proven use under foggy/ humid operational conditions in polluted industrial environment combined with smoke and dust particles. The Bidder shall furnish evidence in the form of certification from the power utilities that the similar type of product supplied to them had been performing satisfactorily. The Bidder shall also submit certified test report for an accelerated ageing test of 5000 hours such as that described in Appendix-C of IEC-61109 or test at multiple stresses of 5000 hrs as described in annexure –B of IEC-62217.

1.5.1.2 Insulators shall have sheds of the “open aerodynamic profile without any under ribs” with good self-cleaning properties. Insulator shed profile, spacing projection etc. shall be strictly in accordance with the recommendation of IEC-60815.

1.5.2 Ball and socket shall be 20 mm designation for 120 kN & 24mm designation for 210 kN Insulators in accordance with the standard dimensions stated in IEC: 60120. Insulators shall be interchangeable and shall be suitable for forming either suspension or tension strings. Each insulator shall have rated strength markings on each composite insulator rod unit. No negative tolerance shall be applicable to creepage distance of composite insulators

1.5.3 All ferrous parts shall be hot dip galvanized to give a minimum average coating of zinc equivalent to 610 gm/sq.m. and shall be in accordance with the latest edition of equivalent International standard. The zinc used for galvanizing shall be of purity of 99.95%. The zinc coating shall be uniform, adherent, smooth, reasonably bright continuous and free from imperfections such as flux, ash rust stains, bulky white deposits and blisters. The galvanized metal parts shall be guaranteed to withstand at least six successive dips each lasting for one (1) minute duration under the standard preece test. The galvanizing shall be carried out only after any machining.

1.5.4 ***Materials***

1.5.4.1 ***Core***

It shall be a glass-fiber reinforced (FRP rod) epoxy resin rod of high strength. The rod shall be resistant to hydrolysis. Glass fibers and resin shall be optimized. The rod shall be electrical grade corrosion resistant (ECR), boron free glass and shall exhibit both high electrical integrity and high resistance to acid corrosion.

1.5.4.2 **Housing & Weathersheds**

The FRP rod shall be covered by a sheath of a silicone rubber compound of a thickness of minimum 3mm. The housing & weathersheds should have silicon content of minimum 30% by weight. It should protect the FRP rod against environmental influences, external pollution and humidity. It shall be extruded or directly molded on the core. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core.

The weathersheds of the insulators shall be of alternate shed profile. The weathersheds shall be vulcanized to the sheath (extrusion process) or molded as part of the sheath (injection moulding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection moulding shall be at high temperature & high pressure. Any seams/ burrs protruding axially along the insulator, resulting from the injection moulding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to IEC60587. The strength of the weathershed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

1.5.4.3 **End Fittings**

End fittings transmit the mechanical load to the core. They shall be made of malleable cast iron/ spheroidal graphite or forged steel. They shall be connected to the rod by means of a controlled compression technique. The manufacturer shall have in-process Acoustic emission arrangement or some other arrangement to ensure that there is no damage to the core during crimping. This verification shall be in-process and done on each insulator. The system of attachment of end fitting to the rod shall provide superior sealing performance between housing and metal connection. The gap between fitting and sheath shall be sealed by a flexible silicone rubber compound. The sealing shall stick to both housing and metal end fitting. The sealing must be humidity proof and durable with time.

End fittings shall have suitable provisions for fixing grading rings at the correct position as per design requirements.

1.5.4.4 **Grading Rings**

Grading rings shall be used at both ends of each composite insulator unit for reducing the voltage gradient on and within the insulator and to reduce radio and TV noise to acceptable levels. The size and placement of the metallic grading rings shall be designed to eliminate dry band arcing/corona cutting/ exceeding of permissible electrical stress of material.

1.5.2 **Tests and Standards**

1.5.2.1 **Type Tests**

The test reports for following type tests on long rod units, components, materials or complete strings shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

1.5.2.1.1 On the complete composite Long Rod Insulator String with Hardware Fittings: -

a) Power frequency voltage withstand test with corona control rings/grading ring and arcing horns (if provided) under wet condition as per IEC: 60383-1993/

b) Switching surge voltage withstand test under wet condition as per IEC: 60383-1993.

c) Impulse voltage withstand test under dry condition as per IEC: 60383-1993

d) Corona and RIV test under dry condition.

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 156kV (rms) for 220kV line to ground under dry condition. There shall be no evidence of Corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC 60383.

Under the conditions as specified above the insulator string alongwith complete hardware fittings shall have a radio interference voltage level below 1000 microvolts at 1 MHz when subjected to 50 Hz AC line to ground voltage of 156kV for 220kV under dry conditions. The test procedure shall be in accordance with IEC 60437.

e) Mechanical Strength test

The complete insulator string alongwith its hardware fitting excluding arcing horn, corona control ring, grading ring, tension/suspension clamps shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to dismantle them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

f) Salt-fog pollution withstand test as per IEC: 60507. The salinity level for composite long rod insulators shall be 160 Kg/m3 NACL.

1.5.2.1.2 ***On Composite Insulator Units***

a) Tests on interfaces and connections of metal fittings as per IEC: 61109-2008.

b) Assembled core load time test as per IEC: 61109-2008.

c) Damage limit proof test and test of tightness of interface between end firings and insulator housing as per IEC: 61109-2008

d) High Pressure washing test

The washing of a complete insulator of each E&M rating is to be carried out at 3800 kPa with nozzles of 6 mm diameter at a distance of 3m from nozzles to the insulator, The washing shall be carried out for 10minutes. There shall be no damage to the sheath or metal fitting to housing interface.

e) Brittle fracture resistance test

The test arrangement shall be according to Damage limit proof test with simultaneous application of 1N-HNO3 acid directly in contact with naked FRP rod. The contact length of acid shall not be less than 40mm and thickness around the core not less than 10mm.The rod shall withstand 80% of SML for 96 hours.

f) Dye penetration test as per IEC: 61109-2008

g) Water diffusion test as per IEC: 61109-2008

h) Tracking and erosion test as per IEC: 61109-2008.

i) Hardness test as per IEC: 61109-2008.

j) Accelerated weathering test as per IEC: 61109-2008.

k) Flammability test as per IEC: 61109-2008.

l) Silicone content test

Minimum content of silicone as guaranteed by supplier shall be verified through FT-IR spectroscopy & TGA analysis or any other suitable method mutually agreed between Employer & Supplier in Quality Assurance Programme.

m) Recovery of Hydrophobicity test

1. The surface of selected samples shall be cleaned with isopropyl alcohol. Allow the surface to dry and spray with water. Record the HC classification. Dry the sample surface.

2. Treat the surface with corona discharges to destroy the hydrophobicity. This can be done utilizing a high frequency corona tester, Holding the electrode approximately 3mm from the sample surface, slowly move the electrode over an area approximately 1" x 1". Continue treating this area for 2 – 3 minutes, operating the tester at maximum output.

3. Immediately after the corona treatment, spray the surface with water and record the HC classification. The surface should be hydrophilic, with an HC value of 6 or 7. If not, dry the surface and repeat the corona treatment for a longer time until an HC of 6 or 7 is obtained. Dry the sample surface.

4. Allow the sample to recover and repeat the hydrophobicity measurement at several time intervals. Silicone rubber should recover to HC 1 – HC 2 within 24 to 48 hours, depending on the material and the intensity of the corona treatment.

n) Torsion test

Three complete insulators of each E&M rating shall be subjected to a torsional load of 55Nm. The torsional strength test shall be made with test specimen adequately secured to the testing machine. The torsional load shall be applied to the test specimen through a torque member so constructed that the test specimen is not subjected to any cantilever stress. The insulator after torsion test must pass the Dye Penetration Test as per IEC 61109.

o) Accelerated ageing test of 5000hrs as described in appendix-C of IEC 61109 or Test at multiple stresses of 5000 hrs as described in Annex-B of IEC -62217

1.5.2.2 ***Acceptance Tests:***

1.5.2.2.1 ***For Composite Long Rod Insulators***

a.	Verification of dimensions	IEC: 61109-2008
b.	Galvanizing test	IEC: 60383
c.	Verification of end fittings	IEC: 61109-2008
d.	Recovery of Hydrophobicity	As per above

e.	Verification of tightness of interface between end fittings and insulator housing and of specified mechanical load	IEC: 61109-2008
f.	Silicone content test	As per above
g.	Brittle fracture resistance test	As per above
h.	Dye penetration test	IEC: 61109-2008
i.	Water diffusion test	IEC: 61109-2008

In the event of failure of the sample to satisfy the acceptance test(s) specified in 4.2 above, the retest procedure shall be as per IEC 61109.

1.5.2.3 **Routine Tests**

1.5.2.3.1 **For Composite Long Rod Insulator Units**

a)	Visual Examination	As per IEC:61109-2008
b)	Mechanical routine test	As per IEC:61109 -2008

1.5.3 ***Guaranteed Technical Particulars***

1.5.3.1 ***Electrical system Data***

Sl.	**Parameters**	**Unit**	**System Voltage**	
1.	Nominal Voltage	kV	**220**	**132**
2.	Maximum system voltage	kV	245	145
3.	BIL (Impulse)	kV (Peak)	±1050	±650
4.	Power frequency withstand voltage (Wet)	kV (rms)	460	275
5.	Switching surge withstand voltage (Wet)	kV (rms)	NA	NA
6.	Minimum Corona extinction voltage at 50 Hz AC system under dry condition	kV (rms) phase to earth	156	NA
7.	Radio interference voltage at one MHz for phase to earth voltage of 508 KV under dry condition.	Micro Volts	1000 (Max)	NA
8.	Minimum creepage distance.	mm	6125	3625
9.	Electromechanical strength of Insulator Unit.	kN	120	120

2.0 **AAC / ACSR CONDUCTOR**

2.1 **Details of AAC Conductor**

2.1.1 The contractor shall supply the conductor as per the standard guaranteed technical particulars enclosed in Annexure-B of the technical specification, Chapter 12 – Switchyard Erection and separate approval is not required during detailed engineering.

Owner has also standardised the guaranteed technical particulars for the conductors which are enclosed in Annexure-E of the technical specification, Chapter 12 – Switchyard Erection. The contractor shall supply the conductor as per the standard guaranteed technical particulars.

2.1.2 The details of the AAC Bull conductor are tabulated below:

Sl. No.	**Description**	**Unit**	**AAC BULL**
a)	Stranding and wire diameter	mm	61/4.25
b)	Number of Strands		
	1st Aluminium Layer	Nos.	1
	2nd Aluminium Layer	Nos.	6
	3rd Aluminium Layer	Nos.	12
	4th Aluminium Layer	Nos.	18
	5th Aluminium Layer	Nos.	24
c)	Total sectional area	Sq.mm	865.36
d)	Overall diameter	mm	38.25
e)	Approximate weight	kg/ km	2400
f)	Calculated d.c. resistance at 20oC	ohm/km	0.0334
g)	Minimum UTS	kN	139

2.1.3 The details of Aluminium strand are as follows:

Sl. No.	**Description**	**Unit**	**AAC BULL**
a)	Minimum breaking load of strand before stranding	KN	2.23
b)	Minimum breaking load of strand after stranding	KN	2.12
c)	Maximum D.C. resistance of strand at 20 deg. Centigrade	Ohm/KM	3.651

2.2 **Details of ACSR Conductor**

2.2.1 The details of the ACSR Moose conductors shall be as per the standard guaranteed technical particulars enclosed in Annexure-A are tabulated below:

ACSR MOOSE CONDUCTOR:

Sl. No.	Description	Unit	ACSR MOOSE
a)	Stranding and wire diameter	mm	54/3.53 (Al)+ 7/3.53 (Steel)
b)	Number of Strands		
	Steel centre	Nos.	1
	1st Steel Layer	Nos.	6
	1st Aluminium Layer	Nos.	12
	2nd Aluminium Layer	Nos.	18
	3rd Aluminium Layer	Nos.	24
c)	Sectional area of Aluminium	Sq. mm	528.5
d)	Total sectional area	Sq. mm	597.00
e)	Overall diameter	mm	31.77
f)	Approximate weight	kg/ km	2004

g)	Calculated d.c. resistance at 20oC	ohm/ km	0.05552
h)	Minimum UTS	kN	161.2

2.2.2 The details of Aluminium strand are as follows:

ACSR MOOSE CONDUCTOR:

Sl. No.	Description	Unit	ACSR MOOSE
a)	Minimum breaking load of strand before stranding	KN	1.57
b)	Minimum breaking load of strand after stranding	KN	1.49
c)	Maximum D.C. resistance of strand at 20 deg. Centigrade	Ohm/ KM	2.921

2.2.3 The details of steel strand are as follows:

ACSR MOOSE CONDUCTOR:

Sl. No.	**Description**	**Unit**	**ACSR MOOSE**
a)	Minimum breaking load of strand before stranding	KN	12.86
b)	Minimum breaking load of strand after stranding	KN	12.22
c)	Minimum number of twists to be withstood in torsion test when tested on a gauge length of 100 times diameter of wire	Nos.	18 (Before stranding) 16 (Before stranding

2.3 Workmanship

2.3.1 The finished conductor shall be smooth, compact, uniform and free from all imperfections including kinks (protrusion of wires), wire cross over, over riding, looseness (wire being dislocated by finger/hand pressure and/or unusual bangle noise on tapping), material inclusions, white rust, powder formation or black spot (on account of reaction with trapped rain water etc.), dirt, grit etc.

2.3.2 All the Aluminium and steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, diemarks, scratches, abrasions, etc., after drawing.

2.3.3 The steel strands shall be hot dip galvanised and shall have a minimum zinc coating of 260 gms/sq.m. after stranding of the uncoated wire surface. The zinc coating shall be smooth, continuous and of uniform thickness, free from imperfections and shall withstand minimum three dips in standard Preece test. The finished strands and the individual wires shall be of uniform quality and have the same properties and characteristics as prescribed in ASTM designation: B 498-74.

2.3.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands in the event of cutting of composite core wire. Care shall be taken to avoid, damages to galvanisation during pre-forming and post-forming operation.

2.4 Joints in Wires

2.4.1 Aluminium Wires

Joints in aluminium wires shall be as per relevant International standard.

2.4.2 Steel Wires

There shall be no joint of any kind in the finished wire entering into the manufacture of the strand. There shall also be no strand joints or strand splices in any length of the completed stranded steel core of the conductor.

2.5 Tolerances

The manufacturing tolerances shall be as per relevant International standard.

A. AAC Bull and AAC Tarantula conductor:

a)	Diameter of Aluminium and Steel Strands						
		AAC BULL			AAC TARANTULA		
		Standard	Maximum	Minimum	Standard	Maximum	Minimum
	Aluminium	4.25 mm	4.29 mm	4.21 mm	5.23	5.28	5.18

b)	Lay ratio of Conductor					
			AAC BULL		AAC TARANTALA	
			Maximum	Minimum	Maximum	Minimum
	Aluminium	6 wire layers	16	10	16	10
		12 wire layers	16	10	16	10
		18 wire layers	16	10	16	10
		24 wire layers	14	10	-	-

B. ACSR Bersimis and ACSR Moose conductor:

a)	Diameter of Aluminium and Steel Strands						
		ACSR BERSIMIS			ACSR MOOSE		
		Standard	Maximum	Minimum	Standard	Maximum	Minimum
	Aluminium	4.57 mm	4.61 mm	4.53 mm	3.53 mm	3.55 mm	3.51 mm
	Steel	2.54 mm	2.57 mm	2.51 mm	3.53 mm	3.60 mm	3.46 mm

b)	Lay ratio of Conductor					
			ACSR BERSIMIS		ACSR MOOSE	
			Maximum	Minimum		
	Steel	6 wire layers	18	13	18	16
	Aluminium	8/12 wire layer	17	10	14	12
		14/18 wire layer	16	10	13	11
		20/24 wire layer	14	10	12	10

2.6 Materials

2.6.1 Aluminium

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity not less than 99.5% and a copper content not exceeding 0.04%.

2.6.2 Steel

The steel wire strands shall be drawn from high carbon steel wire rods and shall conform to the following chemical composition:

Element	% Composition
Carbon	0.50 to 0.85
Manganese	0.50 to 1.10
Phosphorous	Not more than 0.035

Sulphur	Not more than 0.045
Silicon	0.10 to 0.35

2.6.3 **Zinc**

The zinc used for galvanising shall be electrolytic High Grade Zinc of 99.95% purity.

2.7 **Standard Length**

2.7.1 The conductor shall be supplied as required. No joint shall be allowed within a single span of stringing, jumpers and equipment interconnection.

2.8 Tests:

2.8.1 The following type, acceptance & routine tests and tests during manufacturing shall be carried out on the conductor.

2.8.2 **Type Tests**

In accordance with the stipulation of specification, the following type tests reports of the conductor shall be submitted for approval as per clause 9.2 of Chapter 2 -GTR.

a) UTS test on stranded conductor.

b) Corona extinction voltage test (dry)

(c) Radio Interference voltage test (dry)

(d) DC resistance test on stranded conductor

2.8.3 **Acceptance Tests**

a) Visual check for joints, Scratches etc. and lengths of conductor

b) Dimensional check on Steel and aluminium strands

c) Check for lay ratios of various layers

d) Galvanising test on steel strands

e) Torsion and Elongation test on steel strands

f) Breaking load test on steel and aluminium strands

g) Wrap test on steel and aluminium strands

h) DC resistance test on aluminium strands

i) UTS test on welded joint of aluminium strands

NOTE:

All the above tests except test mentioned at (a) shall be carried out on aluminium and steel strands after stranding only.

2.8.4 **Routine Tests**

a) Check to ensure that the joints are as per specification.

b) Check that there are no cuts, fins etc. on the strands.

c) All acceptance test as mentioned in Clause 2.7.3 above to be carried out on

each coil.

2.8.5 **Tests During Manufacture**

a) Chemical analysis of zinc used for galvanising

b) Chemical analysis of aluminium used for making aluminium strands

c) Chemical analysis of steel used for making steel strands

2.8.6 **Sample Batch for Type Testing**

The Contractor shall offer material for selection of samples for type testing, only after getting quality assurance plans approved from Owner's Quality Assurance Department. The sample shall be manufactured strictly in accordance with the Quality Assurance Plan approved by Owner.

3.0 Galvanised Steel Earth wire

3.1 Details of Earth wire

3.1.1 The contractor shall supply the earthwire as per the standard guaranteed technical particulars enclosed in Annexure-E of the technical specification, Chapter 12 – Switchyard Erection and separate approval is not required during detailed engineering.

Owner has also standardised the guaranteed technical particulars for the earthwire which are enclosed in Annexure-E of the technical specification, Chapter 15 – Switchyard Erection. The contractor shall supply the earthwire as per the standard guaranteed technical particulars.

3.1.2 The basic details of the earth wire are tabulated below:

Sl.No.	Description	Unit	Value
1.	Stranding & Wire diameter	mm	7/3.66 (steel)
2.	Strands a) Steel Core b) Outer layer	 No. No.	 1 (one) 6 (six)
3.	Total sectional area	Sq. mm.	73.65

Other technical details are furnished in of Annexure -E of this Specification.

3.2 Workmanship

3.2.1 All steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions and kinks after drawing and also after stranding.

3.2.2 The finished material shall have minimum brittleness as it will be subjected to appreciable vibration while in use.

3.2.3 The steel strands shall be hot dip qalvanised (and shall have minimum Zinc coating of 275 gms/sq.m) after stranding of the uncoated wire surface. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections and shall withstand three and a half dips after stranding in standard Preece test. The steel wire rod shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands shall be of uniform quality and have the same properties and characteristics as prescribed in ASTM designation B498-74.

3.2.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands while cutting of composite earth wire. Care shall be taken to avoid damage to galvanisation during preforming and postforming operation.

3.2.5 To avoid susceptibility towards wet storage stains (white rust), the finished material shall be provided with a protective coating of boiled linseed oil.

3.3 Joints in Wires

There shall be no joint of any kind in the finished steel wire strand entering into the manufacture of the earth wire. There shall be no strand joints or strand splices in any length of the completed stranded earth wire.

3.4 Tolerances

The manufacturing tolerance to the extent of the following limits only shall be permitted in the diameter of the individual steel strands and lay length of the earth wire:

	Standard	Maximum	Minimum
Diameter	3.66 mm	3.75 mm	3.57 mm
Lay length	181 mm	198 mm	165 mm

3.5 **Materials**

3.5.1 Steel

The steel wire strands shall be drawn from high carbon steel rods and shall conform to the following requirements as to the chemical composition.

Element	% Composition
Carbon	Not more than 0.55
Manganese	0.4 to 0.9
Phosphorous	Not more than 0.04
Sulphur	Not more than 0.04
Silicon	0.15 to 0.35

3.5.2 Zinc

The zinc used for galvanising shall be electrolytic High Grade Zinc of 99.95% purity. It shall conform to and satisfy all the requirements of IS: 209 -1979/ Equivqlent BS standard.

3.6 Standard Length

3.6.1 The earth wire shall be supplied in standard drum length of manufacturer.

3.8 **TESTS**

3.8.1 The following type, routine & acceptance tests and tests during manufacturing shall be carried out on the earthwire.

3.8.2 **TYPE TESTS**

In accordance with the stipulation of specification, the following type tests reports of the earthwire shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

a) UTS test

b) DC resistance test

3.8.3 **ACCEPTANCE TESTS**

a) Visual check for joints, scratches etc. and length of Earthwire

b) Dimensional check

c) Galvanising test

d) Lay length check

e) Torsion test

f) Elongation test

g) Wrap test

h) DC resistance test

i) Breaking load test

j) Chemical Analysis of steel

3.8.4 **ROUTINE TESTS**

a) Check that there are no cuts, fins etc. on the strands.

b) Check for correctness of stranding.

3.8.5 **TESTS DURING MANUFACTURE**

a) Chemical analysis of zinc used for galvanising

b) Chemical analysis of steel

3.8.6 **SAMPLE BATCH FOR TYPE TESTING**

The Contractor shall offer material for sample selection for type testing, only after getting quality assurance programme approved by the Owner. The samples for type testing shall be manufactured strictly in accordance with the Quality Assurance Programme approved by the Owner.

4.0 **TUBULAR BUS CONDUCTORS**

4.1 **General**

The contractor shall supply the aluminium tubes as per the standard guaranteed technical particulars enclosed in Annexure- E of the technical specification, Chapter 12 – Switchyard Erection and separate approval is not required during Detailed Engineering.

Owner has also stardardised the guaranteed technical particulars for the aluminium tube which are enclosed in Annexure- E of the technical specification, Chapter 12 – Switchyard Erection. The contractor shall supply the aluminium tube as per the standard guaranteed technical particulars.

4.2 **Constructional Features**

4.2.1 For outside diameter (OD) & thickness of the tube there shall be no minus tolerance, other requirements being as per relevant International standard.

4.2.2 The aluminium tube shall be supplied in suitable cut length to minimize wastage.

4.2.3 The welding of aluminium tube shall be done by the qualified welders duly approved by the owner.

4.3 **Tests**

In accordance with stipulations of the specification, Routine tests shall be conducted on tubular bus conductors. Also, the wall thickness and ovality of the tube shall be

measured. In addition to the above tests, 0.2% proof tests on both parent metal and Aluminium tube after welding shall be conducted.

4.4 **Technical Parameters**

Sl. No.	Description	4" AL. TUBE
1.	Size	4" IPS (EH Type)
2.	Outer diameter	114.2 mm
3.	Thickness	8.51 mm
4.	Cross-sectional area	2825.61 sq.mm
5.	Weight	7.7 kg/m

5.0 **EARTHING CONDUCTORS**

5.0 **General**

The grounding grid shall consist of copper flat conductor cable or stranded copper wire of minimum size (cross sectional area) 160sq. mm. The ground electrodes shall be 16 mm diameter and 3.0 meter long (min.) copper clad steel. The risers shall consist of copper conductor of adequate size (but not less than 160 sq. mm.)

6.0 **SPACERS**

6.1 **General**

The spacers are to be located at a suitable spacing to limit the short circuit forces as per IEC -60865. Wherever Employer's 220kV & 132kV standard gantry structures are being used, the spacer span(s) for different conductor / span configurations and corresponding short circuit forces shall be as per Annexure-D. For strung buses, flexible type spacers shall be used whereas for jumpers and other connections rigid type spacers shall be used.

Wherever Employer's 220kV & 132kV standard gantry structures are not being used, necessary spacer span calculation shall be provided by the contractor during detailed engineering for the approval of Employer.

6.2 **Constructional Features**

6.2.1 No magnetic material shall be used in the fabrication of spacers except for GI bolts and nuts.

6.2.2 Spacer design shall be made to take care of fixing and removing during installation and maintenance.

6.2.3 The design of the spacers shall be such that the conductor does not come in contact with any sharp edge.

6.3 **Tests**

Each type of spacers shall be subjected to the following type tests, acceptance tests and routine tests:

6.3.1 Type Tests: Following type test reports shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

a) **Clamp slip tests**

The sample shall be installed on test span of twin conductor bundle string or quadruple conductor bundle string (as applicable) at a tension of 44.2 kN. One of the clamps of the sample when subjected to a longitudinal pull of 2.5

kN parallel to the axis of the conductor shall not slip on the conductor. The permanent displacement between the conductor and the clamp of sample measured after removal of the load shall not exceed 1.0 mm. Similar tests shall be performed on the other clamps of the same sample.

b) Fault current test.

c) Corona Extinction Voltage Test (Dry).

This test shall be performed on 220 kV equipment as per procedure mentioned at Annexure - C, Minimum Corona Extinction voltage shall be 156 kV (rms) line to ground for 220 kV spacers.

d) RIV Test (Dry)

This test shall be performed as per procedure mentioned at Annexure - C, Maximum RIV level at 156 kV (rms) line to ground for 220 kV spacers shall be 1000 micro volts, across 300 ohm resistor at 1 MHz

e) Resilience test (if applicable)

f) Tension Test

g) Log decremant test (if applicable)

h) Compression test

i) Galvanising test

6.3.2 **Acceptance Test**

a) Visual examination

b) Dimensional verification

c) Movement test

d) Clamp slip test

e) Clamp bolt torque test (if applicable)

f) Assembly torque test

g) Compression test

h) Tension test

i) Galvanising test

j) Hardness test for neoprene (if applicable)

The shore hardness of different points on the elastometer surface of cushion grip clamp shall be measured by shore hardness meter. It shall be between 65 and 80.

k) Ultimate Tensile Strength Test

The UTS of the retaining rods shall be measured. It shall not be less than 35 kg/Sq. mm.

6.3.3 **Routine test**

a) Visual examination

b) Dimensional verification

7.0 **BUS POST INSULATORS**

The post insulators shall conform in general to latest IEC-60168, IEC 60273 and IEC-60815.

7.1 **Constructional Features**

7.1.1 Post type insulators shall consist of a porcelain part permanently secured in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand any shocks to which they may be subjected to by the operation of the associated equipment. Only solid core insulators will be acceptable.

7.1.2 Porcelain used shall be homogeneous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

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

7.1.4 The insulator shall have alternate long and short sheds with aerodynamic profile. The shed profile shall also meet the requirements of IEC-60815 for the specified pollution level.

7.1.5 When operating at normal rated voltage there shall be no electric discharge between conductor and insulators which would cause corrosion or injury to conductors or insulators by the formation of substance produced by chemical action.

7.1.6 The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.

7.1.7 All ferrous parts shall be hot dip galvanized. The zinc used for galvanizing shall be grade Zn 99.95. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux ash, rust stains, bulky white deposits and blisters. The metal parts shall not produce any noise generating corona under the operating conditions.

7.1.8 a) Every bolt shall be provided with a steel washer under the nut so that part of the threaded portion of the bolts is within the thickness of the parts bolted together.

b) Flat washer shall be circular of a diameter 2.5 times that of bolt and of suitable thickness. Where bolt heads/nuts bear upon the beveled surfaces they shall be provided with square tapered washers of suitable thickness to afford a seating square with the axis of the bolt.

c) All bolts and nuts shall be of steel with well-formed hexagonal heads forged from the solid and shall be hot dip galvanized. The nuts shall be good fit on the bolts and two clear threads shall show through the nut when it has been finally tightened up.

7.1.9 Bidder shall make available data on all the essential features of design including the method of assembly of shells and metals parts, number of shells per insulator, the manner in which mechanical stresses are transmitted through shells to adjacent parts, provision for meeting expansion stresses, results of corona and thermal shock tests, recommended working strength and any special design or arrangement employed to increase life under service conditions.

7.2 **Tests**

In accordance with the stipulations of the specification, the post insulators shall be

subject to type, acceptance, sample and routine tests as per IEC-60168.

7.2.1 In addition to acceptance/sample/routine tests as per IEC-60168, the following tests shall also be carried out.

a) Ultrasonic test as an acceptance test

b) Soundness test, metallurgical tests and magnetic test on MCI caps and pedestal tests as acceptance test.

c) All hot dip galvanized components shall be subject to check for uniformity of thickness and weight of zinc coating on sample basis.

d) The bending test shall be carried out at 50% minimum failing load in four directions as a routine test and at 100% minimum failing load in four directions as an acceptance test.

e) Acceptance norms for visual defects allowed at site and also at works shall be agreed in the Quality plan.

7.2.2 In accordance with the stipulation of specification, the following type tests reports of the post insulators shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

a) Power frequency withstand test (dry & wet)

b) Lightning impulse test (dry)

c) Measurement of R.I.V (Dry)

d) Corona extinction voltage test (Dry)

.

e) Test for deflection under load

f) Test for mechanical strength.

7.3 **Technical Parameters of Bus Post Insulators.**

Sl. No.	Description	245 kV	145 kV
a)	Type	Solid Core	Solid Core
b)	Voltage Class (kV)	245	145
c)	Dry and wet one minute power frequency withstand voltage (kV rms)	460	275
d)	Dry lightning impulse withstand Voltage (kVp)	± 1050	±650
e)	Wet switching surge withstand voltage (kVp)	—-	—-
f)	Max. radio interference voltage (in microvolts) at voltage of 508 kV (rms), 305 kV (rms) and 156 (rms) for 765 kV, 400 kV &220 kV respectively between phase to ground.	500	500
g)	Corona extinction voltage (kV rms) (min.)	156	105
h)	***Cantilever Strength***		
(i)	Total minimum cantilever strength (Kg)	800	600
(ii)	***Total minimum breaking strength (Kg)***	***1000***	***720***
i)	Minimum torsional moment	As per IEC-273	As per IEC-273
j)	Total height of insulator (mm)	2300	
k)	P.C.D Top (mm)	127	***127***
	Bottom (mm)	254	***254***
l)	No. of bolts		
	Top	4	***4***
	Bottom	8	***8***

m)	Diameter of bolt/holes (mm)		
	Top	M16	***M16***
	Bottom dia.	18	***18***
n)	Pollution level as per IEC-815	Heavy (III)	Heavy (III)
o)	Minimum total creepage distance for Heavy Pollution (mm)	6125	3165

7.3.1 33kV Bus Post Insulators.

a)	Type	Solid Core
b)	Voltage class (kV)	36
c)	Dry and wet one minute power frequency withstand voltage (kV rms)	70
d)	Dry lightning impulse withstand Voltage (kVp)	±170
e)	Total minimum cantilever strength (Kg)	450
f)	Minimum torsional moment	As per IEC-273
g)	Total height of insulator (mm)	As per requirement
h)	Pollution level as per IEC-815	Heavy (III)
i)	Minimum creepage distance for Heavy Pollution (mm)	900

7.3.2 If corona extinction voltage is to be achieved with the help of corona ring or any other similar device, the same shall be deemed to be included in the scope of the Contractor. Material of Corona ring shall be aluminium/ aluminium alloy of 63401W grade or equivalent.

8.0 GROUNDING SYSTEM

8.1 GENERAL

This specification covers the design, supply, delivery, installation and testing of the complete grounding system as described below.
The complete station grounding work shall be in accordance with the recommendation in the "Guide for Safety in Substation Grounding" IEEE No. 80 and the requirements of this section.

8.2 GROUNDING INSTALLATION FEATURES

8.2.1 The installation shall be complete in all respects for efficient and trouble free service. All work shall be carried out in a first class neat workman like manner. Grounding conductors shall be handled carefully to avoid kinking and cutting of the conductors during laying and installation. All exposed ground conductors run shall be taken in a neat manner, horizontal, vertical and parallel to building walls or columns and shall not be laid haphazardly.

8.2.2 For all connections made to equipment or to the structures, the grounding conductor, connectors and equipment enclosures shall have good clean contact surfaces. Grounding conductor connection to all electrical equipment, switchgear, transformers, motors, panels, conduit system, equipment enclosures, cable trays, distribution boards, equipment frames, bases, steel structure, etc. shall be by pressure type or bolting type connectors.

8.2.3 All lap, cross and tee connections between two grounding conductors shall be made

by thermo-welding process or compression type connector. The various joints shall have adequate mechanical strength as well as necessary electrical conductivity not less than that of the parent conductors of the joints. All accessories for grounding installation shall be of quality and design approved by the Employer. The earthing connection between earthing pad of equipment/structures shall be made by two earthing leads.

8.2.4 Ground conductors, when crossing underground trenches, directly laid underground pipe and equipment foundation, if any, shall be at least 300mm below the bottom elevation of such trenches/pipes.

8.2.5 The maximum size of each grid of grounding mat shall not exceed 4X4 meters. The terminals for connecting ground mat and equipment shall be terminated whenever necessary. The new grounding shall be bonded with existing grounding network at the existing Substations.

8.3 GROUNDING CONDUCTOR

8.3.1 Main Ground Grid
The main ground system shall consist of a grounding grid buried minimum 0.6 meter below grade level. The grounding grid shall consist of copper flat conductor cable or stranded copper wire of minimum size (cross sectional area) 160sq. mm.

8.3.2 Ground Electrodes
The ground electrodes shall be 16mm diameter and 3.0 meter long (min.) copper clad steel. These shall be driven into ground and connected to the main ground grid.

8.3.3 Risers
The risers shall consist of copper conductor of adequate size (but not less than 160 sq. mm.) connected at one end to the main ground mat and at the other end to the equipment.

8.4 DESIGN REQUIREMENTS

8.4.1 The Contractor shall measure the soil resistivity in presence of the Employer. Based on the resistivity the contractor shall calculate the total length of buried ground conductor, number of grounding electrode and their depth and spacing to achieve a grounding system resistance of less than 1.0 (One) Ohm.

8.4.2 The Contractor shall calculate the cross-section considering the maximum fault level of 40 kA.

8.4.3 The Contractor shall submit the details of calculations of the grounding system for the Employer's approval. The earthing system shall be of single earthing system for the whole substation i.e. all earthings shall be connected to main earthing grid.

8.5 TESTS

On completion of the installation, either wholly or in sections, it shall be tested in compliance with relevant Code by the Contractor in presence of the Employer. The cost of any test including labor, material and equipment charges shall be borne by the Contractor. If the ground grid resistance cannot be obtained as per his design, then additional grounding conductors shall be buried in the earth, or if necessary, buried in treated soil to obtain the required low ground resistance without any additional cost.

8.6 LIGHTNING PROTECTION

The outdoor equipment of the substation and the substation building shall be protected against lightning. The lightning protection shall be achieved by an overhead lightning shield system of galvanized steel wire of 7/3.35 mm, which shall be connected to the main grounding grid by steel conductor of 7/3.35 mm. Lighting mast with electrode length of 2.5mtr (maximum) may be used in switchyard area for lighting protection as per requirement. The above electrode may be connected to the main

grounding grid by steel conductor of 7/3.35 mm. The design of the lightning protection system shall be subject to the approval of the Employer.

8.7 **DRAWINGS**

After award of the Contract, the Contractor shall furnish the grounding layout drawing with dimensions showing the location of grounding grids, electrodes, test link chambers and risers, backed up by necessary calculations for Employer's approval. The work shall have to be started at site only after getting approval from the Employer. If alteration is required for any work done before getting Employer's approval, the same shall have to be done by the Contractor at no extra cost to the Employer.

STATION GROUNDING SYSTEM

DESCRIPTION	UNIT	REQD
1. Main ground grid conductor material		Copper
2. Main ground grid conductor size	Sq.mm	≥ 160
3. Cross section of riser conductors	Sq mm	≥ 160
4. Ground electrodes		
-Material		Copper clad steel
-Diameter	mm	≥16
-Length	meter	3
5. Material of risers		Copper
6. Earthing system designed for	ohm	≤ 1

9.0 **Main Bus Bars (Applicable for Aluminium tube)**

The brief description of the bus switching scheme, bus bar layout and equipment connection to be adopted are indicated elsewhere in the specification. The bus bar arrangements are shown in drgs enclosed with the bid documents.

9.1 The Contractor shall furnish supporting calculations where applicable for the bus bars/conductors to show adequacy of design parameters for:

a) Fibre-stress

b) Cantilever strength of post insulators

c) Aeolain vibrations

d) Vertical deflection of bus bars

e) Short circuit forces in bundle conductor and spacer location for each span of ACSR conductor stringing as per layout drawings.

9.1.1 The welds in the aluminium tubes shall be kept to the minimum and there shall not be more than one weld per span. The procedure and details of welding shall be subject to Owner’s approval. Material for welding sleeve shall be same as that of Aluminium tube. Welding sleeve shall be of 600mm length

9.1.2 Corona bells shall be provided wherever the bus extends beyond the clamps and on free ends, for sealing the ends of the tubular conductor against rain and moisture and to reduce the electrostatic discharge loss at the end points. There shall be a small drain hole in the corona bell. The material of Corona bell shall be Aluminium alloy similar to that of clamps & connectors.

9.1.3 To minimise the vibrations in the aluminium tubes, damping conductor shall be provided inside the aluminium tubes. For this purpose, the cut pieces of ACSR conductor which otherwise are considered wastages, shall be used as damping

conductor.

9.1.4 Details of past experience of the persons proposed to be employed for Aluminium tube welding and the test reports of the welded pieces to prove the electrical and mechanical characteristics shall also be furnished along with the bid. Welding at site shall be done by adopting a qualified procedure and employing qualified welders as per ASME-Section IX.

10.0 **BAY EQUIPMENT**

10.1 The disposition of various bay equipment shall be as per single line diagrams and layout drawings.

10.2 Bay Marshalling Kiosk: -

One no. of bay marshalling kiosk shall be provided for each 220 kV and 132 kV bay under present scope. In addition to the requirements specified elsewhere in the specification, the bay marshalling kiosk shall have two distinct compartments for the following purpose: -

(i) To receive two incoming 400V, 3 phase, 63Amps, AC supply with auto changeover and MCB unit and distribute minimum six outgoing 400V, 3 phase, 16 Amps AC supplies controlled by MCB.

(ii) To distribute minimum ten outgoing 230V, 10 Amps single phase supplies to be controlled by MCB to be drawn from above 3 phase incomers.

(iii) 200 nos. terminal blocks in vertical formation for interlocking facilities for substations without automation system.

(iv) Necessary Terminal Blocks for terminating cables from ACDB and switchyard panel rooms.

11.0 **EQUIPMENT ERECTION DETAILS**

11.1 For equipment interconnection, the surfaces of equipment terminal pads, Aluminium tube, conductor & terminal clamps and connectors shall be properly cleaned. After cleaning, contact grease shall be applied on the contact surfaces of equipment terminal pad, Aluminium tube/conductor and terminal clamps to avoid any air gap in between. Subsequently bolts of the terminal pad/terminal connectors shall be tightened and the surfaces shall be cleaned properly after equipment interconnection.

11.2 Muslin or leather cloth shall be used for cleaning the inside and outside of hollow insulators.

11.3 All support insulators, circuit breaker interrupters and other fragile equipment shall preferably be handled with cranes having suitable booms and handling capacity.

11.4 Bending of Aluminium tube and compressed air piping if any should be done by a bending machine and through cold bending only. Bending shall be such that inner diameter of pipe is not reduced.

11.5 Cutting of the pipes wherever required shall be such as to avoid flaring of the ends. Hence only a proper pipe cutting tool shall be used. Hack saw shall not be used.

11.6 Handling of equipment shall be done strictly as per manufacturer's/supplier's instructions/instruction manual.

11.7 Handling equipment, sling ropes etc. should be tested periodically before erection for strength.

11.8 The slings shall be of sufficient length to avoid any damage to insulator due to excessive swing, scratching by sling ropes etc.

12.0 **STORAGE**

12.1 The Contractor shall provide and construct adequate storage shed for proper storage of equipments, where sensitive equipments shall be stored indoors. All equipments during storage shall be protected against damage due to acts of nature or accidents. The storage instructions of the equipment manufacturer/Owner shall be strictly adhered to.

13.0 **CABLING MATERIAL**

13.1 **CABLE TAGS AND MARKERS**

13.1.1 Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.

13.1.2 The tag shall be of aluminium with the number punched on it and securely attached to the cable conduit by not less than two turns of 20 SWG GI wire. Cable tags shall be of rectangular shape for power cables and of circular shape for control cables.

13.1.3 Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanised iron plate.

13.1.4 Location of underground cable joints shall be indicated with cable marker with an additional inscription “Cable joints”.

13.1.5 The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road and drain crossings.

13.1.6 Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry and at each end & turning point in cable tray/trench runs. Cable tags shall be provided inside the switchgear, motor control centres, control and relay panels etc., wherever required for cable identification, where a number of cables enter together through a gland plate.

13.2 **Cable Supports and Cable Tray Mounting Arrangements**

13.2.1 The Contractor shall provide embedded steel inserts on concrete floors/walls to secure supports by welding to these inserts or available building steel structures.

13.2.2 The supports shall be fabricated from standard structural steel members.

13.2.3 Insert plates will be provided at an interval of 750 mm wherever cables are to be supported without the use of cable trays, such as in trenches, while at all other places these will be at an interval of 2000 mm.

13.2.4 Vertical run of cables on equipment support structure shall be supported on perforated cable trays of suitable width which shall be suitably bolted/clamped with the equipment support structure.

.13.3 **Cable Termination and Connections**

13.3.1 The termination and connection of cables shall be done strictly in accordance with cable and termination kit manufacturer’s instructions, drawing and/or as directed by the Owner.

13.3.2 The work shall include all clamping, fittings, fixing, plumbing, soldering, drilling, cutting, taping, heat shrinking (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job.

13.3.3 Supply of all consumable material shall be in the scope of Contractor.

13.3.4 The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The Contractor shall be responsible for drilling of gland plates, painting and touching up. Holes shall not be made by gas cutting.

13.3.5 Control cable cores entering control panel/switchgear/MCCB/MCC/ miscellaneous panels shall be neatly bunched, clamped and tied with nylon strap or PVC perforated strap to keep them in position.

13.3.6 The Contractor shall tag/ferrule control cable cores at all terminations, as instructed by the Owner. In panels where a large number of cables are to be terminated and cable identification may be difficult, each core ferrule may include the complete cable number as well.

13.3.7 Spare cores shall be similarly tagged with cable numbers and coiled up.

13.3.8 All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively closed.

13.3.9 Double compression type nickel plated (coating thickness not less than 10 microns) brass cable glands shall be provided by the Contractor for all power and control cables to provide dust and weather proof terminations.

13.3.10 They shall comprise of heavy duty brass casting, machine finished and nickel plated, to avoid corrosion and oxidation. Rubber components used in cable glands shall be neoprene and of tested quality. Cable glands shall be of approved make.

13.3.11 The cable glands shall also be suitable for dust proof and weather proof termination. The test procedure, if required, has to be discussed and agreed to between Owner and cable gland manufacturer.

13.3.12 If the cable-end box or terminal enclosure provided on the equipment is found unsuitable and requires modification, the same shall be carried out by the Contractor, as directed by the Owner.

13.3.13 Crimping tool used shall be of approved design and make.

13.3.14 Cable lugs shall be tinned copper solderless crimping type conforming to IS-8309 & 8394/ Equivalent International standard. Bimetallic lugs shall be used depending upon type of cables used.

13.3.15 Solderless crimping of terminals shall be done by using corrosion inhibitory compound. The cable lugs shall suit the type of terminals provided.

13.4 STORAGE AND HANDLING OF CABLE DRUMS

13.4.1 Cable drums shall be unloaded, handled and stored in an approved manner and rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum.

14.0 DIRECTLY BURIED CABLES

14.1 The Contractor shall construct the cable trenches required for directly buried cables. The scope of work shall include excavation, preparation of sand bedding, soil cover, supply and installation of brick or concrete protective covers, back filling and ramming, supply and installation of route markers and joint markers. The Bidder shall ascertain the soil conditions prevailing at site, before submitting the bid.

14.2 The cable (power and control) between LT station, control room, DG set location and fire lighting pump house shall be laid in the buried cable trenches. In addition to the above, for lighting purpose also, buried cable trench can be used in outdoor area.

14.3 Cable route and joint markers and RCC warning covers shall be provided wherever required. The voltage grade of cables shall be engraved on the marker.

15.0 **INSTALLATION OF CABLES**

15.1 Cabling in the control room shall be done on ladder type cable trays for vertical runs while cabling in switchyard area shall be done on angles in the trench.

15.2 All cables from bay cable trench to equipment's including and all interpole cables (both power and control) for all equipment, shall be laid in PVC pipes of minimum 50 mm nominal outside diameter which shall be buried in the ground at a depth of 250mm below finish formation level. Separate PVC pipes shall be laid for control and power cables. Cable pull boxes of adequate size shall be provided if required.

15.3 Cables shall be generally located adjoining the electrical equipment through the pipe insert embedded in the floor. In the case of equipments located away from cable trench either pipe inserts shall be embedded in the floor connecting the cable trench and the equipment or in case the distance is small, notch/opening on the wall shall be provided. In all these cases necessary bending radius as recommended by the cable manufacturer shall be maintained.

15.4 Cable racks and supports shall be painted after installation with two coats of metal primer (comprising of red oxide and zinc chromate in a synthetic medium) followed by two finishing coats of aluminium paint.

15.5 Suitable arrangement should be used between fixed pipe / cable trays and equipment terminal boxes, where vibration is anticipated.

15.6 Power and control cables in the cable trench shall be laid in separate tiers. The order of laying of various cables shall be as follows, for cables other than directly buried.

a) Power cables on top tiers.

b) Control instrumentation and other service cables in bottom tiers.

15.7 Single core cables in trefoil formation shall be laid with a distance of three times the diameter of cable between trefoil centre lines. All power cables shall be laid with a minimum centre to centre distance equal to twice the diameter of the cable of higher size of cables.

15.8 Trefoil clamps for single core cables shall be of pressure die cast aluminium (LM-6), Nylon -6 or fibre glass and shall include necessary fixing GI nuts, bolts, washer etc. These are required at every 2 metre of cable runs.

15.9 Power and control cables shall be securely fixed to the trays/supports with self-locking type nylon ties with deinterlocking facility at every 5 metre interval for horizontal run. Vertical and inclined cable runs shall be secured with 25 mm wide and 2 mm thick aluminium strip clamps at every 2m.

15.10 Cables shall not be bent below the minimum permissible limit. The permissible limits are as follows:

Table of Cable and	Minimum bending radius
Power cable	12 D
Control cable	10 D

D is overall diameter of cable

15.11 Where cables cross roads, drains and rail tracks, these shall be laid in reinforced spun concrete or steel pipes buried at not less than one metre depth.

15.12 In each cable run some extra length shall be kept at a suitable point to enable one (for LT cables)/two (for H.T. cables) straight through joints to be made in case the

cable develop fault at a later date.

15.13 Selection of cable drums for each run shall be so planned as to avoid using straight through joints. Cable splices will not be permitted except where called for by the drawings, unavoidable or where permitted by the Owner. If straight through joints are unavoidable, the Contractor shall use the straight through joints kit of reputed make.

15.14 Control cable terminations inside equipment enclosures shall have sufficient lengths so that changing of termination in terminal blocks can be done without requiring any splicing.

15.15 Metal screen and armour of the cable shall be bonded to the earthing system of the station, wherever required by the Owner.

15.16 Rollers shall be used at intervals of about two metres while pulling cables.

15.17 All due care shall be taken during unreeling, laying and termination of cable to avoid damage due to twist, kinks, sharp bends, etc.

15.18 Cable ends shall be kept sealed to prevent damage. In cable vault, fire resistant seal shall be provided underneath the panels.

15.19 Inspection on receipt, unloading and handling of cables shall generally be in accordance with relevant international standard.

15.20 Wherever cable pass through floor or through wall openings or other partitions, GI/PVC wall sleeves with bushes having a smooth curved internal surface so as not to damage the cable, shall be supplied, installed and properly sealed by the Contractor at no extra charges.

15.21 Contractor shall remove the RCC/Steel trench covers before taking up the work and shall replace all the trench covers after the erection-work in that particular area is completed or when further work is not likely to be taken up for some time.

15.22 Contractor shall furnish three copies of the report on work carried out in a particular week, indicating cable numbers, date on which laid, actual length and route, testing carried out, terminations carried out, along with the marked up copy of the cable schedule and interconnection drawing wherever any modifications are made.

15.23 Contractor shall paint the tray identification number on each run of trays at an interval of 10 m.

15.24 In case the outer sheath of a cable is damaged during handling/installation, the Contractor shall repair it at his own cost to the satisfaction of the Owner. In case any other part of a cable is damaged, the same shall be replaced by a healthy cable at no extra cost to the Owner, i.e. the Contractor shall not be paid for installation and removal of the damaged cable.

15.25 All cable terminations shall be appropriately tightened to ensure secure and reliable connections. The Contractor shall cover the exposed part of all cable lugs whether supplied by him or not with insulating tape, sleeve or paint.

15.26 **Cable trays**

i) The cable trays shall be of G.S. sheet and minimum thickness of sheet shall be 2mm.

ii) The Contractor shall perform all tests and inspection to ensure that material and workmanship are according to the relevant standards.

A 2.5 metre straight section of 300mm, 600mm wide cable tray shall be simply supported at two ends. A uniform distributed load of 76 kg/m shall be applied along the length of the tray. The maximum deflection at the mid-span shall not exceed

7mm.

15.27 **Conduits, Pipes and Duct Installation**

15.27.1 Contractor shall supply and install all rigid conduits, mild steel pipes, flexible conduits, hume pipes etc. including all necessary sundry materials such as tees, elbows, check nuts, bushing, reducers, enlargers, coupling cap, nipples, gland sealing fittings, pull boxes e.t.c as specified and to be shown in detailed drawing. The size of the conduit/pipe shall be selected on the basis of 40% fill criterion.

15.27.2 Contractor shall have his own facility for bending, cutting and threading the conduits at site. Cold bending should be used. All cuts & threaded ends shall be made smooth without leaving any sharp edges. Anticorrosive paint shall be applied at all field threaded portions.

15.27.3 All conduit/pipes shall be extended on both sides of wall/floor openings. The fabrication and installation of supports and the clamping shall be included in the scope of work by Contractor.

15.27.4 When two lengths of conduits are joined together through a coupling, running threads equal to twice the length of coupling shall be provided on each conduit to facilitate easy dismantling of two conduits.

15.27.5 Conduit installation shall be permanently connected to earth by means of special approved type of earthing clamps. GI pull wire of adequate size shall be laid in all conduits before installation.

15.27.6 Each conduit run shall be painted with its designation as indicated on the drawings such that it can be identified at each end.

15.27.7 Embedded conduits shall have a minimum concrete cover of 50 mm.

15.27.8 Conduit run sleeves shall be provided with the bushings at each end.

15.27.9 Metallic conduit runs at termination shall have two locknuts and a bushing for connection. Flexible conduits shall also be suitably clamped at each end with the help of bushings. Bushings shall have rounded edges so as not to damage the cables.

15.27.10 Where embedded conduits turn upwards from a slab or fill, the termination dimensions shown on the drawings, if any, shall be taken to represent the position of the straight extension of the conduit external to and immediately following the bend. At least one half of the arc length of the bend shall be embedded.

15.27.11 All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed in an approved manner to prevent damage to threaded portions and entrance of moisture and foreign material.

15.27.12 For underground runs, Contractor shall excavate and back fill as necessary.

15.27.13 Contractor shall supply, unload, store and install conduits required for the lighting installation as specified. All accessories/fittings required for making the installation complete, including but not limited to pull out boxes, ordinary and inspection tees and elbow, checknuts, male and female bushings (brass or galvanised steel), caps, square headed male plugs, nipples, gland sealing fittings, pull boxes, conduits terminal boxes, gaskets and box covers, saddle terminal boxes, and all steel supporting work shall be supplied by the Contractor. The conduit fittings shall be of the same material as conduits.

15.27.14 All unarmoured cables shall run within the conduits from lighting panels to lighting fixtures, receptacles etc.

15.27.15 Size of conduit for lighting shall be selected by the Contractor during detailed

engineering.

15.27.16 Exposed conduits shall be run in straight lines parallel to building columns, beams and walls. Unnecessary bends and crossings shall be avoided to present a neat appearance.

15.27.17 Conduit supports shall be provided at an interval of 750mm for horizontal runs and 1000mm for vertical runs.

15.27.18 Conduit supports shall be clamped on the approved type spacer plates or brackets by saddles or U- bolts. The spacer plates or brackets in turn, shall be securely fixed to the building steel by welding and to concrete or brick work by grouting or by nylon rawl plugs. Wooden plug inserted in the masonry or concrete for conduit support is not acceptable.

15.27.19 Embedded conduits shall be securely fixed in position to preclude any movement. In fixing embedded conduit, if welding or brazing is used, extreme care should be taken to avoid any injury to the inner surface of the conduit.

15.27.20 Spacing of embedded conduits shall be such as to permit flow of concrete between them.

15.27.21 Where conduits are placed along with cable trays, they shall be clamped to supporting steel at an interval of 600mm.

15.27.22 For directly embedding in soil, the conduits shall be coated with an asphalt-base compound. Concrete pier or anchor shall be provided wherever necessary to support the conduit rigidly and to hold it in place.

15.27.23 Conduit shall be installed in such a way as to ensure against trouble from trapped condensation.

15.27.24 Conduits shall be kept, wherever possible, at least 300mm away from hot pipes, heating devices etc. when it is evident that such proximity may reduce the service life of cables.

15.27.25 Slip joints shall be provided when conduits cross structural expansion joints or where long run of exposed conduits are installed, so that temperature change will cause no distortion due to expansion or contraction of conduit run.

15.27.26 For long conduit run, pull boxes shall be provided at suitable intervals to facilitate wiring.

15.27.27 Conduit shall be securely fastened to junction boxes or cabinets, each with a lock nut inside and outside the box.

15.27.28 Conduits joints and connections shall be made thoroughly water-tight and rust proof by application of a thread compound which insulates the joints. White lead is suitable for application on embedded conduit and red lead for exposed conduit.

15.27.29 Field bends shall have a minimum radius of four (4) times the conduit diameter. All bends shall be free of kinks, indentations of flattened surfaces. Heat shall not be applied in making any conduit bend. Separate bends may be used for this purpose.

15.27.30 The entire metallic conduit system, whether embedded or exposed, shall be electrically continuous and thoroughly grounded. Where slip joints are used, suitable bounding shall be provided around the joint to ensure a continuous ground circuit.

15.27.31 After installation, the conduits shall be thoroughly cleaned by compressed air before pulling in the wire.

15.27.32 Lighting fixtures shall not be suspended directly from the junction box in the main conduit run.

16.0 JUNCTION BOX

a) The Contractor shall supply and install junction boxes complete with terminals as required. The brackets, bolts, nuts, screws etc required for erection are also included in the scope of the Contractor.

b) Junction boxes having volume less than 1600 cubic centimeters may be installed without any support other than that resulting from connecting conduits where two or more rigid metallic conduits enter and accurately position the box. Boxes shall be installed so that they are level, plumb and properly aligned to present a pleasing appearance.

c) Boxes with volumes equal to or greater than 1600 cubic cm, and smaller boxes terminating on less than two rigid metallic conduits or for other reasons not rigidly held, shall be adequately supported by auxiliary steel of standard steel shapes or plates to be fabricated and installed. The Contractor shall perform all drilling, cutting, welding, shimming and bolting required for attachment of supports.

17.0 TESTING AND COMMISSIONING

17.1 An indicative list of tests for testing and commissioning is given below. Contractor shall perform any additional test based on 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 equipment instruments and auxiliaries required for testing and commissioning of equipment along with calibration certificates and shall furnish the list of instruments to the Owner for approval.

17.2 GENERAL CHECKS

(a) Check for physical damage.

(b) Visual examination of zinc coating/plating.

(c) Check from name plate that all items are as per order/specification.

(d) Check tightness of all bolts, clamps and connecting terminals using torque wrenches.

(e) For oil filled equipment, check for oil leakage, if any. Also check oil level and top up wherever necessary.

(f) Check ground connections for quality of weld and application of zinc rich paint over weld joint of galvanized surfaces.

(g) Check cleanliness of insulator and bushings.

(h) All checks and tests specified by the manufacturers in their drawings and manuals as well as all tests specified in the relevant code of erection.

(i) Check for surface finish of grading rings (Corona control ring).

(j) Pressure test on all pneumatic lines at 18.5 times the rated pressure shall be conducted.

17.3 STATION EARTHING

a) Check soil resistivity

b) Check continuity of grid wires

c) Check earth resistance of the entire grid as well as various sections of the same.

d) Check for weld joint and application of zinc rich paint on galvanized surfaces.

e) Dip test on earth conductor prior to use.

17.4 **AAC/ ACSR STRINGING WORK, TUBULAR BUS WORK AND POWER CONNECTORS**

a) Physical check for finish

b) Electrical clearance check

c) Testing of torque by torque wrenches on all bus bar power connectors and other accessories.

d) Millivolt drop test on all power connectors.

e) Sag and tension check on conductors.

17.5 **ALUMINIUM TUBE WELDING**

a) Physical check

b) Millivolt drop test on all joints.

c) Dye penetration test & Radiography test on 10% sample basis on weld joints.

d) Test check on 5% sample joints after cutting the weld piece to observe any voids etc.

17.6 INSULATOR

Visual examination for finish, damage, creepage distance etc.

17.7 All pre/commissioning activities and works work for substation equipment shall be carried out in accordance with owner's "Pre- Commissioning procedures and formats for substation bay equipment" by the contractor. This document shall be provided to the successful contractor during detailed engineering stage.

ANNEXURE – A

A. SHORT CIRCUIT FORCES AND SPACER SPAN FOR 220 kV GANTRY STRUCTURE

Sl. No.	Max. Span	Conductor Configuration	Ph-Ph Spacing	Normal Tension	SCF per Phase	Spacer span
I.	**For Fault Level of 40 kA for 1 sec.**					
1.	54 mtr	QUAD ACSR	4.5 mtr	4 T	5.00 T	2.5 mtr
2.	54 mtr	TWIN ACSR	4.5 mtr	2 T	3.50 T	2.5 mtr
3.	74 mtr	TWIN ACSR	4.5 mtr	4 T	5.00 T	2.5 mtr
4.	54 mtr	QUAD ACSR	4.0 mtr	4 T	5.70 T	2.5 mtr
5.	54 mtr	TWIN ACSR	4.0 mtr	2 T	3.50 T	2.5 mtr
6.	74 mtr	TWIN ACSR	4.0 mtr	4 T	5.70 T	2.5 mtr
7.	48 mtr	QUAD ACSR	4.0 mtr	4 T	5.30 T	2.5 mtr
8.	52 mtr	QUAD ACSR	4.0 mtr	4 T	5.35 T	2.5 mtr
9.	68 mtr	TWIN ACSR	4.0 mtr	4 T	5.20 T	2.5 mtr
10.	56 mtr	QUAD ACSR	4.0 mtr	4 T	5.50 T	2.5 mtr
11.	72 mtr	TWIN ACSR	4.0 mtr	4 T	5.27 T	2.5 mtr

NOTE: ACSR conductor as mentioned above indicates that it is suitable for ACSR MOOSE conductor.

B. SHORT CIRCUIT FORCES AND SPACER SPAN FOR 132 kV GANTRY STRUCTURE

Sl. No.	Max. Span	Conductor Configuration	Ph-Ph Spacing	Normal Tension	SCF per Phase	Spacer span
I.	**For Fault Level of 31.5kA for 1 sec.**					
1.	36 mtr	Twin Moose/ Zebra ACSR	3 mtr	1 T	2.15 T	2.5 mtr
2.	31.5 mtr	Twin Moose/ Zebra ACSR	2.7mtr	1 T	2.15 T	2.5 mtr
3.	48 mtr	Single Moose/ Zebra ACSR	3 mtr	1 T	2.05 T	NA
4.	42 mtr	Single Moose/ Zebra ACSR	2.7 mtr	1 T	2.03 T	NA

STANDARD TECHNICAL DATA SHEETS FOR AAC/ACSR CONDUCTORS, GS EARTHWIRE AND ALUMINIUM TUBE

1.0 GENERAL

Owner has stardardised the guaranteed technical particulars for the following AAC/ACSR conductors, Galvanised steel earthwire and aluminum tube. The contractor shall supply the conductors as per the standard GTP mentioned below. Any deviation to the following GTP shall be clearly brought out by the bidder in their bid.

1.1 Guaranteed Technical Particulars (GTP) for conductors:

A. GTP of ACSR MOOSE conductor:

Sl.	Description	Unit	ACSR MOOSE
1.0	**Applicable Standard**	IEC-61089	
2.0	**Raw Materials**		
2.1	Aluminium		
a)	Minimum purity of Aluminium	%	99.50
b)	Maximum copper content	%	0.04
2.2	Steel wires/ rods		
a)	Carbon	%	0.50 to 0.85
b)	Manganese	%	0.50 to 1.10
c)	Phosphorous	%	Not more than 0.035
d)	Sulphur	%	Not more than 0.045
e)	Silicon	%	0.10 to 0.35 (Max.)
2.3	Zinc		
a)	Minimum purity of Zinc	%	99.95
3.0	**Aluminium strands after stranding**		
3.1	Diameter		
a)	Nominal	mm	3.53
b)	Maximum	mm	3.55
c)	Minimum	mm	3.51
3.2	Minimum Breaking load of strand		
a)	Before stranding	KN	1.57
b)	After stranding	KN	1.49
c)	*Maximum D.C. resistance of strand at 20 deg. Centigrade*	*Ohm/ KM*	*2.921*
3.3	Maximum resistance of 1 m length of strand at 20 deg. C	Ohm	0.002921
4.0	**Steel strand after stranding**		
4.1	Diameter		
a)	Nominal	mm	3.53
b)	Maximum	mm	3.60
c)	Minimum	mm	3.46

ANNEXURE-B

Sl.	Description	Unit	ACSR MOOSE
1.0	**Applicable Standard**	IEC-61089	
2.0	**Raw Materials**		
2.1	Aluminium		
4.2	Minimum Breaking load of strand		
a)	Before stranding	KN	12.86
b)	After stranding	KN	12.22
4.3	Galvanising		
a)	Minimum weight of zinc coating per sq.m.	gm	260
b)	Minimum number of dips that the galvanised strand can withstand in the standard preece test	Nos.	2 dips of one minute & 1 dip of half minute
c)	Min. No. of twists in guage length equal 100 times the dia. of wire which the strand can withstand in the torsion test (after stranding)	Nos	16 (After stranding) 18 (Before stranding)
5.0	ACSR Conductor		
5.1.a)	Stranding		Al -54/3.53 mm+ Steel-7/3.53 mm
b)	Number of Strands		
i.	Steel centre	Nos.	1
ii.	1st Steel Layer	Nos.	6
iii.	1st Aluminium Layer	Nos.	12
iv.	2nd Aluminium Layer	Nos.	18
v.	3rd Aluminium Layer	Nos.	24
5.2	Sectional Area of aluminium	Sq. mm	528.50
5.3	Total sectional area	Sq. mm	597.00
5.4	Approximate Weight	Kg/m	2.004
5.5	Diameter of the conductor	mm	31.77
5.6	UTS of the conductor	kN	161.20 (Min.)
5.7	Lay ratio of the conductor	mm	Max Min
a)	Outer Steel layer	mm	18 16
b)	8/12 wire Aluminium layer	mm	14 12
c)	14/ 18 wire Aluminium layer	mm	13 11
d)	20/24 wire Aluminium layer	mm	12 10
5.8	DC resistance of the conductor at 20°C	ohm/ km	0.05552
5.9	Standard length of the conductor	m	1800
5.10	Tolerance on Standard length	%	(+/-) 5
5.11	Direction of lay of outer layer	-	Right Hand

ANNEXURE-B

Sl.	Description	Unit	ACSR MOOSE
1.0	**Applicable Standard**	IEC-61089	
2.0	**Raw Materials**		
2.1	Aluminium		
5.12	Linear mass of the conductor		
a)	Standard	kg/ km	2004
b)	Minimum	kg/ km	1965
c)	Maximum	kg/ km	2045
5.13	Modulus of Elasticity (Final State)	Kg/sq .mm	6860
5.14	Co-efficient of Linear Expansion	Per Deg. C	$19.3x10^{-6}$
5.15	Minimum Corona Extinction Voltage	KV (rms)	320
5.16	RIV at 1 Mhz under dry condition	Micro volts	Max. 1000 at 320 kV (rms)
6.0	**Drum Dimensions**		
a)	Flange Diameter	mm	1800
b)	Traverse width	mm	950
c)	Barrel Diameter	mm	650
d)	Flange thickness	mm	50x50

1.2 Guaranteed technical particulars of Galvanised Steel Earthwire

	Description	Unit	Standard Values
1.0	**Raw Materials**		
1.1	**Steel wires / rods**		
a)	Carbon	%	Not more than 0.55
b)	Manganese	%	0.40 to 0.90
c)	Phosphorous	%	Not more than 0.04
d)	Sulphur	%	Not more than 0.04
e)	Silicon	%	0.15 to 0.35
1.2	**Zinc**		
a)	Minimum purity of Zinc	%	99.95
2.0	**Steel strands**		
2.1	**Diameter**		
a)	Nominal	mm	3.66
b)	Maximum	mm	3.74
c)	Minimum	mm	3.58
2.2.	**Minimum breaking load of strand**		
a)	After stranding	KN	10.58
2.3	**Galvanising**		

a)	Minimum weight of zinc coating per sq.m. after stranding	gms.	275
b)	Minimum number of dips that the galvanized strand can withstand in the standard preece test	Nos.	3 dips of 1 minute and one dip of ½ minute
c)	Minimum number of twists in a gauge length equal to 100 times diameter of wire which the strand can withstand in the torsion test, after stranding	Nos.	18
3.0	**Stranded Earth wire**		
3.1	**UTS of Earth wire**	KN	68.4 (min.)
3.2	**Lay length of outer steel layer**		
a)	Standard	mm	181
b)	Maximum	mm	198
c)	Minimum	mm	165
3.3	**Maximum DC resistance of earth wire at 20^0 C**	Ohm/km	3.375
3.4	**Standard length of earth wire**	M	2000 or actual quantity whichever is less.
3.5	**Tolerance on standard length**	%	±5
3.6	**Direction of lay for outside layer**		Right hand
3.7	**Linear mass**		
a)	Standard	Kg/km	583
b)	Maximum	Kg/km	552
c)	Minimum	Kg/km	600
3.8	**Overall diameter**	mm	10.98

1.3 Guaranteed Technical Parameters of Aluminum Tube

A. <u>GTP for 3" IPS & 4" IPS AL. TUBE</u>

Sl. No.	Description	3" AL. TUBE	4" AL. TUBE
1.	Size	3" IPS (EH Type)	4" IPS (EH Type)
2.	Material	Aluminium Alloy 6101 T6 confirms to 63401 WP (range 2) of IS 5082: 1998/Equivqlent BS standard	
3.	Chemical Composition		
i)	Cu	0.05 Max	
ii)	Mg	0.4 to 0.9	
iii)	Si	0.3 to 0.7	
iv)	Fe	0.5 Max	
v)	Mn	0.03 Max	
Vi)	Al	Remainder	
4.	Outer diameter	88.90 mm	114.2 mm
5.	Tolerance on outer diameter	*+2.2 mm, - 0.0 mm*	*+2.2 mm, - 0.0 mm*
6.	Thickness	7.62 mm	8.51 mm
7.	Tolerance on thickness	*+2.2 mm, - 0.0 mm*	*+2.2 mm, - 0.0 mm*
8.	Cross-sectional area	1945.76 sq.mm	2825.61 sq.mm
9.	Weight	5.25 kg/m	7.7 kg/m
10.	Moment of Inertia	*1621589.99 mm^4*	*3972577.97 mm^4*
11.	Section Modulus	*36481.21 mm^3*	*69572.29 mm^3*

12.	Minimum Ultimate Tensile Strength	20.5 Kg/sq.mm	
13.	Temperature co-efficient of resistance	0.00364 per Deg.C	
14.	Minimum Electrical Conductivity at 20 deg.C	55% of IACS	
15.	Linear Temperature Co-efficient of Expansion (20 Deg.C -200 Deg.C)	0.000023	
16.	Modulus of Elasticity	6700 Kg/sq.mm	
17.	Minimum Elongation on 50 mm	10%	
18.	Thermal Conductivity at 100 Deg.C	0.43 Calories/sec/sq.mm/cm/deg.C	
19.	Minimum 0.2% proof stress	17.34 Kg/sq.mm	
20	Minimum Yield point	17.50 Kg/sq.mm	17.50 Kg/sq.mm
21	Minimum Breaking Strength	20.42 Kg/sq.mm	20.42 Kg/sq.mm

CORONA AND RADIO INTERFERENCE VOLTAGE (RIV) TEST

1. General

Unless otherwise stipulated, all 220kV & 132kV equipment together with its associated connectors, where applicable, shall be tested for external corona 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).

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 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 noisel 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 RIV test 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.

In case corona inception does not take place at 110%, voltage shall not be increased further and corona extinction voltage shall be considered adequate.

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 tests 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 another 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

SECTION-16: LT SWITCHGEAR
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1.1. CONSTRUCTIONAL DETAILS OF SWITCHBOARDS AND DISTRIBUTION BOARDS

1.1.1. All boards shall be of metal enclosed, indoor floor mounted, compartmentalised double front construction and freestanding type.

1.1.2. All board frames, shall be fabricated using suitable mild steel structural sections or pressed and shaped cold-rolled sheet steel of thickness not less than 2.0 mm. Frames shall be enclosed in cold-rolled sheet steel of thickness not less than 1.6 mm. Doors and covers shall also be of cold rolled sheet steel of thickness not less than 1.6 mm. Stiffeners shall be provided wherever necessary. Gland plate shall be cold rolled sheet steel having thickness not less than 3 mm in all cases. However, in case of termination of single core power cables, gland plate shall be of non-magnetic material of at least 4mm thickness.

1.1.3. All panel edges and cover/door edges shall be reinforced against distortion by rolling, bending or by the addition of welded reinforcement members.

1.1.4. The complete structures shall be rigid, self-supporting, and free from flaws, twists and bends. All cut-outs shall be true in shape and devoid of sharp edges.

1.1.5. All boards shall be of dust and vermin proof construction and shall be provided with a degree of protection of IP: 52, for category I enclosure as per IEC 60947 (Part-1). However, the busbar chambers having a degree of protection of IP: 42, in accordance with IEC 60947 (Part-1), are also acceptable where continuous busbar rating exceeds 1000 Amp. Provision shall be made in all draw out Air Circuit Breaker compartments for providing IP: 52 degree of protection, when Circuit breaker trolley, has been removed. Panels with lighting transformers shall have IP 31 degree of protection in accordance with IEC 60947 (Part-1). Door frame of panels, meters, relays, Breaker cut-outs shall be provided with neoprene rubber gaskets generally conforming to IEC/International Standards.

1.1.6. Provision of louvers on boards would not be preferred. However, louvers backed with metal screen are acceptable on the busbar chambers where continuous busbar rating exceeds 1000 Amps. Panels with lighting transformers in lighting distribution boards shall have louvers.

1.1.7. All boards shall be of uniform height not exceeding 2450 mm.

1.1.8. Boards shall be easily extendible on both sides, by the addition of the vertical sections after removing the end covers of bus bar chambers.

1.1.9. Boards shall be supplied with base frames made of structural steel sections, alongwith all necessary mounting hardware required for welding the base frames to the insert plates.

1.1.10. a) All boards shall be of double front construction and shall have:

(i) A completely enclosed busbar compartment for running horizontal busbars and vertical busbars. Busbar chambers shall be completely enclosed with metallic portions. Bolted covers shall be provided for access to horizontal and vertical busbars for repair and maintenance, which shall be feasible without disturbing feeder compartment. Vertical bus bar chambers shall be accessible from front as well as back side of the panel and shall be of at least 350 mm width. One set of vertical busbars shall be used in between two adjacent sections for switchgear connections. In case of ACB feeders, the panel shall have single front without any vertical busbar chamber, however vertical busbars associated with ACBs shall be located in rear side and shall be

additionally covered with metallic perforated/ transparent acrylic or polyvinyl bolted sheets to avoid direct access after opening rear door of chamber.

(ii) Completely enclosed switchgear compartment(s) one for each circuit for housing circuit breaker or MCCB or motor starter.

(iii) A distinct compartment or alley for power and control cables on each side of panel. Cable alley compartment shall have a through metallic partition for segregating cables on both sides. Cable alley door shall preferably be hinged. Cable alley shall have no exposed live parts. Any live terminals shall be fully shrouded/insulated from safety aspects. However, it shall be of atleast 350mm width.

(iv) A compartment for relays and other control devices associated with a circuit breaker.

b) Lighting transformers shall be supplied in separate and distinct panel completely assembled for incoming cable connection from bottom and outgoing connection through busbar with adjacent associated lighting distribution board. Lighting transformers shall have provision of base channel with rollers for taking in and out from the panel in case of maintenance after disconnecting incoming and outgoing connections. Provision of single phase fans at least two (2) numbers of suitable ratings shall be made in the panel for ventilation. These fans shall run in sequential mode at suitable time interval to be controlled by thermostat and timer. The offered design of panel should be such that in no case, temperature rise of lighting transformers shall exceed the permissible limits for the class of insulation of lighting transformer.

1.1.11. Sheet steel barriers shall be provided between two adjacent vertical panels running to the full height of the switchboard, except for the horizontal busbar compartment. Each shipping section shall have full metal sheets at both ends for transport and storage.

1.1.12. All equipments associated with a single circuit except MCB circuits shall be housed in a separate compartment of the vertical section. The Compartment shall be sheet steel enclosed on all sides with the withdrawal units in position or removed. The front of the compartment shall be provided with the hinged single leaf door, with locking facilities. In case of circuits controlled by MCBs, group of MCB feeders can be offered in common compartment. In such case number of MCB feeder to be used in a common compartment shall not exceed 4 (four) and front of MCB compartment, shall have a viewing port of toughen glass sheet for viewing and sheet steel door of module shall be lockable with star knob/panel key.

1.1.13. After isolation of power and control circuit connections it shall be possible to safely carryout maintenance in a compartment with the busbar and adjacent circuit live. Necessary shrouding arrangement shall be provided for this purpose over the cable terminations located in cable alley.

1.1.14. The minimum clearance in air between phases and between phase and earth for the entire run of horizontal and vertical busbars, shall be 25 mm. For all other components, the clearance between "two live parts", " A live part and an earthed part" and isolating distance shall be atleast ten (10) mm throughout. Wherever it is not possible to maintain these clearances, insulation shall be provided by sleeving or barriers. However, for horizontal run of busbar minimum clearance of 25 mm should be maintained even if they are sleeved.

1.1.15. The temperature rise of horizontal & vertical busbars when carrying rated current along its full run shall in no case exceed 55°C, with silver plated joints and 40°C with all other type of joints over an outside ambient temperature of 50°C.

1.1.16. All busbar chambers shall be provided with removable bolted covers. The covers shall be provided with danger labels.

1.1.17. All identical circuit breakers and module chassis of same test size shall be fully interchangeable without having to carryout modifications.

1.1.18. All Circuit breaker boards shall be of Single Front type, with fully drawout circuit breakers, which can be drawn out without having to unscrew any connections. The circuit breakers shall be mounted on rollers and guides for smooth movement between SERVICE, TEST and ISOLATED positions and for withdrawal from the Switchboard. Testing of the breaker shall be possible in the TEST position.

1.1.19. Wherever two breaker compartments are provided in the same vertical section, insulating barriers and shrouds shall be provided in the rear cable compartment to avoid accidental touch with the live parts of one circuit when working on the other circuit.

1.1.20. All disconnecting contacts for power circuits shall be of robust design and fully self aligning. Fixed and moving contacts of the power drawout contact system shall be silver plated. Both fixed and moving contacts shall be replaceable.

1.1.21. All AC & DC boards shall be of double Front type.

1.1.22. All module shall be fixed type except air circuit breaker module, which shall be drawout type.

1.1.23. The connections from busbars to the main switch shall be fully insulated/shrouded, and securely bolted. The partition between the feeder compartment and cable alley may be non-metallic and shall be of such construction as to allow cable cores with lugs to be easily inserted in the feeder compartment for termination.

1.1.24. All equipment and components shall be neatly arranged and shall be easily accessible for operation and maintenance. The internal layout of all modules shall be subject to PURCHASER approval. Bidder shall submit dimensional drawings showing complete internal details of Busbars and module components, for each type and rating for approval.

1.1.25. The tentative power and control cable entries shall be from bottom. However, Purchaser reserves the right to alter the cable entries, if required, during detailed engineering, without any additional commercial implication.

1.1.26. Adopter panels and dummy panels required to meet the various busbar arrangements and layouts required shall be included in Bidder's scope of work.

1.2. DERATING OF EQUIPMENTS

1.2.1. The current ratings of all equipments as specified in the Single Line Diagram for AC & DC System are the minimum standards current ratings at a reference ambient temperature as per relevant Indian Standards.

1.3. POWER BUS BARS AND INSULATORS

1.3.1. All AC Distribution Boards shall be provided with three phase buses and a neutral bus bars and the DC Distribution Boards shall be provided with two busbars.

1.3.2. All busbars and jumper connections shall be of high conductivity aluminium/copper of adequate size.

1.3.3. The Cross-Section of the busbars shall be uniform through out the length of Switchgear and shall be adequately supported and braced to withstand the stresses due to the specified short circuit currents.

1.3.4. All busbars shall be adequately supported by adequate numbers of high strength type Polyester fibre glass Moulded Insulators to withstand short circuit withstand capability of panel. Separate supports shall be provided for each phase and neutral busbar. If a common support is provided anti-tracking barriers shall be provided between the supports.

1.3.5. All busbars joints shall be provided with high tensile steel bolts. Belleville/spring washers and nuts, so as to ensure good contacts at the joints. Non-silver plated Busbars joints shall be thoroughly cleaned at the joint locations and a suitable contact grease shall be applied just before making a joint.

1.3.6. All busbars shall be colour coded as per IEC: 60446.

1.3.7. The Bidder shall furnish calculations, establishing the adequacy of busbar sizes for specified current ratings, On the basis of short circuit current and temperature rise consideration at specified ambient temp.

1.4. EARTH BUS

1.4.1. A galvanised steel earthing shall be provided at the bottom of each panel and shall extend throughout the length of each switchboard. It shall be welded/bolted to the frame work of each panel and breaker earthing contact bar vertical bus shall be provided in each vertical section which shall in turn be bolted/welded to main horizontal ground bus.

1.4.2. The earth bus shall have sufficient cross-section to carry the momentary short circuit and short time fault currents to earth without exceeding the allowable temperature rise.

1.4.3. Suitable arrangements shall be provided at each end of the horizontal earth bus for bolting to Purchaser's earthing conductors. The horizontal earth bus shall project out the switchboard ends and shall have predrilled holes for this connection. A joint spaced and taps to earth bus shall be made through at least two bolts.

1.4.4. All non-current metal work of the Switchboard shall be effectively bonded to the earth bus. Electrical conductivity of the whole switchgear enclosures frame work and the truck shall be maintained even after painting.

1.4.5. The truck and breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker frame shall be maintained in all positions. SERVICES & ISOLATED, as well as through out the intermediate travel.

1.4.6. Air Circuit Breaker (ACB) module frame shall get engaged to the vertical earth bus, before the disconnecting contacts on these modules are engaged to the vertical busbar.

1.4.7. All metallic cases of relays, instruments and other panel mounted equipments shall be connected to earth by independent stranded copper wires of size not less than 2.5

mm^2. Insulation colour code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable clamp connectors and soldering is not acceptable. Looping of earth Connection which would result in loss of earth connection to the devices when a device is removed is not acceptable. However, looping of earth connections between equipment to provide alternative paths or earth bus is acceptable.

1.4.8. VT and CT secondary neutral point earthing shall be at one place only, on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit shall be removed without disturbing the earthing of other circuit.

1.4.9. All hinged doors shall be earthed through flexible earthing braid.

1.4.10. Caution nameplate `Caution-Live Terminals' shall be provided at all points where the terminals are like to remain live and isolation is possible only at remote end.

1.5. AIR CIRCUIT BREAKERS

1.5.1. Circuit breakers shall be three-pole air break horizontal drawout type and shall have inherent fault making and breaking capacities as specified in "Technical Parameters". The circuit breakers which meet specified parameter only after provision of releases or any other devices shall not be acceptable.

1.5.2. Circuit breakers shall be mounted along with it operating mechanism on a wheeled carriage. Suitable guides shall be provided to minimise misalignment of the breaker.

1.5.3. There shall be `Service', `Test' and `Fully withdrawn positions for the breakers. In `Test' position the circuit breaker shall be capable of being tested for operation without energising the power circuits i.e. the power Contacts shall be disconnected while the Control circuits shall remain undisturbed. Locking facilities shall be provided so as to prevent movement of the circuit breaker from the `SERVICE', `TEST' OR FULLY WITHDRAWN' position. It shall be possible to close the door in TEST position.

1.5.4. All circuit breakers shall be provided with 4 NO and 4 NC potentially free auxiliary contacts. These contacts shall be in addition to those required for internal mechanism of the breaker. Separate limit switches each having required number of contacts shall be provided in both `SERVICE' & `TEST' position of the breaker. All contacts shall be rated for making continuously carrying and breaking 10 Amps at 230V AC and 1 Amp (Inductive) at 220V DC.

1.5.5. Suitable mechanical indications shall be provided on all circuit breakers to show `OPEN'. `CLOSE', `SERVICE', `TEST' and `SPRING CHARGED' positions.

1.5.6. Main poles of the circuit breakers shall operate simultaneously in such a way that the maximum difference between the instants of contacts touching during closing shall not exceed half cycle of rated frequency.

1.5.7. All circuit breakers shall be provided with the interlocks as explained in further clauses.

1.5.8. Movement of a circuit breaker between SERVICE AND TEST positions shall not be possible unless it is in OPEN position. Attempted with drawl of a closed circuit breaker shall trip the circuit breaker.

1.5.9. Closing of a circuit breaker shall not be possible unless it is in SERVICE, TEST POSITION or in FULLY WITHDRAWN POSITION.

1.5.10. Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage to cover the stationary isolated contacts when the breaker is withdrawn. It shall however, be possible to open the shutters intentionally, against spring pressure for testing purpose.

1.5.11. A breaker of particular rating shall be prevented from insertion in a cubicle of a different rating.

1.5.12. Circuit breakers shall be provided with electrical anti-pumping and trip free feature, even if mechanical antipumping feature is provided.

1.5.13. Mechanical tripping shall be possible by means of front mounted RED `Trip' push-button. In case of electrically operated breakers these push buttons shall be shrouded to prevent accidental operation.

1.5.14. Breaker controlled motors shall operate satisfactorily under the following conditions:

(i) Direct on-line starting of Induction Motors rated 110 kW to 220 kW with a locked rotor current of seven times the rated current, and starting time of up to 30 seconds.

(ii) Breaking on-load, full load and locked rotor currents of Induction Motors for rated 100 kW to 220 kW.

1.5.15. Means shall be provided to slowly close the circuit breaker in withdrawn position. If required for inspection and setting of Contacts, in service position slow closing shall not be possible.

1.5.16. Power operated mechanism shall be provided with a universal motor suitable for operation 220V DC Control supply with voltage variation from 90% to 110% rated voltage. Motor insulation shall be class `E' or better.

1.5.17. The motor shall be such that it requires not more than 30 seconds for fully charging the closing spring.

1.5.18. Once the closing springs are discharged, after the one closing operation of circuit breaker, it shall automatically initiate, recharging of the spring.

1.5.19. The mechanism shall be such that as long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. After failure of power supply at least one open-close-open operation shall be possible.

1.5.20. Provision shall be made for emergency manual charging and as soon as this manual charging handle is coupled, the motor shall automatically get mechanically decoupled.

1.5.21. All circuit breakers shall be provided with closing and trip coils. The closing coils shall operate correctly at all values of Voltage between 85% and 110% at rated control voltage. The trip coil shall operate satisfactorily under all values of supply voltage between 70% and 110% of rated control voltage.

1.5.22. Provision for mechanical closing of the breaker only in `TEST' and `WITHDRAWN' positions shall be made.

1.5.23. **PROTECTION CO-ORDINATION**

1.5.23.1. It shall be the responsibility of the Contractor to fully co-ordinate the overload and short circuit tripping of the circuit breakers with the upstream and down stream circuit breakers/fuses/motor starters, to provide satisfactory discrimination.

1.6. MOULDED CASE CIRCUIT BREAKER (MCCB) and MCB

1.6.1. MCCB shall in general conform to IEC: 60947 Part-2. All MCCB offered shall have Ics = 100% Icu rating.

1.6.2. MCCB shall be flush mounted on the AC/DC distribution boards and shall have extended handle.

1.6.3 MCCBs shall be provided with thermo-magnetic type release for over current and short circuit protection. The setting of the thermal release shall be adjustable between 80% and 100% of the rated current. The MCCB shall have breaking capacity not less than 20kA.

1.6.4 MCCBs used for ACDB incomers and Bus coupler shall be equipped with stored energy mechanism for electrical closing and tripping. All other MCCBs shall be manually operated. The operating handle should give a clear trip indication.

1.6.5 Miniature circuit breaker (MCB) shall conform to IEC: 60898.

1.7 RELAYS

1.7.1 All relays and timers in protective circuits shall be flush mounted on panel front with connections from the inside. They shall have transparent dust tight covers removable from the front. All protective relays shall have a drawout construction for easy replacement from the front. They shall either have built-in test facilities, or shall be provided with necessary test blocks and test switches located immediately below each relay. The auxiliary relays and timers may be furnished in non-drawout cases.

1.7.2 All AC relays shall be suitable for operation, at 50 Hz with 110 volts VT secondary and 1 amp or 5 amp CT secondary.

1.7.3 All protective relays and timers shall have at least two potentially free output contacts. Relays shall have contacts as required for protection schemes. Contacts of relays and timers shall be silver faced and shall have a spring action. Adequate number of terminals shall be available on the relay cases for applicable relaying schemes.

1.7.4 All protective relays auxiliary relays and timers shall be provided with hand reset operation indicators (Flags) for analysing the cause of operation.

1.7.5 All relays shall withstand a test voltage of 2 KV (rms) for one minute.

1.7.6 Motor starters shall be provided with three element, ambient temperature compensated, time lagged, hand reset type overload relays with adjustable settings. The setting ranges shall be properly selected to suit the motor ratings. These relays shall have a separate black coloured hand reset push button mounted on compartment door and shall have at least one changeover contact.

1.7.7 All fuse-protected contactor-controlled motors shall have single phasing protection, either as a distinct feature in the overload relays (by differential movement of bimetallic strips), or as a separate device. The single phasing protection shall operate even with 80% of the set current flowing in two of the phases.

1.8 CONTACTORS

1.8.1 Motor starter contactors shall be of air break, electromagnetic type rated for uninterrupted duty as per IEC: 60947 Part 4.

1.8.2 Contactors shall be double break; non-gravity type and their main contacts shall be silver faced.

1.8.3 Direct on line starter contactors shall be of utilisation category AC2. These contactors shall be as per IEC: 60947 Part 4.

1.8.4 Each contactor shall be provided with two (2) normally open (NO) and two (2) normally close (NC) auxiliary contacts.

1.8.5 Operating coils of contactors shall be of 230V AC unless otherwise specified elsewhere. The Contactors shall operate satisfactorily between 85% and 110% of the rated voltage. The Contactor shall drop out at 70% of the rated voltage.

1.9 INSTRUMENT TRANSFORMERS

1.9.1 All current and voltage transformers shall be completely encapsulated cast resin insulated type suitable for continuous operation at the temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated condition and the outside ambient temperature is 50°C.

1.9.2 All instrument transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary current ratings of the associated switchgear.

1.9.3 All instrument transformer shall have clear indelible polarity markings. All secondary terminals shall be wired to a separate terminal on an accessible terminal block where star-point formation and earthing shall be done.

1.9.4 Current transformers may be multi or single core type. All voltage transformers shall be single phase type. The Bus VTs shall be housed in a separate compartment.

1.9.5 All VTs shall have readily accessible MCBs on both primary and secondary sides.

1.10 INDICATING INSTRUMENTS

1.10.1 All indicating and integrating meters shall be flush mounted on panel front. The instruments shall be of at least 96 mm square size with 90 degree scales, and shall have an accuracy class of 2.5 or better. The covers and cases of instruments and meters shall provide a dust and vermin proof construction.

1.10.2 All instruments shall be compensated for temperature errors and factory calibrated to directly read the primary quantities. Means shall be provided for zero adjustment without removing or dismantling the instruments.

1.10.3 All instruments shall have white dials with black numerals and lettering. Black knife edge pointer with parallax free dials will be preferred.

1.10.4 Ammeters provided on Motor feeders shall have a compressed scale at the upper current region to cover the starting current.

1.10.5 Watt-hour meters shall be of 3 phase three element type, Maximum demand indicators need not be provided.

1.11 CONTROL & SELECTOR SWITCHES

1.11.1 Control & Selector switches shall be of rotary type with escutcheon plates clearly marked to show the function and positions. The switches shall be of sturdy construction suitable for mounting on panel front. Switches with shrouding of live parts and sealing of contacts against dust ingress shall be preferred.

1.11.2 Circuit breaker selector switches for breaker Controlled motor shall have three stay put positions marked `Switchgear', `Normal' and `Trial' respectively. They shall have two contacts of each of the three positions and shall have black shade handles.

1.11.3 Ammeter and voltmeter selector switches shall have four stay put position with adequate number of contacts for three phase 4 wire system. These shall have oval handles Ammeter selector switches shall have make before break type contacts to prevent open circuiting of CT secondaries.

1.11.4 Contacts of the switches shall be spring assisted and shall be of suitable material to give a long trouble free service.

1.11.5 The contact ratings shall be at least the following:

(i)	Make and carry continuously	10 Amp.
(ii)	Breaking current at 220V DC	1 Amp (Inductive)
(iii)	Breaking current at 230V AC	5 Amp (at 0.3 pf lagging)

1.12 AIR BREAK SWITCHES

1.12.1 Air breaker switch shall be of the heavy duty, single throw group operated, load break, fault make type complying with IEC: 60947 Part-3.

1.12.2 The Bidder shall ensure that all switches are adequately rated so as to be fully protected by the associated fuses during all abnormal operating conditions such as overload, locked motor, short circuit etc.

1.12.3 Switch operating handles shall be provided with padlocking facilities to lock them in `OFF' position.

1.12.4 Interlocks shall be provided such that it is possible to open the cubicle door only when the switch is in `OFF' position and to close the switch only when the door is closed. However suitable means shall be provided to intentionally defeat the interlocks explained above.

1.12.5 Switches and fuses for AC/DC control supply and heater supply wherever required shall be mounted inside and cubicles.

1.13 PUSH BUTTONS

1.13.1 Push-buttons shall be of spring return, push to actuate type. Their contacts shall be rated to make, continuously carry and break 10A at 230V and 0.5A (inductive) at 220V DC.

1.13.2 All push-buttons shall have one normally open and one normally closed contact, unless specified otherwise. The contact faces shall be of silver or silver alloy.

1.13.3 All push-buttons shall be provided with integral escutcheon plates marked with its function.

1.13.4 The colour of the button shall be as follows:

(i)	GREEN	:	For motor START, Breaker CLOSE
(ii)	RED	:	For motor TRIP, Breaker OPEN
(iii)	BLACK	:	For overload reset.

1.13.5 All push-buttons on panels shall be located in such a way that Red-push-buttons shall always be to the left of green push-buttons.

1.14 INDICATING LAMPS

1.14.1 Indicating lamps shall be of the panel mounting cluster LED type. The lamps shall have escutcheon plates marked with its function, wherever necessary.

1.14.2 Lamps shall have translucent lamp-covers of the following colours, as warranted by the application:

(i)	RED	:	For motor ON, Breaker CLOSED
(ii)	GREEN	:	For motor OFF, Breaker OPEN
(iii)	WHITE	:	For motor Auto-Trip
(iv)	BLUE also for	:	For all healthy conditions (e.g. control supply, and 'SPRING CHARGED"
(v)	AMBER	:	For all alarm conditions (e.g. overload) Also for `SERVICE' and `TEST' positions indicators.

1.14.3 Lamps shall be easily replaceable from the front of the cubicle.

1.14.4 Indication lamps should be located just above the associated push buttons/control switches. Red lamps shall invariable be located to the right of green lamps. In case a white lamp is also provided, it shall be placed between the red and green lamps along with the centre line of control switch/push button pair. Blue and Amber lamps should normally be located above the Red and Green lamps.

1.14.5 When associated with push-buttons, red lamps shall be directly above the green push button, and green lamps shall be directly above the red push-button. All indicating lamps shall be suitable for continuous operation at 90 to 110% of their rated voltage.

1.15 FUSES

1.15.1 All fuses shall be of HRC cartridge fuse link type. Screw type fuses shall not be accepted. Fuses for AC Circuits shall be of class 2 type, 20 kA (RMS) breaking current at 400 AC, and for DC circuits Class 1 type 4 kA breaking current.

1.15.2 Fuses shall have visible operation indicators.

1.15.3 Fuses shall be mounted on fuses carriers, which are mounted on fuse bases, wherever it is not possible to mount fuses on carriers' fuses shall be directly mounted on plug in type of bases. In such cases one set of insulated fuses pulling handles shall be supplied with each switchgear.

1.15.4 Fuse rating shall be chosen by the Bidder depending upon the circuit requirements and these shall be subject to approval of PURCHASER.

1.16 TERMINAL BLOCKS

1.16.1 Terminal blocks shall be of 750 volts grade and have continuous rating to carry the maximum expected current on the terminals. It shall be complete with insulating

barriers, clip-on-type/stud type terminals for Control Cables and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring on diagrams. It shall be similar to `ELEMEX' standard type terminals, cage clamp type of Phoenix or WAGO or equivalent

1.16.2 Terminal blocks for CT and VT secondary leads shall be provided with test links and isolating facilities. CT secondary leads shall be provided with short circuiting and earthing facilities. It shall be similar to `Elem.' `CATD' - Type.

1.16.3 In all circuit breaker panels at least 10% spare terminals for external connections shall be provided and these spare terminals shall be uniformly distributed on all terminal blocks. Space for adding another 10% spare terminals shall also be available.

1.16.4 All terminal blocks shall be suitable for terminating on each side, two (2) Nos. of 2.5 mm square size standard copper conductors.

1.16.5 All terminals shall be numbered for identification and grouped according to the function. Engraved white-on-black labels shall be provided on the terminal blocks.

1.16.6 Wherever duplication of a terminal block is necessary it shall be achieved by solid bonding links.

1.16.7 Terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal blocks. The minimum clearance between the first row of terminal block and the associated cable gland plate shall be 250 mm.

1.17 NAME PLATES AND LABELS

1.17.1 All switchgears, AC/DC distribution boards, shall be provided with prominent, engraved identification plates. The module identification plate shall clearly give the feeder number and feeder designation. For single front switchboards, similar panel and board identification labels shall be provided at the rear also.

1.17.2 All name plates shall be of non-rusting metal or 3-ply lamicoid with white engraved lettering on black back ground. Inscriptions and lettering sizes shall be subject to PURCHASER approval.

1.17.3 Suitable plastic sticker labels shall be provided for easy identification of all equipments, located inside the panel/module. These labels shall be positioned so as to be clearly visible and shall give the device number as mentioned in the module wiring drawings.

1.18 SPACE HEATER

1.18.1 Space heater shall be provided in all the boards for preventing harmful moisture condensation.

1.18.2 The space heaters shall be suitable for continuous operation on 230V AC, 50 Hz, single phase supply, and shall be automatically controlled by thermostats. Necessary isolating switches and fuses shall also be provided.

1.19 CONTROL AND SECONDARY WIRING

1.19.1 All switchboards shall be supplied completely wired internally upto the terminal blocks ready to receive Purchaser's control cables.

1.19.2 All inter cubicle and inter panel wiring and connections between panels of same switchboard including all bus wiring for AC and DC supplies shall be provided by the bidder.

1.19.3 All internal wiring shall be carried out with 1100 V grade, single core, 1.5 square mm or larger stranded copper wires having colour coded, PVC insulation. CT circuits shall be wired with 2.5 square mm copper wires. Voltage grade and insulation shall be same as above.

1.19.4 Extra-flexible wires shall be used for wiring to device mounted on moving parts such as hinged doors.

1.19.5 All wiring shall be properly supported, neatly arranged, readily accessible and securely connected to equipment terminals and terminals blocks.

1.20 POWER CABLES TERMINATION

1.20.1 Cable termination compartment and arrangement for power cables shall be suitable for stranded aluminium conductor, armoured XLPE/PVC insulated and sheathed, single core/three core, 1100 V grade cables.

1.20.2 All necessary cable terminating accessories such as Gland plates, supporting clamps and brackets, power cable lugs, hardware etc. shall be provided by the successful bidder, to suit the final cable sizes which would be advised later.

1.20.3 The gland plate shall be of removable type and shall cover the entire cable alley. Bidder shall also ensure that sufficient space is provided for all cable glands. For all single core cables, gland plates shall be of non-magnetic Material.

1.21 TYPE TESTS

1.21.1 Type tests reports on Panels (Switchgear and Control gear assemblies) as per IEC: 60439 Part-1 shall be submitted for the following tests in line with clause 9.0 of Chapter 2 GTR before the fabrication of switchgear is started:

i) Verification of temperature rise limits
ii) Verification of the dielectric properties
iii) Verification of short circuit strength
iv) Verification of the continuity of the protective circuit
v) Verification of clearances and creepage distances
vi) Verification of mechanical operation
vii) Verification of degree of protection

1.21.2 Contractor shall submit type test reports for the following Switchgear and Control gears before the fabrication of switchgear is started:

1. Circuit breakers/MCCB as per IEC: 60947 Part 2.
2. Protective Relays as per IEC: 60255.
3. Lighting transformers as per IEC:60076

For above equipments, test conducted once are acceptable (i.e. the requirement of test conducted within last five years shall not be applicable)

1.22 ERECTION, TESTING AND COMMISSIONING

1.22.1 The Contractor shall unload, erect, install, test and put into commercial use all electrical equipment included in this specification.

1.22.2 Equipment shall be installed in a neat, workman like manner so that it is level, plumb, square and properly aligned and oriented. Tolerance shall be as established in Contractor's drawings or as stipulated by purchaser. No equipment shall be permanently bolted down to foundations until the alignment has been checked and found acceptable by the purchaser.

1.22.3 Contractor shall furnish all supervision, labour tools equipment rigging materials, bolts, wedges, anchors, concrete inserts etc. in proper time required to completely install, test and commission the equipment.

1.22.4 Manufacturers' and purchaser's instructions and recommendations shall be correctly followed in handling, setting, testing and commissioning of all equipment.

1.22.5 Contractor shall move all equipment into the respective room through the regular door or openings specifically provided for this purpose. No part of the structure shall be utilised to lift or erect any equipment without prior permission of Purchaser.

1.22.6 All boards shall be installed in accordance with relevant code of practices and at Purchaser's instructions. All boards shall be installed on finished surfaces, concrete or steel stills. Contractor shall be required to install and align any channel sills which form part of foundations. In joining shipping sections of switchboards together adjacent housing of panel sections or flanged throat sections shall be bolted together after alignment has been completed. Power bus, enclosures ground and control splices of conventional nature shall be cleaned and bolted together being drawn up with torque spanner of proper size or by other approved means.

1.22.7 All boards shall be made completely vermin proof.

1.22.8 Contractor shall take utmost care in holding instruments, relaying and other delicate mechanism wherever the instruments and relays are supplied separately they shall be mentioned only after the associated panels have been erected and aligned. The packing materials employed for safe transit of instrument and relays shall be removed after ensuring that panel have been completely installed and to further movement of the same should be necessary. Any damage shall be immediately reported to Purchaser.

1.22.9 Equipment furnished with finished coats of paint shall be touched by up Contractor if their surface is specified or marred while handling.

1.22.10 After installation of panels, power and control wiring and connections, Contractor shall perform operational tests on all switchboards, to verify proper operation of switch-boards/panels and correctness of all equipment in each and every respect. The cable opening and cables entries for cables terminating to the panels shall be sealed with fire sealing materials.

1.23 COMMISSIONING CHECK TESTS

The Contractor shall carry out the following commissioning checks, in addition to the other checks and tests recommended by the manufacturers.

1.23.1 General

1.23.1.1 Check name plate details according to the specification.

1.23.1.2 Check for physical damage.

1.23.1.3 Check tightness of all bolts, clamps, joints connecting terminals.

1.23.1.4 Check earth connection.

1.23.1.5 Check cleanliness of insulators and bushings.

1.23.1.6 Check all moving parts for proper lubrication.

1.23.1.7 Check settings of all the relays.

1.23.2 **Circuit Breakers**

1.23.2.1 Check alignment of breaker truck for free movement.

1.23.2.2 Check correct operation of shutters.

1.23.2.3 Check control wiring for correctness of connections, continuity and IR values.

1.23.2.4 Manual operation of breaker completely assembled.

1.23.2.5 Power closing/opening operation, manually and electrically.

1.23.2.6 Breaker closing and tripping time.

1.23.2.7 Trip free and anti-pumping operation.

1.23.2.8 IR values, minimum pick up voltage and resistance of coils.

1.23.2.9 Contact resistance

1.23.2.10 Simultaneous closing of all the three phases.

1.23.2.11 Check electrical & mechanical interlocks provided.

1.23.2.12 Check on spring charging motor, correct operation of limit switches, and time of charging.

1.23.2.13 All functional checks.

1.23.3 **Current Transformers**

1.23.3.1 Megger between winding and winding terminals to body.

1.23.3.2 Polarity test

1.23.3.3 Ratio identification checking of all ratios on all cores by primary injection of current.

1.23.3.4 Spare CT cores, if available, to be shorted and earthed.

1.23.4 **Voltage Transformer**

1.23.4.1 Insulation resistance test

1.23.4.2 Ratio test on all cores.

1.23.4.3 Polarity test.

1.23.4.4 Line connections as per connection diagram.

1.23.5 **Cubicle Wiring**

1.23.5.1 Check all switch developments.

1.23.5.2 Each wire shall be traced by continuity tests and it should be made sure that the wiring is as per relevant drawing. All interconnections between panels/equipment shall be similarly checked.

1.23.5.3 All the wires shall be meggered to earth.

1.23.5.4 Functional checking of all control circuit e.g. closing, tripping control, interlock, supervision and alarm circuit.

1.23.6 **Relays**

1.23.6.1 Check connections and wiring.

1.23.6.2 Megger all terminals to body.

1.23.6.3 Megger AC to DC terminals.

1.23.6.4 Check operating characteristics by secondary injection.

1.23.6.5 Check minimum pick up voltage of DC coils.

1.23.6.6 Check operation of electrical/mechanical targets.

1.23.6.7 Relays settings.

1.23.6.8 Check CT and VT connections with particular reference to their polarities for directional relays, wherever required.

1.23.7 **Meters**

1.23.7.1 Check calibration by comparing it with a sub-standard.

1.23.7.2 Megger all insulated portions.

1.23.7.3 Check CT and VT connections with particular reference to their polarities for power type meters.

1.24 **SPECIAL TOOLS AND TACKLES**

1.24.1 The Bidder shall include in his proposal any special tools and tackles required for erection, testing commissioning and maintenance of the equipments offered.

1.24.2 The list of these special tools and tackles shall be given in the bid proposal sheets alongwith their respective prices.

1.24.3 The total price of the special tools and tackles shall be included in proposal sheets.

1.25 **EQUIPMENT TO BE FURNISHED**

1.25.1 The Bidder shall quote for various AC/DC distribution boards in accordance with this specification.

1.25.2 Standard scheme of interconnection of switchboards and distribution boards along with tentative feeder disposition for each board is indicated in Standard SLD of AC & DC system enclosed alongwith bid documents. The bidder shall quote board prices on the basis of standard SLD and their estimation of feeders for entire present and future bays requirement. Any other feeder required as per system requirement for efficient and reliable operation shall be deemed to be included in bidder's scope.

1.25.3 The Bill of Materials for each type of module shall be as under. These are minimum indicative requirement of the system. The necessary auxiliary relays, push buttons and indicating lamps shall be provided as per scheme requirement. Any other item/component required with in a module for efficient and reliable operation shall be deemed to be included in bidder's scope.

1.25.4 Module Type AE (Electrically controlled circuit breaker for incoming and Bus Coupler Circuit).

(i) One (1) and — Triple pole air circuit breaker complete with all accessories power operated mechanism as specified.

(ii) Two (2) — Neutral link.

(iii) Three (3) — Current Transformer for metering.

(iv) One (1) — Ammeter with selector switch.

(v) Three (3) — Current Transformer for relaying.

(vi) One (1) secondary — Triple pole instantaneous over-current relay having the setting range of 200-800% or 500-2000% of CT and adjustable definite minimum time.

(vii) One (1) — Instantaneous earth fault relay having an adjustable setting range of 10-40% or 20 - 80% of CT secondary current and adjustable definite minimum time. The earth fault relay shall be provided with a stabilising resistor.

(viii) One (1) set — Current and Voltage transducers.

(ix) One (1) set — High speed tripping relays.

1.25.5 **Module Type - M1 (Circuit Breaker Controlled Motor Feeder)**

(i) One (1) — Triple pole Air Circuit Breaker complete with accessories, and power operated mechanism as specified.

(ii) One (1) — Three position 6 pole selector switch 'SWITCHGEAR/NORMAL /TRIAL'.

(iii) Three (3) — Current Transformer for metering.

(iv) One (1) — Ammeter with Ammeter Selector Switch

(v) Three (3) — Current Transformer for relaying.

(vi) One (1) — Triple pole instantaneous over-current relay for providing positive sequence current protection in all the three phases. The relay setting range shall be continuously adjustable between 200-800% or 400-1600% of CT secondary rated current as required.

(vii) One (1) Double pole inverse definite minimum time over current relays connected in R & B phases for over current protection of motor rated 110 kW - 200 kW. The relay shall have an adjustable setting range of 50% - 200% of CT Secondary current and time setting range of 0-30 second. The relay shall be CDGM-22 of EE or equivalent.

(viii) One (1) Single pole adjustable definite time delay relay for motor overload alarm connected in Y-phase only. The relay shall have resetting ratio of not less than 90%. The relay shall have continuously adjustable time delay range of 2.5 to 25 Sec.

(ix) One (1) Instantaneous earth fault relay having an adjustable setting range of 10-40% or 20-80% of CT secondary current. The earth fault relay shall be provided with a stabilising resistor.

(x) One (1) set Current and Voltage transducers.

(xi) One (1) set High speed tripping relay.

1.25.6 **Module Type E**

(i) One (1) Four pole MCCB

1.25.7 **Module G-1 (VT Module with under Voltage Relay)**

(i) Three (3) $\frac{400}{\sqrt{3}} / \frac{110}{\sqrt{3}}$ volts single phase voltage transformer star/star Connect with star point solidly earthed mounted on common draw out chassis. Accuracy Class 0.5 for protection and One (1) four position voltmeter selector switch.

(ii) One (1) Voltmeter (0-500V)

(iii) One (1) Double pole instantaneous under voltage relays with continuous variable setting range of 40-80% of 110 Volts.

(iv) One (1) Time delay pick up relay having a time setting range of 0.5 to 3 secs. with 3 `NO'. Self reset contacts, suitable for 220V DC.

(v) One (1) Auxiliary relay 220V DC with 2 NO. self reset contacts.

(vi) Three (3) Indicating lamps with series resistor and colour lenses (Red, Blue & Yellow).

1.25.8 **Module Type G-2**

(i) Three (3) HRC Fuse

(ii) One (1) Voltmeter (0-500V)

(iii) One (1) Voltmeter selector switch four position (R-Y, Y-B, B-R OFF).

(iv) Three (3) Indication lamps (Red, Blue & Yellow)

1.25.9 **Module Type H & H (BC) (Isolating Switch Controlled Incoming Circuit)**

(i) One (1) Four pole MCCB

(ii) One (1) Red Indicating lamp to indicate isolating switch closed position.

1.25.10 **Module Type S: (DC Metering and Protection Module)**

(i) One (1) Voltmeter 300-0-300V DC for 220V DC DB/Voltmeter 0-75V DC for 50V DCDB

(ii) One (1) Three (3) position voltmeter selector switch

(iii) One (1) Instantaneous under voltage relay with 95% of 220V DC. The resetting ratio of relay of relay should not be more than 1.25. The relay shall be provided with a series resistor and a push button across if for resetting (pick up) the relay at about 105% of the drop out voltage.

(iv) One (1) Instantaneous over voltage relay with setting range of 110% of 220V DC. The resetting ratio of relay should not be less than 0.8. The relay shall have a push button in series of resetting the relay at about 95% of the operating voltage.

(v) One (1) Earth leakage relay only for 220V DC system having adjustable pick up range between 3 to 7 milliamps the relay shall be suitable for 220V DC/230V AC Auxiliary supply.

1.25.11 **Module Type X**

One (1) One (1) Double pole 250 V MCB/ MCCB suitable for 20kA for 1 sec. Fault level

1.25.12 **Module Type-DC (Incomer from Battery & Chargers)**

(i) One (1) Double pole 250V DC MCCB for incomer from Battery.

(ii) One (1) DC ammeter with shunt and range of 90-0-400 Amps. For 220V DC DB and 90-0-200 Amp for 50V DC DB.

(iii) Two (2) Double pole 250V DC MCCB/MCB

(iv) One (1) Double pole single throw 250V DC air break switch connecting battery & charger sections to DC DB.

(v) One (1) set Voltage and Current Transducers

1.25.13 **Module Type DG-1 (Electrically Controlled Circuit Breaker for Incomer from DG Set)**

a) One (1) Triple pole circuit breaker complete with all accessories and power operated mechanism as specified.

b) One (1) Frequency meter.

c) One (1) Voltmeter with selector switch.

d) One (1) Remote/Local Selector switch.

e) Three (3) Current transformer for metering.

f) Six (6) Current Transformers for differential protection (out of this 3 Nos. will be supplied loose for mounting in DG set panel).

g) Three (3) Current transformer for relaying.

h) One (1) Ammeter Selector Switch.

i) One (1) Ammeter

j) One (1) Wattmeter of range 0-300 KW.

k) One (1) Three pole voltage controlled definite time delay relay having current setting range of 50-200% of CT secondary current and adjustable time delay 0.3 to 3 secs.

l) One (1) Watt hour meter with six (6) digits and minimum count of one (1) kwh.

m) One (1) Single pole definite time over current relay having a continuous setting range of 50-200% of CT secondary current and a time delay of 2.5-25 secs connected in CT of Y phase for overload alarm. The relay shall have a setting ratio of not less than 90%.

n) One (1) Three pole differential protection relay having an operating current setting range of 10-40% of generator full load current. The relay shall be of high impedance type, with necessary stabilizing resistors.

o) Two (2) Push buttons for Remote starting & stopping of DG Set (Red, Green).

p) One (1) set of Current and Voltage transducers.

q) One (1) set High speed tripping relays.

1.25.14 **Module Type H1**

One (1) Double pole DC Switch with pad locking facility in off position.

1.25.15 **Module Type EL**

(i) One (1) Four pole MCCB

(ii) One (1) Contactor

(iii) Electronic Timer suitable for continuous operation, push button and selector switch be as per scheme requirement

1.26 **PARAMETERS**

1.26.1 **Power Supply**

1.26.1.1.1 AC System 3 phase, 4 wire, solidly earthed

a) Voltage 400 Volts, ± 10%

b) Frequency 50 Hz ± 2.5%

c) Combined variation ± 105% Absolute Sum in Voltage & frequency

d) Fault Level 20 kA (rms)

1.26.1.1.1.1.1 **DC System** 2 Wire, unearthed

a) System voltage 220V ± 10%

b) Fault Level 4 kA

c) System Voltage 48 V ± 10%

d) Fault Level --

1.26.2 **Control Supply Voltage**

a) Trip and closing coils 220V DC Unearthed

b) Spring charging 220V DC Unearthed

1.26.3 **Cubicle Data**

1.26.3.1 **Busbar Rating**

a) Continuous for Vertical panels. As specified in Standard SLD For AC & DC system.

b) Short time (1 sec. kA (rms) 20 kA

c) Momentary (kA) PEAK 45 kA

d) Ambient Temperature 50°C

e) One Minute Power Frequency Withstand

I. Power Circuit 2500 Volts (rms)
II. Control Circuit 2500 Volts (rms)

1.26.3.2 **Cubicle Colour Finish**

a) Interior Smoke Grey shade No.692

b) Exterior Smoke Grey shade No.692

1.26.4 **Circuit Breaker**

a)	Type	Air Break
b)	No. of poles	3
c)	Voltage & Frequency	400 Volts, ± 10%, 50 HZ + 2.5%
d)	Rated Operating Duty	As per IEC
e)	Rated service short-circuit Breaking capacity (Ics)	20 kA (RMS)
f)	Short Circuit making current	45 kA (Peak)
g)	Short time withstand current for 1 sec. duration.	20 kA (RMS) for 1 sec.
h)	Operating Mechanism current for 1 sec. duration.	20 kA (RMS) for 1 sec.
i)	No. of auxiliary contacts	4 NO & 4 NC contacts for Purchaser's use on fixed portion of the cubicle
j)	Short Circuit breaking current	
	I. AC Component	20 kA (RMS)
	II. DC Component	As per IEC: 60947 (Part 2)

1.26.5 **MOULDED CASE CIRCUIT BREAKER**

		AC System	DC System
a)	No. of poles	4	2
b)	Voltage & Frequency	400 Volts, ± 10% 50 HZ ± 2.5%	250V
c)	Rated Operating Duty	As per IEC	
d)	Rated service short-circuit Breaking capacity (Ics)	20 kA (RMS)	4 kA
e)	Short Circuit making current	45 kA (Peak)	-
f)	No. of auxiliary Contacts (only for incomer And bus-coupler MCCBs)	1 NO &1 NC	1 NO &1 NC
g)	Rated Ultimate Short Circuit		

	breaking capacity		
	I. AC Component	20 kA (RMS)	As per IEC
	II. DC Component	As per IEC 60947	As per IEC 60947

1.26.6 **Meters**

a)	Accuracy class	2.5
b)	One minute power frequency withstand test voltage in KV	2.0

1.26.7 **Current Transformers**

a)	Type	Cast resin, Bar primary
b)	Voltage class and frequency	650V, 50 Hz
c)	Class of Insulation	E or better
d)	Accuracy class metering CT	Class 1, VA adequate for application but not less than 7.5 VA.
e)	Accuracy class protection CT	5 P 15, VA adequate for application, but not less than 7.5 VA.
f)	Accuracy class differential protection	PS, KPV = 300V
g)	Short Time Current Rating (for CTs Associated with circuit breakers)	
	I. Current	20 kA (RMS)
	II. Duration	One Second
	III. Dynamic Rating	45 kA (Peak)
	IV. One minute power frequency withstand test voltage.	2.5 kV (rms)

1.26.8 **Voltage Transformer**

a)	Type	Cast Resin
b)	Rated Voltage	
	Primary	400/√3 V
	Secondary	110/√3 V

c)	Method of connection	
	Primary	Star
	Secondary	Star
d)	Rated voltage factor	1.1 continuous, 1.5 for 3 seconds
e)	Class of insulation	E or better
f)	One minute power frequency withstand voltage	2.5 KV (RMS)
g)	Accuracy class	0.5, not less than 20VA

1.26.9 **Relay**

a) One minute power Frequency withstand test	2 kV (rms)

1.26.10 **Transducers (1 phase)**

	Current	**Voltage**
a) Operating Voltage	220 V DC	220V DC
b) I/P	1A.	110V AC
c) O/P	4-20 mA	4-20 mA
d) Type	Analogue	Analogue

1.26.11 **Lighting Transformers**

Lighting transformers shall be of 100 KVA rating, 400/4400 V, 3 phase, 50 Hz Dry type natural air cooled type. The technical parameters of these lighting transformers are as follows:

Technical Parameters of Lighting Transformer

Type of transformer	:	Dry type natural air cooled
Rating	:	100 KVA
Voltage ratio	:	400/400 volts
No. of phases	:	Three
Frequency	:	50 Hz
Winding connection	:	Dyn-1
Class of insulation	:	'B' class
Impedance	:	4% ± 10%
No. of taps & steps	:	5, ± 5% in steps of 2.5%
Ref. standard	:	IEC: 60076

1.27 AUTOMATIC CONTROL OF OUTDOOR LIGHTING

1.27.1 EL-type module of 400V Main lighting distribution board and Emergency lighting distribution board and shall be controlled by timer and contactor module to facilitate its operation automatically.

1.28 AUTOMATIC SUPPLY CHANGEOVER

Automatic changeover between Incomer I, Incomer II, and DG set is to be carried out during the failure of supply in one/or both the incomers. After the restoration of the supply, system shall be restored to normal condition automatically. The requirement of changeover under various conditions are as below:

(i) Under normal conditions i.e. when supply is available in both the incomers, incomers
I&II of 400 V Main switchboard, ACDB shall be in closed condition and Bus couplers and DG set breaker shall be in open condition.

(ii) In case of failure of either of the sources, the incomer of that source shall trip and Bus coupler shall get closed. On restoration of supply, normal conditions described above are to be established automatically.

iii) In case of failure of supply in both the sources, both incomers, incomers of ACDBs and ACDB Bus coupler shall trip and DG set breaker switched on. On restoration of one or both sources, DG set breaker shall trip, DG set stopped and Conditions described in paragraph (i) /(ii) shall be restored.

To avoid unnecessary operation of switchgear for momentary disturbances all changeovers from one state to another shall be initiated after a time delay, after the conditions warranting such change has been detected.

1.29 ANALOGUE INPUTS

LT System shall have provision of following analogue inputs for owner's substation automation purpose. These analogue inputs shall be generated by distinct transducers to be provided in respective modules. These inputs shall be wired up to respective terminal blocks.

ANALOGUE INPUTS:

i) Voltage R-Y, Y-B, B-R of Main Switch Board section-I
ii) Voltage R-Y, Y-B, B-R of Main Switch Board section-II
iii) Current from LT transformer-I
iv) Current from LT transformer-II
v) Voltage of 220V DCDB-I
vi) Voltage of 220V DCDB-II
vii) Current from 220V Battery set-I
viii) Current from 220V Battery set-II
ix) Voltage of 48V DCDB-I
x) Voltage of 48V DCDB-II
xi) Current from 48V Battery set-I
xii) Current from 48V Battery set-II

1.30 DIGITAL (Potential Free) INPUTS:

LT System shall have provision of following digital inputs for owner's substation automation purpose. These digital inputs shall be made available in the form of potential free contacts to be provided in respective modules. These potential free contacts shall be wired up to respective terminal blocks.

i) Main (MSB) Incomer-I breaker On/Off
ii) Main (MSB) Incomer-II breaker On/Off
iii) Main(MSB) 400V Bus-I/II U/V
iv) Main (MSB) bus coupler breaker on/off
v) DG set breaker on/off
vi) LT transformer-I Bunchholz Alarm & trip

vii) LT transformer-II Buchloz Alarm & trip
viii) LT transformer-I WTI Alarm & trip
ix) LT transformer-II WTI Alarm & trip
x) LT transformer-I OTI Alarm & trip
xi) LT transformer-II OTI Alarm & trip
xii) 220 V DC-I earth fault
xiii) 220V DC-II earth fault

SECTION 17: SUBSTATION AUTOMATION SYSTEM

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1.0 GENERAL

1.1. The substation automation system shall be offered from a manufacturer who must have designed, manufactured, tested, installed and commissioned substation automation system which must be in satisfactory operation on 220kV system or higher for at least 2 (Two) years as on the date of bid opening.

1.2. The Substation Automation System (SAS) shall be installed to control and monitor all the sub-station equipment from remote control centre (RCC) as well as from local control centre.

The SAS shall contain the following main functional parts:

- Bay control Intelligence Electronic Devices (IEDs) for control and monitoring.
- Station Human Machine Interface (HMI)
- Redundant managed switched Ethernet Local Area Network communication infrastructure with hot standby.
- Gateway for remote control via industrial grade hardware (to RCC) through IEC60870-5-101 protocol.
- Gateway for remote supervisory control (to RSCC), the gateway should be able to communicate with RSCC on IEC 60870-5-101 protocol. The specific protocol to be implemented is enclosed as Appendix-I.. It shall be the bidder's responsibility to integrate his offered system with existing RSCC system for exchange of desired data. The requirement of IO point shall be worked out by the bidder as per criterion enclosed as Appendix-II for data exchange with RLDCs.
- Remote HMI.

1.3. Peripheral equipment like printers, display units, key boards, Mouse etc. It shall enable local station control via a PC by means of human machine interface (HMI) and control software package, which shall contain an extensive range of supervisory control and data acquisition (SCADA) functions. It shall include communication gateway, intelligent electronic devices (IED) for bay control and inter IED communication infrastructure. An architecture drawing for SAS is enclosed.

1.4. The communication gateway shall facilitate the information flow with remote control centres. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions.

2. System design

2.1 General system design

The Substation Automation System (SAS) shall be suitable for operation and monitoring of the complete substation including future extensions as given in Chapter 1 - GTS.

The systems shall be of the state-of-the art suitable for operation under electrical environment present in Extra High Voltage substations, follow the latest engineering practice, ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

The offered SAS shall support remote control and monitoring from Remote Control centres via gateways.

The system shall be designed such that personnel without any background knowledge in Microprocessor-based technology are able to operate the system. The operator interface shall be intuitive such that operating personnel shall be able to operate the system easily after having received some basic training.

The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signalling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records.

Maintenance, modification or extension of components may not cause a shutdown of the whole substation automation system. Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

Bidder shall offer the Bay level unit (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer), bay mimic along with relay and protection panels and PLCC panels (described in other sections of technical specifications) housed in air-conditioned *Switchyard Panel Room* suitably located in switchyard and Station HMI in Control Room building for overall optimisation in respect of cabling and control room building.

2.2 System architecture

The SAS shall be based on a decentralized architecture and on a concept of bay-oriented, distributed intelligence.

Functions shall be decentralized, object-oriented and located as close as possible to the process.

The main process information of the station shall be stored in distributed databases. The typical SAS architecture shall be structured in two levels, i.e. in a station and a bay level.

At bay level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The IEDs should be directly connected to the switchgear without any need for additional interposition or transducers.

Each bay control IED shall be independent from each other and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station.

The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fibre-optic cables, thereby guaranteeing disturbance free communication. The fibre optic cables shall be run in G.I. conduit pipes. Data exchange is to be realised using IEC 61850 protocol with a redundant managed switched Ethernet communication infrastructure

The communication shall be made in fault tolerant ring in redundant mode, excluding the links between individual bay IEDs to switch wherein the redundant connections are not envisaged, such that failure of one set of fiber shall not affect the normal operation of the SAS. However, failure of fiber shall be alarmed in SAS. Each fiber optic cable shall have four (4) spare fibers.

At station level, the entire station shall be controlled and supervised from the station HMI. It shall also be possible to control and monitor the bay from the bay level equipment at all times.

Clear control priorities shall prevent operation of a single switch at the same time from more than one of the various control levels, i.e. RCC, station HMI, bay level or apparatus level. The priority shall always be on the lowest enabled control level.

The station level contains the station-oriented functions, which cannot be realised at bay level, e.g. alarm list or event list related to the entire substation, gateway for the communication with remote control centres.

The GPS time synchronising signal (as specified in the section relay & protection) for the synchronization of the entire system shall be provided.

The SAS shall contain the functional parts as described in para 1.2 above.

2.3 FUNCTIONAL REQUIREMENTS

The high-voltage apparatus within the station shall be operated from different places:

- Remote control centres
- Station HMI.
- Local Bay controller IED (in the bays)

Operation shall be possible by only one operator at a time.

The operation shall depend on the conditions of other functions, such as interlocking, synchro check, etc. (see description in ”Bay level control functions”).

2.3.1 Select-before-execute

For security reasons the command is always to be given in two stages: selection of the object and command for operation under all mode of operation except emergency operation. Final execution shall take place only when selection and command are actuated.

2.3.2 Command supervision

Bay/station interlocking and blocking

Software Interlocking is to be provided to ensure that inadvertent incorrect operation of switchgear causing damage and accidents in case of false operation does not take place.

In addition to software interlocking hardwired interlocking are to be provided for:

(a) Bus Earth switch Interlocking

(b) Transfer Bus interlocking (if applicable)

It shall be a simple layout, easy to test and simple to handle when upgrading the station with future bays. For software interlocking the bidder shall describe the scenario while an IED of another bay is switched off or fails.

A software interlock override function shall be provided which can be enabled to bypass the interlocking function.

2.3.3 Run Time Command cancellation

Command execution timer (configurable) must be available for each control level connection. If the control action is not completed within a specified time, the command should get cancelled.

2.3.4 Self-supervision

Continuous self-supervision function with self-diagnostic feature shall be included.

2.3.5 User configuration

The monitoring, controlling and configuration of all input and output logical signals and binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely.

It shall also be possible to interconnect and derive input and output signals, logic functions, using built-In functions, complex voltage and currents, additional logics (AND-gates, OR gates and timers). (Multi-activation of these additional functions should be possible).

The Functional requirement shall be divided into following levels:

a. Bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer) Level Functions

b. System Level Functions

3.1. Bay level functions

In a decentralized architecture the functionality shall be as close to the process as possible. In this respect, the following functions can be allocated at bay level:

- Bay control functions including data collection functionality in bay control/protection unit.
- Bay protection functions

Separate IEDs shall be provided for bay control function and bay protection function.

3.1.1. Bay control functions

3.1.1.1. Overview

Functions

- Control mode selection
- Select-before-execute principle
- Command supervision:
  - Interlocking and blocking
  - Double command
- Synchrocheck, voltage selection
- Run Time Command cancellation
- Transformer tap changer control (Raise and lower of tap) (for power transformer bays)
- Operation counters for circuit breakers and pumps
- Hydraulic pump/ Air compressor runtime supervision
- Operating pressure supervision through digital contacts only
- Breaker position indication per phase
- Alarm annunciation
- Measurement display
- Local HMI (local guided, emergency mode)
- Interface to the station HMI.
- Data storage for at least 200 events
- Extension possibilities with additional I/O's inside the unit or via fibre-optic communication and process bus

3.1.1.2. Control mode selection

Bay level Operation:

As soon as the operator receives the operation access at bay level the operation is normally performed via bay control IED. During normal operation bay control unit allows the safe operation of all switching devices via the bay control IED.

EMERGENCY Operation

It shall be possible to close or open the selected Circuit Breaker with ON or OFF push buttons even during the outage of bay IED.

REMOTE mode

Control authority in this mode is given to a higher level (Remote Control Centre) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

3.1.1.3. Synchronism and energizing check

The synchronism and energizing check functions shall be bay-oriented and distributed to the bay control and/or protection devices. These features are:

- Settable voltage, phase angle, and frequency difference.
- Energizing for dead line - live bus, live line - dead bus or dead line – dead bus with no synchro-check function.
- Synchronising between live line and live bus with synchro-check function

Voltage selection

The voltages relevant for the Synchro-check functions are dependent on the station topology, i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronizing and energizing is derived from the auxiliary switches of the circuit breakers, the isolator, and earthing switch and shall be selected automatically by the bay control and protection IEDs.

3.1.1.4. Transformer tap changer control

Raise and lower operation of OLTC taps of transformer shall be facilitated through Bay controller IED.

3.1.2. Bay protection functions

3.1.2.1. General

The protection functions are independent of bay control function. The protection shall be provided by separate protection IEDs (numerical relays) and other protection devices as per section Relay & Protection.

IEDs, shall be connected to the communication infrastructure for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.

Event and disturbance recording function

Each IED should contain an event recorder capable of storing at least 200 time-tagged events. The disturbance recorder function shall be as per detailed in Chapter 15 – Control, Relay & Protection Panels.

3.1.2.2. **Bay Monitoring Function:**

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated in the Bay control/protection unit.

3.2. System level functions

3.2.1. Status supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, transformer tap changer etc., shall be supervised continuously. Every detected change of position shall be immediately displayed in the single-line diagram on the station HMI screen, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in the case of spontaneous position changes.

The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.

The SAS shall also monitor the status of sub-station auxiliaries. The status and control of auxiliaries shall be done through separate one or more IED and all alarm and analogue values shall be monitored and recoded through this IED.

3.2.2. Measurements

The analogue values acquired/calculated in bay control/protection unit shall be displayed locally on the station HMI and in the control centre. The abnormal values must be discarded. The analogue values shall be updated every 2 seconds.

Threshold limit values shall be selectable for alarm indications.

3.2.3. Event and alarm handling

Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All, or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time-tagged with a time resolution of 1 ms. The tentative list for various feeders and systems are enclosed as Annexure-I

3.2.4. Station HMI

3.2.4.1. Substation HMI Operation:

On the HMI the object has to be selected first. In case of a blocking or interlocking condition are not met, the selection shall not be possible and an appropriate alarm annunciation shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object.

Control operation from other places (e.g. REMOTE) shall not be possible in this operating mode.

3.2.4.2. Presentation and dialogues

General

The operator station HMI shall be a redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear on the screen via mouse clicks.

The HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log.

An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from any screen selected by the operator.

The following standard pictures shall be available from the HMI:

- Single-line diagram showing the switchgear status and measured values
- Control dialogues with interlocking or blocking information details. This control dialogue shall tell the operator whether the device operation is permitted or blocked**.**
- Measurement dialogues
- Alarm list, station / bay-oriented
- Event list, station / bay-oriented
- System status

3.2.4.3. HMI design principles

Consistent design principles shall be adopted with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

The object status shall be indicated using different status colours for:

- Selected object under command
- Selected on the screen
- Not updated, obsolete values, not in use or not sampled
- Alarm or faulty state

- Warning or blocked
- Update blocked or manually updated
- Control blocked
- Normal state

3.2.4.4. Process status displays and command procedures

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap-changers shall be displayed in the station single-line diagram.

In order to ensure a high degree of security against undesired operation, a "select-before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen, and all other switchgear shall be blocked. As communication between control centre and device to be controlled is established, the operator shall be prompted to confirm the control action and only then final execute command shall be accepted**.** After the "execution" of the command the operated switching symbol shall flash until the switch has reached its new position.

The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level.

After command execution the operator shall receive a confirmation that the new switching position has been reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

3.2.4.5. System supervision & display

The SAS system shall be comprehensively self-monitoring such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are recorded as a faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication infrastructure and remote communication links, and printers at the station level, etc.

3.2.4.6. Event list

The event list shall contain events that are important for the control and monitoring of the substation.

The event and associated time (with1 ms resolution) of its occurrence has to be displayed for each event.

The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.

A printout of each display shall be possible on the hard copy printer.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer for at least one month. The information shall be obtainable also from a printed event log.

The chronological event list shall contain:

- Position changes of circuit breakers, isolators and earthing devices
- Indication of protective relay operations
- Fault signals from the switchgear
- Indication when analogue measured values exceed upper and lower limits. Suitable provision shall be made in the system to define two level of alarm on either side of the value or which shall be user defined for each measurands.
- Loss of communication.

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

- Date and time
- Bay
- Device
- Function e.g. trips, protection operations etc.
- Alarm class

3.2.4.7. Alarm list

Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control centre. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated.

The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

- The date and time of the alarm
- The name of the alarming object
- A descriptive text
- The acknowledgement state.

Whenever an alarm condition occurs, the alarm condition must be shown on the alarm list and must be displayed in a flashing state along with an audible alarm. After acknowledgement of the alarm, it should appear in a steady (i.e. not flashing) state and the audible alarm shall stop. The alarm should disappear only if the alarm condition has physically cleared and the operator has reset the alarm with a reset command. The state of the alarms shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent).

Filters for selection of a certain type or group of alarms shall be available as for events.

3.2.4.8. Object picture

When selecting an object such as a circuit breaker or isolator in the single-line diagram, the associated bay picture shall be presented first. In the selected object picture, all attributes like

- Type of blocking
- Authority
- Local / remote control
- RSCC / SAS control
- Errors
- etc.

shall be displayed.

3.2.4.9. Control dialogues

The operator shall give commands to the system by means of mouse click located on the single-line diagram. Data entry is performed with the keyboard. Dedicated control dialogues for controlling at least the following devices shall be available:

- Breaker and disconnector
- Transformer tap-changer

3.2.5. User-authority levels

It shall be possible to restrict activation of the process pictures of each object (bays, apparatus...) within a certain user authorisation group. Each user shall then be given access rights to each group of objects, e.g.:

- Display only
- Normal operation (e.g. open/close of switchgear)
- Restricted operation (e.g. by-passed interlocking)
- System administrator

For maintenance and engineering purposes of the station HMI, the following authorisation levels shall be available:

- No engineering allowed
- Engineering/configuration allowed
- Entire system management allowed

The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

3.2.6. Reports

The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise:

- Trend reports:
  - Day (mean, peak)
  - Month (mean, peak)
  - Semi-annual (mean, peak)
  - Year (mean, peak)
- Historical reports of selected analogue Values:
  - Day (at 15 minutes interval)
  - Week
  - Month
  - Year

It shall be possible to select displayed values from the database in the process display on-line. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.

Following printouts shall be available from the printer and shall be printed on demand:

i. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.

ii. Weekly trend curves for real and derived analogue values.

iii. Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.

iv. Provision shall be made for logging information about breaker status like number of operations with date and time indications along with the current value it interrupts (in both conditions i.e. manual opening and fault tripping)

v. Equipment operation details shift wise and during 24 hours.

vi. Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each feeder and transformer as well as Tap Positions, temperature and status of pumps and fans for transformers.

vii. Printout on adjustable time period as well as on demand system frequency and average frequency.

viii. Reports in specified formats which shall be handed over to successful bidder. The bidder has to develop these reports. The reports are limited to the formats for which data is available in the SAS database.

3.2.7. Trend display (historical data)

It shall be possible to illustrate all types of process data as trends - input and output data, binary and analogue data. The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen. Adjustable time span and scaling ranges must be provided.

It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

3.2.8. Automatic disturbance file transfer

All recorded data from the IEDs with integrated disturbance recorder as well as dedicated disturbance recording systems shall be automatically uploaded (event triggered or once per day) to a dedicated computer and be stored on the hard disc.

3.2.9. Disturbance analysis

The PC-based work station shall have necessary software to evaluate all the required information for proper fault analysis.

3.2.10. IED parameter setting

It shall be possible to access all protection and control IEDs for reading the parameters (settings) from the station HMI or from a dedicated monitoring computer. The setting of parameters or the activation of parameter sets shall only be allowed after entering a password.

3.2.11. Automatic sequences

The available automatic sequences in the system should be listed and described, (e.g. sequences related to the bus transfer). It must be possible to initiate pre-defined automatic sequences by the operator and also define new automatic sequences.

3.3. Gateway

3.3.1 Communication Interface

The Substation Automation System shall have the capability to support simultaneous communications with multiple independent remote master stations,

The Substation Automation System shall have communication ports as follows:
(a) Two ports for Remote Control Centre
(b) Two ports for Regional System Coordination Centre (RSCC)

The communication interface to the SAS shall allow scanning and control of defined points within the substation automation system independently for each control centre. The substation automation system shall simultaneously respond to independent scans and commands from employer's control centres (RCC & RSCC). The substation automation system shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to

each remote control centre. Also, each control centre's data scan and control commands may be different for different data points within the substation automation system's database.

3.3.2 Remote Control Centre Communication Interface

Employer will supply communication channels between the Substation Automation System and the remote control centre. The communication channels provided by Employer will consist either of power line carrier, microwave, optical fibre, VSAT or leased line, the details of which shall be provided during detailed Engineering.

3.3.3 **Interface equipment:**

The Contractor shall provide interface equipment for communicating between Substation Automation system and Remote control centre and between Substation Automation system and Regional System Coordination Centre (RSCC). However, the communication channels available for this purpose are specified in Chapter 1 - GTS.

In case of PLCC communication any modem supplied shall not require manual equalization and shall include self-test features such as manual mark/space keying, analogue loop-back, and digital loop-back. The modems shall provide for convenient adjustment of output level and receive sensitivity. The modem should be standalone complete in all respects including power supply to interface the SAS with communication channel. The configuration of tones and speed shall be programmable and maintained in non-volatile memory in the modem. All necessary hardware and software shall also be in the scope of bidder.

3.3.4 Communication Protocol

The communication protocol for gateway to control centre must be open protocol and shall support IEC 60870-5-101 and IEC 61850 for all levels of communication for substation automation such as Bay to station HMI, gateway to remote station etc.

4.0 System hardware:

4.1 Redundant Station HMI, Remote HMI and Disturbance Recorder Work station:

The contractor shall provide redundant station HMI in hot standby mode. The servers used in these work stations shall be of industrial grade**.**

It shall be capable to perform all functions for entire substation including future requirements as indicated in the SLD. It shall use industrial grade components. Processor and RAM shall be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used. Supplier shall demonstrate these features.

The capacity of hard disk shall be selected such that the following requirement should occupy less than 50% of disk space:

1. Storage of all analogue data (at 15 Minutes interval) and digital data including alarm, event and trend data for thirty (30) days,
2. Storage of all necessary software,
3. 20GB space for OWNER'S use.

Supplier shall demonstrate that the capacity of hard disk is sufficient to meet the above requirement.

4.1.1 **HMI (Human Machine Interface**)

The VDU shall show overview diagrams (Single Line Diagrams) and complete details of the switchgear with a colour display. All event and alarm annunciation shall be selectable in the form of lists. Operation shall be by a user-friendly function keyboard and a cursor positioning device. The user interface shall be based on WINDOWS concepts with graphics & facility for panning, scrolling, zooming, decluttering e.t.c.

4.1.2 Visual Display Units/TFT's (Thin Film Technology)

The display units shall have high resolution and reflection protected picture screen. High stability of the picture geometry shall be ensured. The screen shall be at least 21" diagonally in size and capable of colour graphic displays.

The display shall accommodate resolution of 1280 X 1024 pixels.

4.1.3 Printer

It shall be robust & suitable for operation with a minimum of 132 characters per line. The printing operation shall be quiet with a noise level of less than 45 dB suitable for location in the control room. Printer shall accept and print all ASCII characters via master control computer unit interface.

The printer shall have in built testing facility. Failure of the printer shall be indicated in the Station HMI. The printer shall have an offline mode selector switch to enable safe maintenance. The maintenance should be simple with provisions for ease of change of print head, ribbon changing, paper insertion etc.

All reports and graphics prints shall be printed on laser printer. One dot matrix printer shall be exclusively used for hourly log printing.

All printers shall be continuously online.

4.1.4 Mass Storage Unit

The mass storage unit shall be built-in to the Station HMI. All operational measured values, and indications shall be stored in a mass-storage unit **in form** of **DVD RW.** The unit should support at least Read (48X), Write (24X), and Re-Write (10X) operations, with Multi-Session capability. It should support ISO9660, Rockridge and Joliet Filesystems. It should support formatting and use under the operating system provided for Station HMI. The monthly back up of data shall be taken on disc. The facility of back up of data shall be inherent in the software**.**

4.1.5 Switched Ethernet Communication Infrastructure:

The bidder shall provide the redundant switched optical Ethernet communication infrastructure for SAS. One switch shall be provided to connect all IEDs for two bays of 220kV yard to communication infrastructure. Each switch shall have at least two spare ports for connecting bay level IEDs and one spare port for connecting station bus.

4.2 Bay level unit

The bay unit shall use industrial grade components. The bay level unit, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select-before-operate control principles as safety measures for operation via the HMI. They shall perform all bay related functions, such as control commands, bay interlocking, data acquisition, data storage, event recording and shall provide inputs for status indication and outputs for commands. They shall be directly connected to the switchgear. The bay unit shall acquire and process all data for the bay (Equipment status, fault indications, measured values, alarms etc.) and transmit these to the other devices in sub-station automation system. In addition, this shall receive the operation commands from station HMI and control centre. The bay unit shall have the capability to store all the data for at least 24 hours.

One number Bay level unit shall be provided for supervision and control of each 220 kV bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer). The Bay level unit shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All bay level interlocks are to be incorporated in

the Bay level unit so as to permit control from the Bay level unit/ local bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out of service.

The bay control unit to be provided for the bays shall be preferably installed in the CB relay panel/feeder protection panel for respective bay.

The bay control unit for future bay (if required as per Chapter 1 – Project Specification Requirement) shall be installed in a separate panel.

The Bay level unit shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 61850. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.

4.2.1 Input/ Output (I/O) modules

The I/O modules shall form a part of the bay level unit and shall provide coupling to the substation equipment. The I/O modules shall acquire all switchgear information (i.e. data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear. The measured values of voltage and current shall be from the secondaries of instrument transformers. The digital inputs shall be acquired by exception with 1 ms resolution. Contact bouncing in digital inputs shall not be assumed as change of state

4.3 Switchyard Panel Room:

The switchyard panel room shall be constructed to house Bay level units, bay mimic, relay and protection panels, PLCC panels etc.. The layout of equipment/panel shall be subject to Owner's approval. The switchyard panel room shall be provided with necessary illuminations, fire alarm system with at least two detectors with necessary power supply if required and it shall be wired to SAS. The detailed constructional requirement of switchyard panel room is detailed in chapter 14 civil of technical specification and air conditioning requirement of switchyard panel room shall be as detailed in chapter 10 Air conditioning system of technical specification. The air conditioner provided in switchyard panel room shall be monitored from substation automation system.

4.4 Extendibility in future

Offered substation automation system shall be suitable for extension in future for additional bays. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the employer. During such event, normal operation of the existing substation shall be unaffected and system shall not require a shutdown. The contractor shall provide all necessary software tools along with source codes to perform addition of bays in future and complete integration with SAS by the user. These software tools shall be able to configure IED, add additional analogue variable, alarm list, event list, modify interlocking logics etc. for additional bays/equipment which shall be added in future.

5.0 Software structure

The software package shall be structured according to the SAS architecture and strictly divided in various levels. Necessary firewall shall be provided at suitable points in software to protect the system. An extension of the station shall be possible with lowest possible efforts. Maintenance, modification or an extension of components of any feeder may not force a shut-down of the parts of the system which are not affected by the system adaptation.

5.1.1 Station level software

5.1.1.1 Human-machine interface (HMI)

The base HMI software package for the operator station shall include the main SAS

functions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. Systems shall contain a library with standard functions and applications.

5.1.2 Bay level software

5.1.1.1 System software

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. The lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance engineer for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage. In case of restoration of links after failure, the software along with hardware shall be capable of automatically synchronising with the remaining system without any manual interface. This shall be demonstrated by contractor during integrated system test.

5.1.1.2 Application software

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They form part of a library.
The application software within the control/protection devices shall be programmed in a functional block language.

5.1.1.3 Network Management System (NMS):

The contractor shall provide a network management system software for following management functions:

a. Configuration Management
b. Fault Management
c. Performance Monitoring

This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in DR work-station and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any fault in the monitored devices. The NMS shall

(a) Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports.
(b) Maintain a graphical display of SAS connectivity and device status.
(c) Issue alarms when error conditions occurs
(d) Provide facility to add and delete addresses and links

5.1.1.4 The contractor shall provide each software in two copies in CD to load into the system in case of any problem related with Hardware/Communication etc.

6.0 TESTS

The substation automation system offered by the bidder shall be subjected to following tests to establish compliance with IEC 61850 for EHV sub-station equipment installed in sheltered area in the outdoor switchyard and specified ambient conditions:

6.1 Type Tests:

6.1.1 Control IEDs and Communication Equipment:

a. Power Input:

i. Auxiliary Voltage

ii. Current Circuits
iii. Voltage Circuits
iv. Indications

b. Accuracy Tests:

i. Operational Measured Values
ii. Currents
iii. Voltages
iv. Time resolution

c. Insulation Tests:

i. Dielectric Tests
ii. Impulse Voltage withstand Test

d. Influencing Quantities

i. Limits of operation
ii. Permissible ripples
iii. Interruption of input voltage

e. Electromagnetic Compatibility Test:

i. 1 MHZ. burst disturbance test
ii. Electrostatic Discharge Test
iii. Radiated Electromagnetic Field Disturbance Test
iv. Electrical Fast transient Disturbance Test
v. Conducted Disturbances Tests induced by Radio Frequency Field
vi. Magnetic Field Test
vii. Emission (Radio interference level) Test.
viii. Conducted Interference Test

f. Function Tests:

i. Indication
ii. Commands
iii. Measured value Acquisition
iv. Display Indications

g. Environmental tests:

i. Cold Temperature
ii. Dry Heat
iii. Wet heat
iv. Humidity (Damp heat Cycle)
v. Vibration
vi. Bump
vii. Shock

6.2 Factory Acceptance Tests:

The supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual bay level IED's applicable type test certificates shall be submitted**.**

The manufacturing and configuration phase of the SAS shall be concluded by the factory acceptance test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the user. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab. During FAT the entire Sub-station Automation System including complete control and protection system to be supplied under present scope shall be tested for complete functionality and configuration in factory itself. The extensive testing shall be carried out during FAT. The purpose of Factory Acceptance Testing is to ensure trouble free installation at site. No major configuration setting of system is envisaged at site.

If the complete system consists of parts from various suppliers or some parts are already installed on site, the FAT shall be limited to sub-system tests. In such a case, the complete system test shall be performed on site together with the site acceptance test (SAT).

6.2.1 Hardware Integration Tests:

The hardware integration test shall be performed on the specified systems to be used for Factory tests when the hardware has been installed in the factory. The operation of each item shall be verified as an integral part of system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software integration and factory testing of the system. The equipment expansion capability shall also be verified during the hardware integration tests. The vendor specifically demonstrates how to add a device in future in SAS during FAT. The device shall be from a different manufacturer than the SAS supplier.

6.2.2 Integrated System Tests:

Integrated system tests shall verify the stability of the hardware and the software. During the tests all functions shall run concurrently and all equipment shall operate a continuous 100 Hours period. The integrated system test shall ensure the SAS is free of improper interactions between software and hardware while the system is operating as a whole.

6.3 Site Acceptance Tests:

The site acceptance tests (SAT) shall completely verify all the features of SAS hardware and software. The bidder shall submit the detailed SAT procedure and SAT procedure shall be read in conjunction with the specification.

7.0 SYSTEM OPERATION

7.1 Substation Operation

7.1.1 NORMAL OPERATION

Operation of the system by the operator from the remote RCC or at the substation shall take place via industry standard HMI (Human Machine interface) subsystem consisting of graphic colour VDU, a standard keyboard and a cursor positioning device (mouse).

The coloured screen shall be divided into 3 fields:

i) Message field with display of present time and date
ii) Display field for single line diagrams
iii) Navigation bar with alarm/condition indication

For display of alarm annunciation, lists of events e.t.c a separate HMI View node shall be provided.

All operations shall be performed with mouse and/or a minimum number of function keys and cursor keys. The function keys shall have different meanings depending on the operation. The operator shall see the relevant meanings as function tests displayed in the command field (i.e. operator prompting). For control actions, the switchgear (i.e. circuit breaker etc.) requested shall be selectable on the display by means of the cursor keys. The switching element selected shall then appear on the background that shall be flashing in a different color. The operator prompting shall distinguish between: -

- Prompting of indications e.g. fault indications in the switchgear, and

- prompting of operational sequences e.g. execution of switching operations

The summary information displayed in the message field shall give a rapid display of alarm/message of the system in which a fault has occurred and alarm annunciation lists in which the fault is described more fully.

Each operational sequence shall be divided into single operation steps which are initiated by means of the function keys/WINDOW command by mouse. Operator prompting shall be designed in such a manner that only the permissible keys are available in the command field related to the specific operation step. Only those switching elements shall be accessed for which control actions are possible. If the operation step is rejected by the system, the operator prompting shall be supported by additional comments in the message field. The operation status shall be reset to the corresponding preceding step in the operation sequence by pressing one of the function keys. All operations shall be verified. Incorrect operations shall be indicated by comments in the message field and must not be executed.

The offer shall include a comprehensive description of the system. The above operation shall also be possible via WINDOWS based system by mouse.

8.0 POWER SUPPLY

Power for the substation automation system shall be derived from substation 220V DC system.
2No.s of Inverter of minimum 2KVA capacity shall be provided for servers, gateways station HMI disturbance recorder evaluation unit and its peripheral devices e.g. printer etc. In the event of Power failure, necessary safeguard software shall be built for proper shutdown. Inverter shall be connected to 220V DC independent source and should be used to drive 1No. each server/HMI/Gateway so that in case any failure of DC power supply system is not affected.

9.0 DOCUMENTATION

The following documents shall be submitted for employer's approval during detailed engineering:

(a) System Architecture Drawing
(b) Hardware Specification
(c) Functional Design Document
(d) Clear procedure describing how to add an IED/bay/diameter in future covering all major supplier

The following documentation to be provided for the system in the course of the project shall be consistent, CAD supported, and of similar look/feel. All CAD drawings to be provide in "dxf" format.

- List of Drawings
- Substation automation system architecture
- Block Diagram
- Guaranteed technical parameters, Functional Design Specification and Guaranteed availability and reliability
- Calculation for power supply dimensioning
- I/O Signal lists
- Schematic diagrams
- List of Apparatus
- List of Labels
- Logic Diagram (hardware & software)
- **Switchyard Panel Room** layout drawing
- Control Room Lay-out
- Test Specification for Factory Acceptance Test (FAT)
- Product Manuals
- Assembly Drawing

- Operator's Manual
- Complete documentation of implemented protocols between various elements
- Listing of software and loadable in CD ROM
- Other documents as may be required during detailed engineering

Two sets of hard copy and four sets of CD ROM containing all the as built documents/drawings shall be provided.

10.0 TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES

10.1 Training

Contractor personnel who are experienced instructors and who speak understandable English shall conduct training. The contractor shall arrange on its own cost all hardware training platform required for successful training and understanding in Nepal. The Contractor shall provide all necessary training material. Each trainee shall receive individual copies of all technical manuals and all other documents used for training. These materials shall be sent to Employer at least two months before the scheduled commencement of the particular training course. Class materials, including the documents sent before the training courses as well as class hand-outs, shall become the property of Employer. Employer reserves the right to copy such materials, but for in-house training and use only. Hands-on training shall utilize equipment identical to that being supplied to Employer.

The Contractor shall quote training prices as indicated in BPS.

The schedule, location, and detailed contents of each course will be finalized during Employer and Contractor discussions.

10.2 Computer System Hardware Course

A computer system hardware course shall be offered, but at the system level only. The training course shall be designed to give Employer hardware personnel sufficient knowledge of the overall design and operation of the system so that they can correct obvious problems, configure the hardware, perform preventive maintenance, run diagnostic programs, and communicate with contract maintenance personnel. The following subjects shall be covered:

(a) System Hardware Overview: Configuration of the system hardware.
(b) Equipment Maintenance: Basic theory of operation, maintenance techniques and diagnostic procedures for each element of the computer system, e.g., processors, auxiliary memories, LANs, routers and printers. Configuration of all the hardware equipments.
(c) System Expansion: Techniques and procedures to expand and add equipment such as loggers, monitors, and communication channels.
(d) System Maintenance: Theory of operation and maintenance of the redundant hardware configuration, failover hardware, configuration control panels, and failover switches. Maintenance of protective devices and power supplies.
(e) Subsystem Maintenance: Theory of design and operation, maintenance techniques and practices, diagnostic procedures, and (where applicable) expansion techniques and procedures. Classes shall include hands-on training for the specific subsystems that are part of Employer's equipment or part of similarly designed and configured subsystems. All interfaces to the computing equipment shall be taught in detail.
(f) Operational Training: Practical training on preventive and corrective maintenance of all equipment, including use of special tools and instruments. This training shall be provided on Employer equipment, or on similarly configured systems.

10.3 Computer System Software Course

The Contractor shall provide a computer system software course that covers the

following subjects:

(a) System Programming: Including all applicable programming languages and all stand-alone service and utility packages provided with the system. An introduction to software architecture, Effect of tuning parameters (OS software, Network software, database software etc.) on the performance of the system.
(b) Operating System: Including the user aspects of the operating system, such as program loading and integrating procedures; scheduling, management, service, and utility functions; and system expansion techniques and procedures
(c) System Initialization and Failover: Including design, theory of operation, and practice
(d) Diagnostics: Including the execution of diagnostic procedures and the interpretation of diagnostic outputs,
(e) Software Documentation: Orientation in the organization and use of system software documentation.
(f) Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

10.4 Application Software Course

The Contractor shall provide a comprehensive application software courses covering all applications including the database and display building course. The training shall include:

(a) Overview: Block diagrams of the application software and data flows. Programming standards and program interface conventions.
(b) Application Functions: Functional capabilities, design, and major algorithms. Associated maintenance and expansion techniques.
(c) Software Development: Techniques and conventions to be used for the preparation and integration of new software functions.
(d) Software Generation: Generation of application software from source code and associated software configuration control procedures.
(e) Software Documentation: Orientation in the organization and use of functional and detailed design documentation and of programmer and user manuals.
(f) Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

10.5 Requirement of training:

The contractor shall provide training for OWNER'S personnel comprehensively covering following courses.

S. No.	Name of Course
1	Computer System Hardware
2	Computer System Software
3	Application Software

11.0 Maintenance

11.1 Maintenance Responsibility during the Guaranteed Availability Period.

During Guaranteed Availability Period, the Contractor shall take continual actions to ensure the guaranteed availability and shall make available all the necessary resources such as specialist personnel, spare parts, tools, test devices etc. for replacement or repair of all defective parts and shall have prime responsibility for keeping the system operational. **During guarantee period as specified in tender document, contractor shall arrange bi-monthly visit of their representative to site to review the performance of system and in case any defect/shortcoming etc. is observed during the period, the same shall be set right by the contractor within 15 days.**

12.0 RELIABILITY AND AVAILABILITY

The SAS shall be designed so that the failure of any single component, processor, or device shall not render the system unavailable. The SAS shall be designed to satisfy the very high demands for reliability and availability concerning:

- Mechanical and electrical design
- Security against electromagnetic interference (EMI)
- High quality components and boards
- Modular, well-tested hardware
- Thoroughly developed and tested modular software
- Easy-to-understand programming language for application programming
- Detailed graphical documentation and application software
- Built-in supervision and diagnostic functions
- Security
  - Experience of security requirements
  - Process know-how
  - Select before execute at operation
  - Process status representation as double indications
- Distributed solution
- Independent units connected to the local area network
- Back-up functions
- Panel design appropriate to the harsh electrical environment and ambient conditions
- Panel grounding immune against transient ground potential rise

Outage terms

1) Outage

The state in which substation automation system or a unit of SAS is unavailable for Normal Operation as defined in the clause 7.1 due to an event directly related to the SAS or unit of SAS. In the event, the owner has taken any equipment/ system other than Sub-station Automation System for schedule/forced maintenance, the consequent outage to SAS shall not be considered as outage for the purpose of availability.

2) Actual outage duration (AOD)

The time elapsed in hours between the start and the end of an outage. The time shall be counted to the nearest $1/4^{th}$ of an hour. Time less than $1/4^{th}$ of an hour shall be counted as having duration of $1/4^{th}$ of an hour.

3) Period Hours (PH)

The number of hours in the reporting period. In a full year the period hour is 8760h (8784h for a leap year).

4) Actual Outage hours (AOH)

The sum of actual outage duration within the reporting period

$AOH = \sum AOD$

5) Availability:

Each SAS shall have a total availability of 99.98 % i.e. the ratio of total time duration minus the actual outage duration to total time duration.

12.1 Guarantees Required

The availability for the complete SAS shall be guaranteed by the Contractor. Bidder shall include in their offer the detailed calculation for the availability. The contractor shall demonstrate their availability guaranteed by conducting the availability test on the total sub-station automation system as a whole after commissioning of total Sub-station Automation system. The test shall verify the reliability and integrity of all sub-systems. Under these conditions the test shall establish an overall availability of 99.98%. After the lapse of 1000 Hours of cumulative test time, test records shall be examined to determine the conformance with availability criterion. In case of any outage during the availability test, the contractor shall rectify the problem and after rectification, the 1000 Hours period

start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.

The contractor has to establish the availability in a maximum period of three months from the date of commencement of the availability test.

After the satisfactory conclusion of test both contractor and employer shall mutually agree to the test results and if these results satisfy the availability criterion, the test is considered to be completed successfully. After that the system shall be taken over by the employer and then the guarantee period shall start.

13.0 Spares

13.1 Consumables:

All consumables such as paper, cartridges shall be supplied by the contractor till the SAS is taken over by the owner.

13.2 Availability Spares:

In addition to mandatory spares as listed in section project for SAS, the bidder is required to list the spares, which may be required for ensuring the guaranteed availability during the guaranteed availability period. The final list of spares shall form part of scope of supply and accordingly the price thereof shall be quoted by the bidder and shall be considered in the evaluation of the bids. During the guaranteed availability period, the spare parts supplied by the Contractor shall be made available to the Contractor for usage subject to replenishment at the earliest. Thus, at the end of availability period the inventory of spares with the Employer shall be fully replenished by the Contractor. However, any additional spares required to meet the availability of the system (which are not a part of the above spares supplied by the Contractor) would have to be supplied immediately by the Contractor free of cost to the Employer.

14.0 LIST OF EQUIPMENTS

Quantity of equipments shall be decided by bidder in order to achieve guaranteed reliability and availability as declared by bidder.

i) Station HMI
ii) Redundant Station HMI (in Hot-standby mode)
iii) Bay level units along with bay mimic as detailed in Chapter 1 – Project Specification Requirement.
iv) Bay Level Unit for Auxiliary system (as per requirement)
v) Disturbance Recorder Work Station (Maintenance HMI)
vi) Colour Laser Printer – 1 No. (For Reports & Disturbance records)
vii) Dot matrix printers - (one each for Alarms and log sheets)
viii) All interface equipment for gateway to RCC and RSCC
ix) Communication infrastructure between Bay level units, Station HMI, Printers, gateways, redundant LAN etc. as required
x) Remote workstation including HMI and along with one printer
xi) Modems as per requirement.
xii) Any other equipment as necessary.

List of Analogue and Digital Inputs

Basic Monitoring requirements are:

- Switchgear status indication
- Measurements (U, I, P, Q, f)
- Event
- Alarm
- Winding temperature of transformers & reactors
- ambient temperature
- Status and display of 400V LT system, 220V & 48V DC system
- Status of display of Fire protection system and Air conditioning system.
- Acquisition of all counters in PLCC panels through potential free contacts from PLCC or independently by counting the receive/send commands.
- Acquisition of alarm and fault record from protection relays
- Disturbance records
- Monitoring the state of batteries by displaying DC voltage, charging current and load current etc.
- Tap-position of Transformer

List of Inputs

The list of input for typical bays is as below: -

Analogue inputs

i) For line
Current R phase
Y phase
B phase
Voltage R-Y phase
Y-B phase
B-R phase

ii) For transformer/reactor
Current R phase
Y phase
B phase
WTI (for transformer and reactor)
Tap position (for transformer only)

iii) For TBC and bus coupler

Current R phase
Y phase
B phase

iv) Common

a) Voltage for Bus-I, Bus-II and Transfer bus wherever applicable

Voltage R-Y phase

Y-B phase
B-R phase

b) Frequency for Bus-I and Bus-II

c) Ambient temperature (switchyard)
d) Switchyard Panel Room Temperature.
e) LT system

i) Voltage R-Y, Y-B, B-R of Main Switch Board section-I
ii) Voltage R-Y, Y-B, B-R of Main Switch Board section-II
iii) Voltage R-Y, Y-B, B-R of Diesel Generator
iv) Current from LT transformer-I
v) Current from LT transformer-II
vi) Current from Diesel Generator
vii) Voltage of 220V DCDB-I
viii) Voltage of 220V DCDB-II
ix) Current from 220V Battery set-I
x) Current from 220V Battery set-II
xi) Current from 220V Battery charger-I
xii) Current from 220V Battery charger-I
xiii) Voltage of 48V DCDB-I
xiv) Voltage of 48V DCDB-II
xv) Current from 48V Battery set-I
xvi) Current from 48V Battery set-II
xvii) Current from 48V Battery charger-I
xviii) Current from 48V Battery charger-I

Digital Inputs

The list of input for various bays/SYSTEM is as follows:

1. Line bays

i) Status of each pole of CB.
ii) Status of Isolator, Earth switch
iii) CB trouble
iv) CB operation/closing lockout
v) Pole discrepancy optd
vi) Trip coil faulty
vii) LBB optd
viii) Bus bar protn trip relay optd
ix) Main bkr auto recloser operated
x) Tie/transfer auto recloser operated
xi) A/r lockout
xii) Tie/transfer bkr a/r lockout
xiii) Direct trip-I/II sent
xiv) Direct trip-I/II received
xv) Main I/II blocking
xvi) Main I/II-Inter trip send
xvii) Main I/II-Inter trip received
xviii) O/V STAGE – I operated
xix) O/V STAGE – II operated
xx) FAULT LOCATOR FAULTY
xxi) MAIN-I/II CVT FUSE FAIL
xxii) MAIN-I PROTN TRIP
xxiii) MAIN-II PROTN TRIP
xxiv) MAIN-I PSB ALARM
xxv) MAIN-I SOTF TRIP
xxvi) MAIN-I R-PH TRIP
xxvii) MAIN-I Y-PH TRIP
xxviii) MAIN-I B-PH TRIP

xxix) MAIN-I START
xxx) MAIN-I/II Carrier aided trip
xxxi) MAIN-I/II fault in reverse direction
xxxii) MAIN-I/II ZONE-2 TRIP
xxxiii) MAIN-I/II ZONE-3 TRIP
xxxiv) MAIN-I/II weak end infeed optd
xxxv) MAIN-II PSB alarm
xxxvi) MAIN-II SOTF TRIP
xxxvii) MAIN-II R-PH TRIP
xxxviii) MAIN-II Y-PH TRIP
xxxix) MAIN-II B-PH TRIP
xl) MAIN-II start
xli) MAIN-II aided trip
xlii) MAIN-I/II fault in reverse direction
xliii) Back-up o/c optd
xliv) Back-up e/f optd
xlv) 220V DC-I/II source fail
xlvi) SPEECH CHANNEL FAIL
xlvii) PLCC Protection Channel-I FAIL
xlviii) PLCC Protection Channel-II FAIL

2. **Transformer bays**

i) Status of each pole of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd.
v) Trip coil faulty
vi) LBB optd.
vii) Bus bar protn trip relay optd.
viii) REF OPTD
ix) DIF OPTD
x) OVERFLUX ALARM (MV)
xi) OVERFLUX TRIP (MV)
xii) OVERFLUX ALARM (HV)
xiii) OVERFLUX TRIP (HV)
xiv) HV BUS CVT ½ FUSE FAIL
xv) MV BUS CVT ½ FUSE FAIL
xvi) OTI ALARM/TRIP
xvii) PRD OPTD
xviii) OVERLOAD ALARM
xix) BUCHOLZ TRIP
xx) BUCHOLZ ALARM
xxi) OLTC BUCHOLZ ALARM
xxii) OLTC BUCHOLZ TRIP
xxiii) OIL LOW ALARM
xxiv) back-up o/c (HV) optd
xxv) back-up e/f (HV)optd
xxvi) 220v DC-I/II source fail
xxvii) TAP MISMATCH
xxviii) GR-A PROTN OPTD
xxix) GR-B PROTN OPTD
xxx) back-up o/c (MV) optd
xxxi) back-up e/f (MV)optd

3. **Transformer bays**

i) Status of each pole of CB, Isolator, Earth switch

ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty
vi) LBB optd
vii) Bus bar protn trip relay optd
viii) REF OPTD
ix) DIF OPTD
x) HV BUS CVT ½ FUSE FAIL
xi) OTI ALARM/TRIP
xii) PRD OPTD
xiii) BUCHOLZ TRIP
xiv) BUCHOLZ ALARM
xv) OIL LOW ALARM
xvi) Back-up impedance relay
xvii) 220v DC-I/II source fail
xviii) GR-A PROTN OPTD
xix) GR-B PROTN OPTD

4. Line/Bus Reactor bays (as applicable):

i) Status of each pole of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty
vi) LBB optd
vii) Bus bar protn trip relay optd
viii) REF OPTD
ix) DIF OPTD
x) Line/ BUS CVT ½ FUSE FAIL
xi) OTI ALARM/TRIP
xii) PRD OPTD
xiii) BUCHOLZ TRIP
xiv) BUCHOLZ ALARM
xv) OIL LOW ALARM
xvi) Back-up impedance relay
xvii) 220V DC-I/II source fail
xviii) GR-A PROTN OPTD
xix) GR-B PROTN OPTD

5 **Bus bar Protection**

i) Bus bar main-I trip
ii) Bus bar main-II trip
iii) Bus bar zone-I CT open
iv) Bus bar zone-II CT open
v) Bus transfer CT sup. Optd
vi) Bus transfer bus bar protn optd
vii) Bus protection relay fail

6. **Auxiliary system**

i) Incomer-I On/Off
ii) Incomer-II On/Off
iii) 400V Bus-I/II U/V
iv) 400V bus coupler breaker on/off
v) DG set bkr. on/off
vi) Alarm/trip signals as listed in Section: DG set

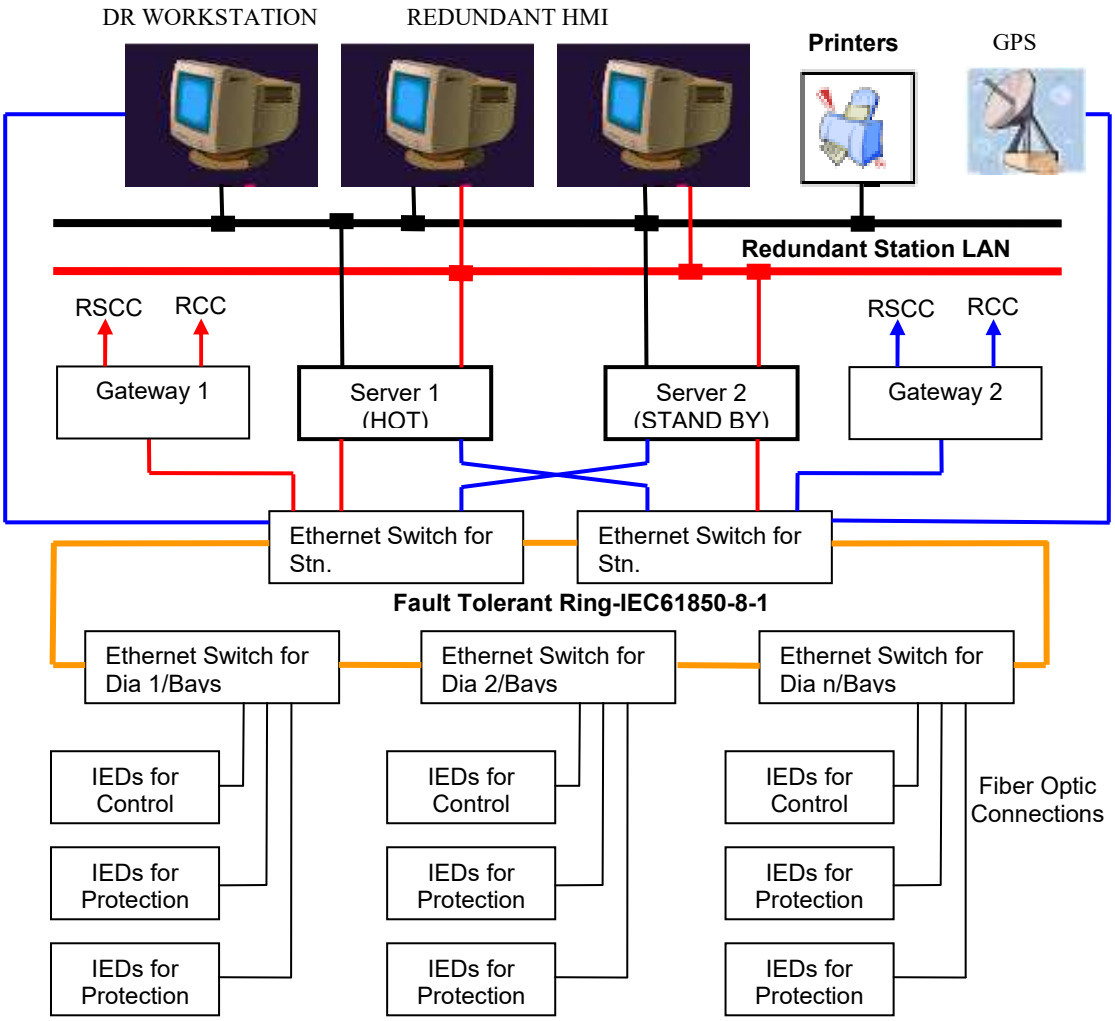
vii) LT transformer-I Bunchholz Alarm & trip
viii) LT transformer-II Buchloz Alarm & trip
ix) LT transformer-I WTI Alarm & trip
x) LT transformer-II WTI Alarm & trip
xi) LT transformer-I OTI Alarm & trip
xii) LT transformer-II OTI Alarm & trip
xiii) PLCC exchange fail
xiv) Time sync. Signal absent
xv) Alarm/trip signals as listed in Section: Battery and Battery charger
xvi) 220V DC-I earth fault
xvii) 220V DC-II earth fault
xviii) Alarm/trip signals as listed in Section: Fire protection system

7. Switchyard Panel Room:

i) AC Compressor 1 ON/OFF
ii) AC Compressor 2 ON/OFF
iii) Fire Detection 1 ON/OFF
iv) Fire Detection 2 On/OFF
v) Switchyard Panel Room Temperature High Alarm

The exact number and description of digital inputs shall be as per detailed engineering requirement Apart from the above mentioned digital inputs, minimum of 200 inputs shall be kept for future use.

TYPICAL ARCHITECTURAL DRAWING
OF
SUBSTATION AUTOMATION SYSTEM



Note:

1. The redundant managed bus shall be realized by high speed optical bus using industrial grade components and shall be as per IEC 61850.
2. Inside the sub-station, all connections shall be realized as per IEC 61850 protocol.
3. For gateway, it shall communicate with Remote Supervisory Control Centre (RSCC) on IEC 60870-5-101 protocol.
4. The printer as required shall be connected to station bus directly and can be managed either from station HMI, HMI view node or disturbance recorder work station.
5. The above layout is typical. However, if any contractor offers slightly modified architecture based on their standard practice without compromising the working, the same shall be subject to approval during detailed engineering.

List of IO Points to be transmitted to RSCC

a) MW and MVAR for all lines, transformers, reactors and Capacitors
b) Voltage of all buses
c) Frequency of 220kV Bus
d) All Breakers
e) All isolators
f) Tap Position for all transformers
g) Master protection signal for all feeders, transformers Units and Bus Bar
h) Loss of Voltage signal for Bus bar
i) All the points identified in point (e), (h) and (j) above as GPS Time stamped.
j) Temperature value per substation.
k) Any other point decided during detailed engineering

SECTION- 18: STRUCTURE

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1.0 GENERAL

The scope of specification covers design, fabrication, trial assembly, supply and erection of galvanized steel structures for towers, girders, lightning masts and equipment support structures. Structures shall be lattice or Pipe type structure fabricated from structural steel conforming to relevant British standard Codes (BS Codes)/ equivalent International Standards.

Line diagrams of Towers, girders, Lightning mast, equipment support structures for 220kV structures enclosed with the tender document are for information only. However, the line diagram of all structures of 220 kV, 132kV and 33 kV for new switch yards shall be prepared by the contractor based on their design during detailed engineering stage. The fabrication drawing/line diagram of structures for extension of existing switch yards shall be furnished by NEA/Consultant to the successful bidder progressively during detailed engineering stage. The bidder shall mention in their bid for the type of proposed structure i.e. Pipe or lattice type structure. The fabrication drawings, proto corrected drawings along with Bill of Material (BOM) for all the structures (Both Gantry and Equipment support structures) shall be prepared by the contractor during detailed engineering for submission to NEA/Consultant for their approval. Support structure for circuit breaker shall also be designed by the Manufacturer/Contractor.

It is the intent of the NEA/Consultant to provide structures which allow interchangeability of equipments at a later stage. Accordingly, Contractor is expected to design the equipment support structures with the provision of stool. Stools shall be provided by the Contractor between the equipment and its support structure to match the bus bar height. The top of stool shall be connected to the equipment and the bottom of the stool shall be connected to the Base support structure.

The scope shall include supply and erection of all types of structures including bolts, nuts, washers, step bolts, inserts in concrete, gusset plates, equipment mounting bolts, structure earthing bolts, foundation bolts, spring washers, fixing plates, ground mounted marshalling boxes (AC/DC Marshalling box & equipment control cabinets), structure mounted marshalling boxes and any other items as required to complete the job.

The connection of all structures to their foundations shall be with base plates and embedded anchor/foundation bolts. All steel structures and anchor/foundation bolts, fasteners (Nuts, bolts, washers) shall be fully galvanized as per relevant British standard Codes (BS Codes)/ equivalent International Standards. The weight of the zinc coating shall be at least 610 gram/sq. m for anchor bolts/foundation bolts and for structural members. One additional nut shall be provided below the base plate which may be used for the purpose of leveling.

Contractor shall provide suitable arrangement on the equipment support structures wherever required to suit fixation of accessories such as marshalling boxes, MOM boxes, Control Cabinets, Junction box, surge counter, etc. in the equipment structure fabrication drawings.

2.0 DESIGN REQUIREMENTS FOR STRUCTURES

2.1 For design of steel structures loads such as dead loads, live loads, wind loads etc. shall be based on relevant British standard Codes (BS Codes) / equivalent International Standards.

2.2 For materials and permissible stresses, relevant British standard Codes (BS Codes) / equivalent International Standards. Shall be followed in general. However, additional requirements given in following paragraphs shall be also considered.

2.3 Minimum thickness of galvanized lattice structure member shall be as follows:

Members Min Thickness	(mm)
Leg members, Ground wire	5
Peak members\/Main members	5
Other members	4
Redundant members	4

2.4 Maximum slenderness ratios for leg members, other stressed members and redundant members for compression force shall be as per relevant British standard Codes (BS Codes) / equivalent International Standards.

2.5 Minimum distance from hole center to edge shall be 1.5 x bolt diameter. Minimum distance between center to center of holes shall be 2.5 x bolt diameter.

2.6 All bolts shall be M16 or higher as per design requirement.

2.7 **Step Bolts**

In order to facilitate inspection and maintenance, the tower structures shall be provided with climbing devices. Each tower shall be provided with M16 step bolts 175mm long spaced not more than 450mm apart, staggered on faces on diagonally opposite legs extending from about 0.5 meters above plinth level to the top of the tower. The step bolt shall conform to relevant British standard Codes (BS Codes) / equivalent International Standards. Ladders along with safety guard shall be provided for the Lightning Mast Tower.

2.8 **Design Criteria**

a) All gantry structures shall be designed for the worst combination of dead loads, live loads, wind loads and Seismic forces as per relevant British standard Codes (BS Codes) / equivalent International Standards (latest), loads due to deviation of conductor, load due to unbalanced tension in conductor, torsional load due to unbalanced vertical and horizontal forces, erection loads, short circuit forces including “snatch” in the case of bundled conductors etc. Short circuit forces shall be calculated considering a fault level of 40.0 kA for 220kV, 31.5KA for 132kV and 25KA for 33kV or as applicable. Relevant British standard Codes (BS Codes) / equivalent International Standards. May be followed for evaluation of short circuit forces.

b) Switchyard gantry structures shall be designed for the two conditions i.e. normal condition and short circuit condition. In both conditions the design of all structures shall be based on the assumption that stringing is done only on one side i.e. all the three (phase) conductors broken on the other side.
Factor of safety of 2.0 under normal conditions and 1.5 under short circuit condition shall be considered on all external loads for the design of switchyard structures.

c) Vertical load of half the span of conductors/string and the earth wires on either side of the beam shall be taken into account for the purpose of design. Weight of man with tools shall be considered as 150 kg for the design of structures.

d) Terminal/line take off gantries shall be designed for a minimum conductor tension of 2 metric tonnes per phase for 220 kv, 1 Metric tonne per phase for 132 kV and 0.50 Metric Tonne for 33 kV or as per requirements whichever is higher. The distance between terminal gantry and dead end tower shall be taken as 200 meters for 220kV, 150m for 132kV and 80 m for 33 kV switch yard. The design of these terminal gantries shall also be checked considering +/- 30 deg deviation of conductor in both vertical and horizontal planes. For other gantries the structural layout requirements shall be adopted in design.

e) The girders / beams shall be connected with lattice/Tower columns by bolted joints.

f). All equipment support structures shall be designed for the worst combination of dead loads, erection load. Wind load/seismic forces, short circuit forces and operating forces acting on the equipment and associated bus bars as per relevant British standard Codes (BS Codes) / equivalent International Standards.

g) If luminaries are proposed to be fixed on gantries/towers, then the proper loading for the same shall be considered while designing. Also holes for fixing the brackets for luminaries should be provided wherever required.

h) Foundation bolts shall be designed for the loads for which the structures are designed.

i) The height of Lightning Mast shall be as per approved structural layout and designed for diagonal wind condition. The lightning mast shall be provided with platform for mounting of lighting fixtures and a structural steel ladder within its base up to the level of platform. The ladder shall be provided with protection rings The platforms shall also have protection railing. The details of lighting fixtures would be as per approved drawings of electrical fixtures.

3.0 DESIGN, DRAWINGS, BILL OF MATETRIALS AND DOCUMENTS

3.1 The Contractor shall submit design and line diagram of each structure for approval of NEA/Consultant. Fabrication drawing based on approved line diagram shall be prepared by the contractor for approval of NEA/Consultant. The BOM (Bill Of Material) shall be prepared by the contractor based on approved fabrication drawing. The Line diagram should indicate not only profile, but section, numbers and sizes of bolts and details of typical joints. In case NEA/Consultant feels that any design or drawings are to be modified even after its approval, Contractor shall modify the designs & drawings and resubmit the same for approval.

3.2 The fabrication drawings shall indicate complete details of fabrication and erection including all erection splicing details and typical fabrication splicing details, lacing details, weld sizes and lengths. Bolt details and all customary details in accordance with standard structural engineering practice. The fabrication drawing and bill of material based on design/line diagram shall be submitted to NEA/Consultant for approval. Approved bill of materials prepared on the basis of fabrication drawing shall be the basis for payment.

3.3 Such approvals shall, however, not relieve the contractor of his responsibility for safety and durability of the structure and good connection and any loss occurring due to defective fabrication, design or workmanship shall be borne by the contractor.

3.4 The contractor shall submit editable soft copy of all designs preferably in Staad / excel form and drawings in AutoCAD to NEA/Consultant. The list of British standard codes relevant to steel structures have been given in Chapter-14-Civil section of technical specification This list is illustrative but not exhaustive. The contractor shall submit the copy of relevant portion of BS codes/equivalent International standard referred to NEA/Consultant for reference if necessary during detailed engineering stage.

4.0 FABRICATION AND ERECTION

4.1 The fabrication and erection works shall be carried out generally in accordance with relevant British standard Codes (BS Codes) / equivalent International Standards. All materials shall be completely shop fabricated and finished with proper connection material and erection marks for ready assembly in the field.

4.2 The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged and shall be so prepared that the specified camber, if any, is provided. In order to minimize distortion in member the component parts shall be positioned by using the clamps, clips, dogs, jigs and other suitable means and fasteners (bolts and welds) shall be placed in a balanced pattern. If the individual components are to be bolted, paralleled and tapered drifts shall be used to align the part so that the bolts can be accurately positioned.

4.3 Sample towers, beams and lightning masts and equipment support structures may be trial assembled in the fabrication shop to ensure fitment of various members and to avoid problems during erection.

4.4 For all structures, BOM along with fabrication drawings in hard and editable soft copies shall be submitted to NEA/Consultant as document for information. The responsibility of correctness of such fabrication drawing and BOM shall be fully with the contractor.

4.5 Approval of fabrication drawings and BOM shall, however, not relieve the Contractor of his responsibility for the safety and durability of the structure and good connections and any loss or damage occurring due to defective fabrication, design or workmanship shall be borne by the Contractor.

4.6 The Contractor should arrange on his own all plant and equipment, welding set, tools

and tackles, scaffolding, trestles equipments and all other accessories and ancillaries required for carrying out erection without causing any stresses in the members which may cause deformation and permanent damage. Minor modification if any, required during erection shall be done at site with the approval of NEA/Consultant.

5.0 BOLTING

i) Every bolt shall be provided with a washer under the nut so that no part of the threaded portion of the bolt is within the thickness of the parts bolted together.

ii) In case of fasteners, the galvanizing shall confirm to relevant British Standard Codes (BS Codes) / equivalent International Standards. The spring washer shall be electro galvanized as per relevant British standard Codes (BS Codes) / equivalent International Standards.

6.0 WELDING

The work shall be done as per approved fabrication drawings which shall clearly indicate various details of joints to be welded, type of weld, length and size of weld, Symbols for welding on erection and shop drawings shall be according to relevant British standard Codes (BS Codes) / equivalent International Standards. Welding shall be carried out in accordance to relevant British standard Codes (BS Codes) / equivalent International Standards.

7.0 FOUNDATION BOLTS

7.1 Foundation bolts for the towers and equipment supporting structures and elsewhere shall be embedded in first stage concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate.

7.2 The Contractor shall be responsible for the correct alignment and leveling of all steel work on site to ensure that the towers/structures are plumb.

7.3 All foundation bolts for lattice structure, pipe structures are to be supplied by the Contractor.

7.4 All foundation bolts shall be fully galvanised so as to achieve minimum 610 grammes Per Sq.m. of Zinc Coating as per relevant British standard Codes (BS Codes) / equivalent International Standards.

7.5 All foundation bolts and its material shall conform to relevant British standard Codes (BS Codes) / equivalent International Standards. All foundation bolts shall be provided with two number standard nuts, one check nut, one plain washer and MS plate at the bottom of foundation bolt.

8.0 STABILITY OF STRUCTURE

The Supplier shall be responsible for the stability of the structure at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations.

9.0 GROUTING

The method of grouting the column bases shall be subject to approval of NEA/Consultant and shall be such as to ensure a complete uniformity of contact over the whole area of the steel base. No additional payment for grouting shall be admissible.

10.0 GALVANISING

10.1 All structural steel works (Gantry structures, Equipment support structures) and foundation bolts shall be galvanized after fabrication. The galvanization shall be done as per requirement relevant British standard Codes (BS Codes) / equivalent International Standards.

10.2 Zinc required for galvanizing shall have to be arranged by the Contractor/manufacturer. Purity of zinc to be used shall be 99.95% as per relevant British standard Codes (BS Codes) / equivalent International Standards.

10.3 The Contractor shall be required to make arrangement for frequent inspection by the owner as well as continuous inspection by a resident representative of the owner, if so desired for fabrication work.

11.0 TOUCH-UP PAINTING

Minor defects in hot dip galvanized members shall be repaired by applying zinc rich primer and two coats of enamel paint to the satisfaction of NEA/Consultant before erection.

12.0 INSPECTION BEFORE DISPATCH

Each part of the fabricated steel work shall be inspected as per approved quality plans and certified by NEA/Consultant or his authorized representative as satisfactory before it is dispatched to the erection site. Such certification shall not relieve the Contractor of his responsibility regarding adequacy and completeness of fabrication.

13.0 TEST CERTIFICATE

Copies of all test certificates relating to material procured by the Contractor for the works shall be submitted to NEA/Consultant.

14.0 MODE OF MEASUREMENT

The measurement of the structure, fasteners (Nuts, Bolts, and Washers) and foundation bolts including its nuts washers and MS Plate at bottom shall be done as per Bid price schedule (BPS). The weight of all structural members and foundation bolts (Bolt, Nuts, washer and MS steel plates welded at bottom of bolt) shall be measured under one head in Metric Tonne. The weight of fasteners and step bolts (Nuts, bolts and washers) used to erect/complete structures shall be measured under another head in Metric tons.

15.0 SAFETY PRECAUTIONS

The Contractor shall strictly follow all precautions at all stages of fabrication, transportation and erection of steel structures. The stipulations contained in relevant British standard Codes (BS Codes) / equivalent International Standards for Safety during erection of structural steel work shall also be adhered to.

16.0 MANUFACTURING QUALITY PLAN

The material specification shall also be as per relevant British standard Codes (BS Codes) / equivalent International Standards.
The Contractor shall prepare the manufacturing quality plan to accept/check the material, galvanization and welding as per relevant international standards/BS codes within 1 month after award of work and submit the same to NEA/ Consultant for approval.

SECTION 19: CIVIL WORKS
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1.0 GENERAL

The intent of specification covers the following:

Design, engineering, drawing and construction of all civil works at sub-station. All civil works shall also satisfy the general technical requirements specified in other Sections of Specification and as detailed below. They shall be designed to the required service conditions/loads as specified elsewhere in this Specification or implied as per relevant British standard codes (B S Codes)/ equivalent International Standards.

All civil works shall be carried out as per applicable Standards and Codes. All materials shall be of best quality conforming to relevant International Standards and Codes. In case of any conflict between Standards/ Code and Technical Specification, the provisions of Technical Specification shall prevail.

The Contractor shall furnish all design, drawings, labour, tools, equipment, materials, temporary works, constructional plant and machinery, fuel supply, transportation and all other incidental items not shown or specified but as may be required for complete performance of the Works in accordance with approved drawings, specifications and direction of NEA/Consultant.

The work shall be carried out according to the design/drawings to be developed by the Contractor and approved by the NEA/Consultant. For all buildings, structures, foundations etc. necessary layout and details shall be developed by the Contractor keeping in view the functional requirement of the substation facilities and providing enough space and access for operation, use and maintenance. Certain minimum requirements are indicated in this specification for guidance purposes only. However, the Contractor shall quote according to the complete requirements.

2.0 GEOTECHNICAL INVESTIGATION

2.1 The Contractor shall perform a detailed soil investigation to arrive at sufficiently accurate, general as well as specific information about the soil profile and the necessary soil parameters of the Site in order that the foundation of the various structures can be designed and constructed safely and rationally.
A detailed soil report including field data duly certified by site engineers of NEA/Consultant will be submitted by the Contractor for specific approval of NEA/Consultant**.** The report shall contain all soil parameters along with recommendation of soil consultant for type of foundation i.e. pile or open type, soil treatment if any etc to be used for the design of civil foundations.

2.2 The Contractor may visit the site to ascertain the soil parameters. Any variation in soil data shall not constitute a valid reason for any additional cost & shall not affect the terms & conditions of the contract. Field tests must be conducted covering entire substation area including all the critical locations i.e. Control Room and GIS Building, township buildings, Lightning Mast. Towers, transformer/Reactor etc.

2.3 SCOPE OF WORK

This specification covers all the work required for detailed soil investigation and preparation of a detailed report. The work shall include mobilisation of necessary equipment, providing necessary engineering supervision and technical personnel, skilled and unskilled labour etc. as required to carry out field investigation as well as, laboratory investigation, analysis and interpretation of data and results, preparation of detailed Geotechnical report including specific recommendations for the type of foundations and the allowable safe bearing capacity for different sizes of foundations at different founding strata for the various structures of the substation. The Contractor shall make his own arrangement for locating the co-ordinates and various test positions in field as per the

information supplied to him and also for determining the reduced level of these locations with respect to the benchmark indicated by the NEA/Consultant. The soil investigation for substation extension in existing switch yard has not been envisaged. Soil data of existing substation shall be referred for the design of foundations in switch yard extension under present scope of work.

All the work shall be carried out as per latest edition of the corresponding relevant British standard codes (B S Codes)/ equivalent International Standards. The Agency carrying out the soil investigation work must have the experience of carrying out soil investigation successfully in the relevant field. NEA shall assess the capability of the agency for soil investigation work for which technical inputs may be furnished by consultant to NEA.

2.3.1 Bore Holes

Bore holes of Minimum 150 mm diameter in accordance with the provisions of relevant international standards/British standards (BS) at the rate of minimum one number bore hole per hectare up to 25meter depth (Minimum) or to refusal which ever occur earlier shall be drilled for new areas (220 kV Yards and 220/132/33 kV yards wherever applicable). In any case number of boreholes shall not be less than five. By refusal it shall mean that a standard penetration blow count (N) of 100 is recorded for 30 cm penetration. Number of boreholes may be increased in case soil strata are varying from borehole to borehole in order to have fair idea of soil profile. In case of deep pile foundations soil investigation is to be carried out up to 30 m depth from ground level or refusal whichever is earlier. In case rock is encountered, coring in all the boreholes shall be carried out up to 3 meter in rock.

Performing Standard Penetration Tests at approximately 1.5 m interval in the borehole starting from 1.5 m below ground level onwards and at every change of stratum. The disturbed samples from the standard penetrometer shall also be collected for necessary tests. Standard Penetration Test shall be performed as per relevant British standard codes (B S Codes)/ equivalent International Standards.

Undisturbed samples shall be collected in accordance with the recommendation of relevant British standard codes (B S Codes)/ equivalent International Standards. Or an alternative recognize method as agreed by NEA/Consultant. Undisturbed samples shall be taken in cohesive material or weak cemented granular material where ever possible at 1.0 m interval or at each change in stratum.

The depth of Water Table, if encountered, shall be recorded in each borehole. In case the soil investigation is carried out in winter/summer, the water table for rainy season shall be collected from reliable sources and recorded in the report.

All samples, both disturbed and undisturbed, shall be identified properly with the borehole number and depth from which they have been taken.

The sample shall be sealed at both ends of the sampling tubes with wax immediately after the sampling and shall be packed properly and transported to the Contractor's laboratory without any damage or loss.

The logging of the boreholes shall be compiled immediately after the boring is completed and a copy of the bore log shall be handed over to the Engineer-in-change.

2.3.2 Trial Pits

The Contractor shall excavate two number trial pits per substation (New) as and where directed by NEA/Consultant, of Plan area 10 sq.m. and not exceeding 4 m depth. Undisturbed samples shall be taken from the trial pits as per the direction of the NEA/Consultant. All Trial Pits shall be re-filled with approved material after the tests are

complete and shall be compacted in layers of not more than 500mm.

2.3.3 Electrical Resistivity Test

This test shall be conducted to determine the Electrical resistivity of soil required for designing safety-grounding system for the entire station area. The specifications for the equipments and other accessories required for performing electrical resistivity test, the test procedure, and reporting of field observations shall confirm to relevant British standard codes (B S Codes)/ equivalent International Standards. The test shall be conducted using Wagner's four electrode method as specified in relevant British standard codes (B S Codes)/ equivalent International Standards. Unless otherwise specified at each test location, the test shall be conducted along two perpendicular lines parallel to the coordinate axis. On each line a minimum of 8 to 10 readings shall be taken by changing the spacing of the electrodes from an initial small value of 0.2 m up to a distance of 50.0 m.

2.3.4 Plate load test

Two number of Plate load tests shall be conducted each at the location of control room / GIS building and township area as applicable only to determine the bearing capacity, modulus of sub grade reaction and load/settlement characteristics of soil at shallow depths by loading a plane and level steel plate kept at the desired depth and measuring the settlement under different loads, until a desired settlement takes place or failure occurs. The specification for the equipment and accessories required for conducting the test, the test procedure, field observations and reporting of results shall conform to relevant BS standard. Plate load test shall be performed at the proposed foundation depth below finished ground level for bearing capacity.

Undisturbed tube samples shall also be collected from the pit at 1.0 m depth and bottom of pit from natural ground level for carrying out laboratory tests.

The size of the pit in plate load test shall not be less than five times the plate size and shall be taken up to the specified depth. All provisions regarding excavation and visual examination of pit shall apply here.

Unless otherwise specified the reaction method of loading shall be adopted. Settlement shall be recorded from dial gauges placed at four diametrically opposite ends of the test plate.

The load shall be increased in stages. Under each loading stage, record of Time vs. Settlement shall be kept as specified in relevant British standard codes (B S Codes)/ equivalent International Standards.
Backfilling of the pit shall be carried out as per the directions of the NEA/Consultant**.** Unless otherwise specified the excavated soil shall be used for this purpose. In cases of gravel-boulder or rocky strata, respective relevant codes shall be followed for tests.

2.3.5 Water Sample

Representative samples of ground water shall be taken when ground water is first encountered before the addition of water to aid drilling of boreholes. The samples shall be of sufficient quantity for chemical analysis to be carried out and shall be stored in air-tight containers.

2.3.6 Back Filling of Bore Holes

On completion of each hole, the Contractor shall backfill all bore holes as directed by the NEA/Consultant. The backfill material can be the excavated material.

2.3.7 Laboratory Test

1. The laboratory tests shall be carried out progressively during the field work after sufficient number of samples has reached the laboratory in order that the test results of the initial bore holes can be made use of in planning the later stages of the field investigation and quantum of laboratory tests.

2. All samples brought from field, whether disturbed or undisturbed shall be extracted/prepared and examined by competent technical personnel, and the test shall be carried out as per the procedures laid out in the relevant British standard codes (B S Codes)/ equivalent International Standards.

   The following laboratory tests shall be carried out

   a) Visual and Engineering Classification

   b) Atterberg limits Tests.

   c) Natural moisture content, bulk density and specific gravity.

   d) Grain size distribution analysis.

   e) Swell pressure and free swell index determination.

   f) California bearing ratio.

   g) Consolidated drained test with pore pressure measurement.

   h) Chemical tests on soil and water to determine the carbonates, sulphates, nitrates, chlorides, Ph value, and organic matter and any other chemical harmful to the concrete foundation.

   i) In case rock is encountered, the soil test required for rock as per relevant British standard codes (B S Codes)/ equivalent International Standards including following tests shall also be conducted.
      (i) UCC test.
      (ii) Point load index test.

2.3.8 Test Results and Reports

The Contractor shall submit the detailed report in two (2) copies wherein information regarding the geological detail of the site, summarised observations and test data, bore logs, and conclusions and recommendations on the type of foundations with supporting calculations for the recommendations. The contractor shall also submit the bearing capacity calculation in editable soft copy to NEA/consultant. Initially the contractor shall submit draft report and after the draft report is approved, the final report in four (4) copies shall be submitted. The field and laboratory test data shall bear the signatures of the Investigation Agency, Contractor and also site representative of NEA/Consultant.

The report shall include, but not limited to the following: -

a) A plan showing the locations of the exploration work i.e. bore holes, trial pits. Plate load test, electrical resistivity test, CBR sample location etc.
b) Bore Logs: Bore logs of each bore holes clearly identifying the stratification and the type of soil stratum with depth. The values of Standard Penetration Test (SPT) at the depths where the tests were conducted on the samples collected at

various depths shall be clearly shown against that particular stratum.

Test results of field and laboratory tests shall be summarised strata wise as well in combined tabular form. All relevant graphs, charts tables, diagrams and photographs, if any, shall be submitted along with report. Sample illustrative reference calculations for settlement, bearing capacity, pile capacity shall be enclosed.

Recommendations: The report should contain specific recommendations for the type of foundation for the various structures envisaged at site. The Contractor shall acquaint himself about the type of structures and their functions from the NEA/Consultant. The observations and recommendations shall include but not limited to the following:

a) Geological formation of the area, past observations or historical data, if available, for the area and for the structures in the nearby area, fluctuations of water table etc.

b) Recommended type of foundations for various structures. If piles are recommended the type, size and capacity of pile and groups of piles shall be given after comparing different types and sizes of piles and pile groups.

c) Allowable bearing pressure on the soil at various depths for different sizes of the foundations based on shear strength and settlement characteristics of soil with supporting calculations. Minimum factor of safety for calculating net safe bearing capacity shall be taken as 3.0 (three). Recommendation of liquefaction characteristics of soil if applicable shall be provided.

d) Recommendations regarding slope of excavations and dewatering schemes, if required.

e) Comments on the Chemical nature of soil and ground water with due regard to deleterious effects of the same on concrete and steel and recommendations for protective measures.

f) If expansive soil is met with, recommendations on removal or retainment of the same under the structure, road, drains, etc. and thickness of treatment shall be given. In the latter case detailed specification of any special treatment required including specification or materials to be used, construction method, equipments to be deployed etc. shall be furnished. Illustrative diagram of a symbolic foundation showing details shall be furnished.

g) Recommendations for additional investigations beyond the scope of the present work, if considered such investigation as necessary.

f) In case of foundation in rocky strata, type of foundation and recommendation regarding rock anchoring etc. should also be given.

3.0 CONTOUR SURVEY, SITE LEVELLING

3.1 CONTOUR SURVEY & SITE LEVELLING:

The land for construction of substation will be handed over to the successful bidder as on where basis progressively after award of work. The contractor shall carry out survey work by taking spot level at 05 m x05 m grid interval with respect to temporary bench mark transferred from permanent bench mark in the locality if available either on bridge, government buildings of local authorities or any other permanent structure. The contractor shall submit the spot levels (in grid format) in editable soft copy in excel format and contour map with contour interval of 0.5 m in editable auto cad soft drawing.

The contractor will level the area required for construction of substation work either at single level, multi-level or gradual slope with the finished ground level as approved by NEA/Consultant during detailed engineering based on highest flood level. The levelling area shall be decided by NEA/Consultant during detailed Engineering stage.

The layout and levels of all structure etc shall be made by the Contractor at his own cost from the general grids of the plot and benchmarks set by the Contractor and approved by NEA/Consultant. The Contractor shall provide all assistance in instruments, materials and personnel to NEA/Consultant for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

3.2 **SCOPE**

This clause covers clearance of site, contour survey, site levelling, maintaining finished ground level by cutting/filling in all types of soil and soft/ disintegrated rock, supplying and compaction of fill material if required. Cutting/felling of trees and their disposal has not been envisaged under the present scope.

3.3 **GENERAL**

Site shall be cleared, surveyed and levelled/sloped by the contractor as per approved general arrangement drawing or levelling area decided during detailed engineering after award of work.

Work covered under this clause comprises the site clearance, survey work/setting out and making profiles (preparation of plot plan, setting up Bench Mark and taking spot levels at 05m x 05 m interval, preparation of contour plan with contour interval of 0.50 m), Earth work in Excavation & filling in specified area with all lifts and leads and earth work in filling with borrowed earth with all leads and lifts (Borrow areas including payment of royalty for borrowed earth shall be arranged by the contractor at his own cost). During detailed engineering stage, the contractor will prepare the levelling proposal for optimum levelling and submit to NEA/Consultant for approval. Contractor shall submit the hard copy and editable soft copy of levelling proposal (levelling quantity calculation in Excel form and levelling drawing in Auto CAD) to NEA/Consultant for approval.

3.4 Filling material shall conform to relevant British standard codes (BS Codes)/ equivalent International Standards. Unsuitable filling material if any shall be removed and replaced by suitable fill material. The filling shall be compacted in layers to achieve 95% of standard Proctor's density at Optimum moisture contents (OMC). Cohesion less material shall be compacted to 70% relative density (minimum). Levelling/Filling shall be carried out as per relevant British standard codes (B S Codes)/ equivalent International Standards.

3.5 All materials involved in excavation shall be classified by NEA/ Consultant in the following groups:

3.5.1 **All kinds of soils and soft/disintegrated rocks (Not requiring blasting):** The material which can be quaried/excavated with pick, shovel, jumpers, scarifiers, crowbars and mechanical implements and will include various types of soils, plain cement concrete, shingle, river/nallah boulders, soling of road/foot path, stone masonry, soft conglomerate and laterite stone, lime stone and hard conglomerate etc.

3.5.2 **Hard Rocks**: All kinds of rocks which can only be excavated by machines and requires blasting, chiselling in edging or in another agreed method and will also include reinforcement cement concrete.

3.6 The quantity of excavation in all types of soils and soft/disintegrated rock shall be worked out by using initial and final level and no void deduction shall be made to calculate net quantity of earth work with 95% compaction.

3.7 The volume of hard rock shall be computed on the basis of stack of excavated rubble after making 50 % deduction for voids.

3.8 The surface of excavation or filling shall be neatly dressed to the required formation level

with tolerance of (±) 100 mm.

4.0 SITE PREPERATION, EXCAVATION, BACKFILL & DISPOSAL OF SURPLUS EARTH.

4.1 SITE PREPERATION

The layout and levels of all structure etc shall be made by the Contractor at his own cost from the general grids of the plot and benchmarks set by the Contractor and approved by the NEA/Consultant. The Contractor shall give all help in instruments, materials and personnel to the NEA/Consultant for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

4.2 SCOPE

This clause covers clearing of the site, maintaining the finished ground level with available surplus excavated suitable back fill material generated from foundation works etc.

4.3 GENERAL

1) The Contractor shall develop the site area to meet the requirement of the intended purpose. The site preparation shall conform to the requirements of relevant sections of this specification or as per stipulations of relevant British standard codes (B S Codes)/ equivalent International Standards.

2) The fill material shall be suitable for the above requirement. The fill shall be with such a material that the site so designed shall not be affected by erosion from wind and water from its final compacted position or the in-situ position of undisturbed soil.

3) Material unsuitable for founding of foundations shall be removed and replaced by suitable fill material to be approved by the NEA/Consultant.

4) Backfill material around foundations or other works shall be suitable for the purpose for which it is used and compacted to the density described under Compaction. Excavated material not suitable or not required for backfill shall be disposed off in areas as directed by purchaser up to a maximum lead of 2 km.

4.4 EXCAVATION AND BACKFILL

SCOPE

This clause covers excavation for foundation works of Towers, Equipment support structures, Transformer/Reactor foundations, External Lighting poles, Cable trenches, Buildings, Car parking shed, Fire Wall, DG set, Water tanks, etc, backfilling of Foundations Works.

1. Excavation and backfill for foundations shall be in accordance with the relevant British standard codes (B S Codes)/ equivalent International Standards.

2. Whenever water table is met during the excavation, it shall be dewatered and water table shall be maintained below the bottom of the excavation level during excavation, concreting and backfilling.

3. When embankments are to be constructed on slopes of 15% or greater, benches or steps with horizontal and vertical faces shall be cut in the original slope prior to placement of embankment material. Vertical faces shall measure not more than 1 m in height.

4. Embankments adjacent to abutments, culverts, retaining walls and similar structures shall be constructed by compacting the material in successive uniform horizontal layers not exceeding 15 cm in thickness. (Of loose material before compaction). Each layer shall be compacted as required by means of mechanical tampers approved by the Purchaser. Rocks larger than 10 cm in any direction shall not be placed in embankment adjacent to structures.

5. Earth embankments of roadways and site areas adjacent to buildings shall be placed in successive uniform horizontal layers not exceeding 20 cm in thickness in loose stage measurement and compacted to the full width specified. The upper surface of the embankment shall be shaped so as to provide complete drainage of surface water at all times.

4.5 COMPACTION

1. The density to which fill materials shall be compacted shall be as per relevant BS and as per direction of NEA/Consultant. All compacted sand filling shall be confined as far as practicable. Backfilled earth shall be compacted to minimum 95% of the Standard Proctor's density at OMC. The sub grade for the roads and embankment filling shall be compacted to minimum 95% of the Standard Proctor's density at OMC. Cohesion less material sub grade shall be compacted to 70% relative density (minimum).

2. At all times unfinished construction shall have adequate drainage upon completion of the road's surface course, adjacent shoulders shall be given a final shaping, true alignment and grade.

3. Each layer of earth embankment when compacted shall be as close to optimum moisture content as practicable. Embankment material which does not contain sufficient moisture to obtain proper compaction shall be wetted. If the material contains any excess moisture, then it shall be allowed to dry before rolling. The rolling shall begin at the edges overlapping half the width of the roller each time and progress to the centre of the road or towards the building as applicable. Rolling will also be required on rock fills. No compaction shall be carried out in rainy weather.

4.6 REQUIREMENT FOR FILL MATERIAL UNDER FOUNDATION

The thickness of fill material under the foundations shall be such that the maximum pressure from the footing, transferred through the fill material and distributed onto the original undisturbed soil will not exceed the allowable soil bearing pressure of the original undisturbed soil. For expansive soils, the fill materials and other protections etc. to be used under the foundation is to be got approved by the NEA/Consultant.

4.7 DISPOSAL OF SURPLUS EARTH

The surplus earth generated from foundation work shall be disposed away from levelling area boundary at low lying areas within 2Km lead. The surplus earth if disposed within substation main boundary, the same shall be spread in uniform layers and compacted with suitable compacting equipment to achieve 95% compaction at O.M.C.

5.0 ANTIWEED TREATMENT & STONE SPREADING

5.1 SCOPE OF WORK

The Contractor shall furnish all labour, equipment and materials required for complete performance of the work in accordance with the drawings, specification.

Stone spreading along with cement concrete layer shall be done in the areas of the switchyard under present scope of work within fenced area. However, the stone spreading along with cement concrete layer in future areas within fenced area shall also be provided in case step potential without stone layer is not well within safe limits.

5.2 GENERAL REQUIREMENT

The material required for site surfacing/stone filling shall be free from all types of organic materials and shall be of standard quality, and as approved by the Purchaser.

The material to be used for stone filling/site surfacing shall be uncrushed/crushed/broken stone of 40mm nominal size (ungraded single size) conforming to relevant BS. Hardness, flakiness shall be as required for wearing courses shall be as are per relevant BS.

(a) Hardness
Abrasion value as per relevant BS.
Impact value as per relevant BS.

(b) Flakiness Index
One test shall be conducted as per relevant British standard codes (B S Codes)/ equivalent International Standards.

After all the structures/equipments are erected, anti-weed treatment shall be applied in the switchyard where ever stone spreading along with cement concrete is to be done and the area shall be thoroughly de-weeded including removal of roots. The recommendation of local agriculture or horticulture department may be sought where ever feasible while choosing the type of chemical to be used. The anti-weed chemical shall be procured from reputed manufacturers. The doses and application of chemical shall be strictly done as per manufacturer's recommendation. Nevertheless, the effectiveness of the chemical shall be demonstrated by the contractor in a test area of 10MX10M (appx.) and shall be sprinkled with water at least once in the afternoon every day after forty eight hours of application of chemical. The treated area shall be monitored over a period of two to three weeks for any growth of weeds by the NEA/Consultant. The final approval shall be given by NEA/Consultant based on the results.

NEA/Consultant shall decide final formation level so as to ensure that the site appears uniform devoid of undulations. The final formation level shall however be very close to the formation level indicated in the approved drawing.

After anti weed treatment is complete, the surface of the switchyard area shall be maintained, rolled/compacted to the lines and grades as decided by NEA/Consultant. The sub grade shall be consolidated by using half ton roller with suitable water sprinkling arrangement to form a smooth and compact surface. The roller shall run over the sub grade till the soil is evenly and densely consolidated and behaves as an elastic mass.

In areas that are considered by the NEA/Consultant to be too congested with foundations and structures for proper rolling of the site surfacing material by normal rolling equipments, the material shall be compacted by hand, if necessary. Due care shall be exercised so as not to damage any foundation structures or equipment during rolling compaction.

The sub grade shall be in moist condition at the time the cement concrete is placed. If

necessary, it should be saturated with water for not less than 6 hours but not exceeding 20 hours before placing of cement concrete. If it becomes dry prior to the actual placing of cement concrete, it shall be sprinkled with water and it shall be ensured that no pools of water or soft patches are formed on the surface.

Over the prepared sub grade, 75mm thick base layer of cement concrete in 1:5:10 (1 cement :5 sand: 10 Stone aggregates) shall be provided in the area excluding roads, drains, cable trenches as per detailed engineering drawing. For easy drainage of water, the slope of 1:1000 is to be provided from the ridge to the nearest drain. The ridge shall be suitably located at the centre of the area between the nearest drains. The above slope shall be provided at the top of base layer of cement concrete in 1:5:10. A layer of cement slurry of mix 1:6 (1 cement: 6 sand) shall be laid uniformly over cement concrete layer. The cement consumption for cement slurry shall not be less than 150 kg. Per 100 sq.m.

A final layer of 100mm thickness of uncrushed/crushed/broken stone of 40mm nominal size (ungraded size) shall be spread uniformly over cement concrete layer after curing is complete.

6.0 SITE DRAINAGE

Preparation of overall drainage layout, design, drawing and providing rain water drainage system within the substation boundary under the present scope including connection at one or more points to the outfall point located outside the substation boundary wall is in the scope of contractor. Invert level of drainage system at outfall point shall be decided in such a way that the water can easily be discharged outside the substation boundary wall. In case outfall point is more than 50M away from boundary wall, only 50 metre drain outside the boundary wall is in the scope of contractor. Outfall point shall be got approved from NEA/Consultant before commencement of construction. While designing the drainage system following points shall be taken care of:

(a) The surface of the switchyard shall be sloped to prevent accumulation of water.
(b) Drain shall be constructed at suitable locations in such a way that substation is not flooded and roads are not affected with ponding of surface water. In the switchyard maximum spacing between two drains shall not be more than 100 meter. It will be ensured that no area is left undrained.
(c) Open surface drains having 300mm bottom width and 300mm depth at starting point of drain shall be provided. The depth of drain shall be measured with respect to finished ground level of switch yard i.e. from bottom of switch yard stone filling.
(d) Longitudinal slope shall not be less than 1 in 1000.
(e) Open surface drains shall be constructed with brick masonry or concrete blocks. As per design of contractor. PCC (1:2:4) shall be laid over 40mm thick layer of PCC 1:4:8 (1 cement: 4coarse sand: 8 stone aggregate 20mm nominal size.)
(f) The side wall of the drains shall be 25 mm above the gravel level to prevent falling of gravel into drain. Groove of 125 mm width shall be provided at 2000 mm spacing with suitable mild steel grating.
(g) The maximum velocity for pipe drains and open drains shall be limited to 2.4m/sec and 1.8m/sec respectively. However, minimum non-silting velocity of 0.6m/sec shall be ensured.
(h) Pipe drains shall be provided in areas of switchyard where movement of crane will be necessary in operating phase of the substation.
(i) For pipe drains, concrete pipe of class NP2 shall be used. However, for road crossings etc. higher strength pipe of class NP3 shall be provided. For rail crossings, RCC pipes of class NP4 shall be provided. For design of RCC pipes for drains and culverts, relevant British standard codes (B S Codes)/ equivalent International Standards. Shall be followed.
(j) Two Nos. of portable pumps of 5 hp capacity for drainage of water shall be

provided by the Contractor.

(k) Pipe drains shall be connected through manholes at an interval of max. 30m.

(l) If the invert level of outfall point is above the last drain point in the substation boundary, sump of suitable size has to be constructed with in the substation boundary.

(m) The drainage scheme and associated drawings shall be got approved from NEA/Consultant before commencement of construction.

6.1 **RAINWATER HARVESTING:**

In addition to drainage of rainwater in accordance with above clause 6.0, the contractor shall design, prepare drawings and provide rainwater harvesting system also. Rainwater harvesting shall not be done if the depth of underground water table is within 8.0m from finished ground level or as per provision of relevant British standard codes (B S Codes)/ equivalent International Standards. While designing the rain water harvesting system, following points may be taken care of:

Rainwater harvesting shall be done by providing two numbers recharge structures with bore wells. The recharge structures shall be suitably located within the sub-station. Branch drains from the main drain carrying rainwater from entire switchyard, constructed in accordance with clause 5.0, shall be connected to the recharge structures.

The internal diameter of recharge shafts shall be 4.5 meter with 230mm thick lining of brick work up to a depth of 2.0 meter from ground level and 345mm thick brickwork below 2.0 meter depth. The brick/concrete block work shall be constructed with cement mortar 1:6 (1 cement: 6 coarse sand). The overall depth of shaft shall be 5.0 meter below invert level of drain. The shaft shall be covered with RCC slab for a live load of 300 kg. Per sq.m. Two openings of size 0.7 x 0.7 meter shall be provided in the RCC cover slab as shown in the drawing. An iron cover made of 5mm thick chequered plate with hinges shall be provided on the openings. Galvanized M.S. rungs of 20mm diameter at spacing of 300 mm shall be provided in the wall of shaft below the opening in the RCC slab to facilitate cleaning of shaft.

A 300 mm diameter bore well shall be drilled in the centre of the shaft. The depth of bore well shall be 5.0 meter more than the depth of sub soil water.

A 100 mm dia. medium duty MS pipe conforming to relevant BS shall be lowered in the bore well keeping bail plug towards bottom of bore well. The pipe shall have 1.58mm holes for 4.0 meter length starting from 1.0 meter from bottom of bore well. Holes of 3.0mm dia. shall be provided for a length of 2.0 meter starting from the bottom level of coarse sand and down wards. The overall length of pipe shall be equal to total depth of bore well plus depth of shaft.

Gravel of size 3mm to 6mm shall be filled around 100 dia. MS pipe in the borewell. The shaft shall be filled with 500 mm thick layers each from the bottom of shaft with boulders of size 50mm to 150mm, gravel of size 5mm to 10mm, coarse sand having particle size 1.5mm to 2.0mm and boulders of size not less than 200mm respectively.

7.0 ROADS

a). All the roads as shown in the General Arrangement drawing for the substation issued along with the tender documents are in the present scope. Adequate turning space for vehicles shall be provided and bend radii shall be set accordingly. Road to the Transformer /Reactor shall be as short and straight as possible.

b) All concrete roads within substation boundary wall shall be with 3.75 m RCC concrete pavement of suitable thickness and 1.3 m wide earthen shoulder on either side of the

road. Below RCC concrete pavement, water bound macadam of adequate thickness as per design (WBM) shall be laid.

c) All black top (Bituminous/Asphalt) roads within substation boundary wall if any shall be with 3.75 m asphaltic pavement of suitable thickness and 1.3 m wide earthen shoulder on either side of the road. Below black top pavement, water bound macadam of adequate thickness as per design (WBM) shall be laid.

d) Strengthening of existing roads as applicable (as shown in General Arrangement Drawing) shall be carried out with 2.5 cm thick premix carpet and 100 mm thick compacted layer of WBM (Water Bound Macadum) after filling the pot holes of existing roads with WBM material.

e) All roads shall be designed as per relevant British standard codes (B S Codes)/ equivalent International Standards. All drawings of road and culverts shall be prepared by the contractor.

f) All the culverts and allied structures (required for road/rail, drain, trench crossings etc.) shall be designed as per relevant British standard codes (B S Codes)/ equivalent International Standards.

8.0 TRANSFORMERS/REACTOR FOUNDATION, RAIL TRACK/ RAIL CUM ROAD TRACK

The Contractor shall design, prepare drawing and provide a RCC Rail cum road system integrated with the Transformer/Reactor foundation to enable installation and the replacement of any failed unit. The transfer track system shall be suitable to permit the movement of any failed unit fully assembled (including OLTC, bushings) with oil. This system shall enable the removal of any failed unit from its foundation to the nearest road. If trench/drain crossings are required then suitable R.C.C. culverts shall be provided in accordance with relevant BS.

The Contractor shall provide a pylon support system for supporting the fire fighting system.

Each Transformer /Reactor including oil conservator tank and cooler banks etc. shall be placed in a self-sufficient pit surrounded by retaining walls (Pit walls). The clear distance of the retaining wall of the pit from the Transformer/Reactor shall be 20% of the Transformer /Reactor height or 0.8m whichever is more. The oil collection pit thus formed shall have a void volume equal to 200% volume for 220 kV & above and 130% for 132 kV & below of total oil in the Transformer /Reactor. The minimum height of the retaining walls shall be 15 cm above the finished level of the ground to avoid outside water pouring inside the pit. The bottom of the pit shall have a uniform slope towards the sump pit. While designing the oil collection pit, the movement of the Transformer must be taken into account.

The grating shall be made of MS flat of size 40mmx 5mm placed at 30mm center to center and 25mmx5mm MS flat at spacing of 150mm at right angle to each other. Maximum length of grating shall be 2000mm and width shall not be more than 500mm. The gratings, supported on ISMB 150mm, shall be placed at the formation level and will be covered with 100mm thick layer of broken/crushed/non-crushed stone having size 40mm to 60mm which acts as an extinguisher for flaming oil. All steel works used for grating and support in transformer foundation shall be painted with Zinc phosphate primer (two packs) conforming to relevant British standard codes (B S Codes)/ equivalent International Standards.

Each oil collection pit shall be drained towards a sump pit within the collection pit whose role is to drain water and oil due to leakage within the collection pit so that collection pit remains dry.

8.1 MATERIALS

Complete foundation shall be made of reinforced cement concrete and shall be designed as per guidelines for design of foundations given in clause 10.0 in the specification.

8.2 **DRAINAGE**

One 0.5 H.P. pump for each pit shall be supplied and installed by the Contractor to evacuate the fire fighting & rain water from the sump pit in to the nearest drain.

9.0 FIRE PROTECTION WALLS

9.1 **GENERAL**

Fire protection walls shall be provided, if required, in accordance with Local Advisory Committee (LAC) recommendations. The scope of works covers design, preparation of drawing and construction of RCC fire protection walls. While designing the wall, following points may be taken care of:

9.1.1 **FIRE RESISTANCE**

The firewall shall have a minimum fire resistance of 3 hours. The partitions, which are made to reduce the noise level, shall have the same fire resistance. The walls of the building, which are used as firewalls, shall also have a minimum fire resistance of 3 hours.

The firewall shall be designed to protect against the effect of radiant heat and flying debris from an adjacent fire.

9.1.2 **DIMENSIONS**

The firewall shall extend 600 mm on each side of the Transformer /Reactors and 600 mm above the conservator tank or safety vent.

These dimensions might be reduced in special cases, as per the approval of owner where there is lack of space. A minimum of 2.0meter clearance shall be provided between the equipments e.g. Transformer /Reactors and firewalls.

The building walls, which act as firewalls, shall extend at least 1 m above the roof in order to protect it.

9.1.3 **MATERIALS**

The firewall will be made of reinforced cement concrete as per the relevant British standard codes (B S Codes)/ equivalent International Standards.

10.0 CABLE TRENCHES AND CABLE TRENCH CROSSINGS

The work covered under this clause comprises of design, drawing and construction of cable trenches and cable trench crossings. While designing, following points may be taken care of:

a). The cable trenches and pre-cast removable RCC cover (with lifting arrangement) shall be constructed using RCC of M25 (Minimum) grade as per relevant British standard codes (B S Codes)/ equivalent International Standards.

b). The cable trench walls shall be designed for the following loads.

(i) Dead load of 155 kg/m length of cable support + 75 Kg on one tier at the outer edge of tier.
(ii) Earth pressure + uniform surcharge pressure of 2T/m2.

c). Cable trench covers shall be designed for self-weight of top slab + concentrated load of 150 kg at centre of span on each panel.

d). Necessary sumps shall be provided and each sump shall be provided with pumps of 5 HP capacity shall be supplied for pumping out water collected in cable trench. Cable trenches shall not be used as storm water drains.

e). The top of trenches shall be kept at least 100 mm above the finished ground level. The top of cable trench shall be such that the surface rainwater do not enter the trench.

f). All metal parts inside the trench shall be connected to the earthing system.

g). Trench wall shall not foul with the foundation. Suitable clear gap shall be provided.

h). The trench bed shall have a slope of 1/500 along the run & 1/250 perpendicular to the run.

i). Cable trenches shall be blocked at the ends if required with brick masonry in cement sand mortar 1:6 and plaster with 12mm thick 1:6 cement sand mortar.

J) Cable trench crossings shall be designed for critical load likely to be passed over the crossing. The cable trench crossing may be of either RCC box culvert type or RCC hume pipes embedded in plain concrete as per design of contractor.

11.0 FOUNDATION / RCC CONSTRUCTION

11.1 GENERAL

1. Work covered under this Clause of the Specification comprises the design ,drawing and construction of foundations and other RCC constructions for switchyard tower structures, bus supports, equipment supports, cable trenches, Transformer /Reactors, jacking pad, pulling blocks, fire protection walls, control cubicles, marshalling kiosks, auxiliary equipments, Control Room Cum Administrative building, GIS hall, Fire fighting Pump house, fire fighting water tanks, Auxiliary Building, Panel room, ,township buildings, Parking shed ,RCC retaining wall, or for any other equipment or service and any other foundation required to complete the work. This clause is as well applicable to the other RCC constructions.

2. Concrete shall conform to the requirements mentioned in relevant British standard codes (B S Codes)/ equivalent International Standards. And all the tests shall be conducted as per relevant British standard codes (B S Codes)/ equivalent International Standards. However, a minimum grade of M25 (design Mix) concrete shall be used for all foundations and structural/load bearing members as per relevant British standard codes (B S Codes)/ equivalent International Standards.

3. If the site is sloppy, the foundation height will be adjusted to maintain the exact level of the top of structures to compensate such slopes.

4. The switchyard foundation’s plinths and building plinths shall be minimum 300mm and 500 mm above finished ground level respectively.

5. Minimum 75mm thick lean concrete (1:4:8) shall be provided below all underground structures, foundations, trenches etc. to provide a base for construction.

6. Concrete made with Portland slag cement shall be carefully cured and special importance shall be given during the placing of concrete and removal of shuttering.

7. The design and detailing of foundations shall be done based on the approved soil data and sub-soil conditions as well as for all possible critical loads and the combinations thereof. The Spread footings foundation or pile foundation as may be required based on soil/sub-soil conditions and superimposed loads shall be provided.

8. If pile foundations are adopted, the same shall be cast-in-situ driven/bored or pre-cast or under reamed type as per relevant parts of relevant British standard codes (B S Codes)/ equivalent International Standards. Only RCC piles shall be provided. Suitability of the adopted pile foundations shall be justified by way of full design calculations. Detailed design calculations shall be submitted by the contractor showing complete details of piles/pile groups proposed to be used. Necessary initial load test shall also be carried out by the bidder at their cost to establish the piles design capacity. Only after the design capacity of piles has been established, the Contractor shall take up the job of piling. Routine tests for the piles shall also be conducted. All the work (design & testing) shall be planned in such a way that these shall not cause any delay in project completion.

11.2 DESIGN

While designing foundations, following may be taken care of:

11.2.1. All foundations except for external lighting poles shall be of reinforced cement concrete. The external lighting pole shall be embedded in plain cement concrete (1:2:4) foundation. The design and construction of RCC structures shall be carried out as per relevant BS and minimum grade of concrete shall be M-25 (design Mix). Higher grade of concrete than specified above may be used at the discretion of Contractor without any additional financial implication to the NEA/Consultant.

11.2.2. Limit state method or any other method as per relevant British standard codes (B S Codes)/ equivalent International Standards of design shall be adopted unless specified otherwise in the specification.

11.2.3. For detailing of reinforcement relevant BS followed. Cold twisted deformed bars conforming to relevant British standard codes (B S Codes)/ equivalent International Standards. Two layers of reinforcement (on inner and outer face) shall be provided for wall & slab sections having thickness of 150 mm and above. Clear cover to reinforcement shall be as per relevant British standard codes (B S Codes)/ equivalent International Standards.

11.2.4. RCC water retaining structures like storage tanks, etc. shall be designed as uncracked section in accordance with relevant British standard codes (B S Codes)/ equivalent International Standards. However, water channels shall be designed as cracked section with limited steel stresses as per relevant BS.

11.2.5. The procedure used for the design of the foundations shall be the most critical loading combination of the steel structure and or equipment and/or superstructure and other conditions which produces the maximum stresses in the foundation or the foundation component and as per the relevant British standard codes (B S Codes)/ equivalent International Standards of foundation design. Detailed design calculations shall be submitted by the bidder showing complete details of piles/pile groups proposed to be used.

11.2.6. Design shall consider any sub-soil water pressure that may be encountered following relevant standard strictly.

11.2.7. Necessary protection to the foundation work, if required shall be provided to take care of any special requirements for aggressive alkaline soil, black cotton soil or any other type of soil which is detrimental/harmful to the concrete foundations.

11.2.8. RCC columns shall be provided with rigid connection at the base.

11.2.9. All sub-structures shall be checked for sliding and overturning stability during both construction and operating conditions for various combinations of loads. Factors of safety for these cases shall be taken as mentioned in relevant British standard codes (B S

Codes)/ equivalent International Standards or as stipulated elsewhere in the Specifications. For checking against overturning, weight of soil vertically above footing shall be taken and inverted frustum of pyramid of earth on the foundation should not be considered.

11.2.10. Earth pressure for all underground structures shall be calculated using co-efficient of earth pressure at rest, co-efficient of active or passive earth pressure (whichever is applicable). However, for the design of substructures of any underground enclosures, earth pressure at rest shall be considered.

11.2.11. In addition to earth pressure and ground water pressure etc., a surcharge load of 2T/Sq.m. shall also be considered for the design of all underground structures including channels, sumps, tanks, trenches, substructure of any underground hollow enclosure etc., for the vehicular traffic in the vicinity of the structure.

11.2.12. Following conditions shall be considered for the design of water tank in pumps house, channels, sumps, trenches and other underground structures:

a) Full water pressure from inside and no earth pressure & ground water pressure & surcharge pressure from outside (application only to structures which are liable to be filled up with water or any other liquid).

b) Full earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.

c) Design shall also be checked against buoyancy due to the ground water during construction and maintenance stages. Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the superimposed loadings.

11.2.13. Base slab of any underground enclosure shall also be designed for empty condition during construction and maintenance stages with maximum ground water table (GWT). Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the super-imposed loadings.

11.2.14. Base slab of any underground enclosure like water storage tank shall also be designed for the condition of different combination of pump sumps being empty during maintenance stages with maximum GWT. Intermediate dividing piers of such enclosures shall be designed considering water in one pump sump only and the other pumps sump being empty for maintenance.

11.2.15. The foundations shall be proportioned so that the estimated total and differential movements of the foundations are not greater than the movements that the structure or equipment is designed to accommodate.

11.2.16. The foundations of transformer/reactor and circuit breaker shall be of lock type foundation. Minimum reinforcement shall be governed by relevant British standard codes (B S Codes)/ equivalent International Standards.

11.2.17. The tower and equipment foundations shall be checked for a factor of safety as per relevant British standard codes (B S Codes)/ equivalent International Standards for two conditions i.e. Normal condition and short circuit condition against sliding, overturning and pullout. The same factors shall be used as partial safety factor over loads in limit state design also.

11.3 **ADMIXTURES & ADDITIVES**

11.3.1. Only approved admixtures shall be used in the concrete for the Works. When more than one admixture is to be used, each admixture shall be batched in its own batch and added

to the mixing water separately before discharging into the mixer. Admixtures shall be delivered in suitably labelled containers to enable identification.

11.3.2. Admixtures in concrete shall conform to relevant British standard codes (B S Codes)/ equivalent International Standards. The water proofing cement additives shall conform to relevant BS. Concrete Admixtures/ Additives shall be approved by NEA/Consultant.

11.3.3. The Contractor may propose and the NEA/Consultant may approve the use of a water-reducing set-retarding admixture in some of the concrete. The use of such an admixture will not be approved to overcome problems associated with inadequate concrete plant capacity or improperly planned placing operations and shall only be approved as an aid to overcoming unusual circumstances and placing conditions.

11.3.4. The water-reducing setting-retarding admixture shall be an approved brand as per relevant British standard codes (B S Codes)/ equivalent International Standards.

11.3.5 The water proofing cement additives shall be used as required/advised by NEA/Consultant.

12.0 CHAINLINK FENCING AND GATE

12.1 **General**

Work covered under this clause comprises of design, drawing, supply, fabrication, erection, painting or galvanisation as specified etc of switch yard Fencing and gate, construction of foundation of steel posts and toe wall. While providing switch yard fencing and gate, following points may be taken care of:

12.2 **Areas requiring Fencing**

12.2.1 Fencing shall be provided for complete switchyard as per drawing. Separate gate shall be provided for men and equipment.

12.2.2 Internal fence surrounding the various equipments (if) mounted on ground or a height lower than 2.5m. Necessary gates shall be provided for each area so surrounded.

12.3 **Product materials**

The minimum requirements are as follows:
Chain link fence fabric (galvanization) in accordance to relevant British standard codes (B S Codes)/ equivalent International Standards.

12.4 **Posts**

The posts shall be of medium M.S. tubes of 50mm diameter conforming to grade as per relevant international /BS standard. The tubes shall also conform relevant British standard codes (B S Codes)/ equivalent International Standards. The length of tubular post shall be 2600 mm.

An M.S. base plate of size 160 X 160 X 6mm thick shall be welded with the tubular post. The post shall be provided on the top with M S plate.

The tubular post shall be welded with 8 number of M S flat of size 50 x 6mm – 75mm long at suitable locations. Two number of 13.5 mm diameter holes on each cleats shall be provided to bolt the fence fabric panel. The cleats shall be welded at equal spacing in such a way that 4 numbers of cleats are on one side and remaining 4 cleats are on the opposite side of the post. The cleats on the corner posts shall be welded in such a way that it suits the site requirement.

The whole assembly of tubular post shall be hot dip galvanized. The zinc coating shall

be minimum 610 gram per sq. meter. The purity of zinc shall be 99.95% as per relevant BS.

12.5 **Fence Fabric & Fence Panel**

Chain link fencing shall be made of 3.15 mm diameter wire with 75 X 75 mm mesh size. Fence fabric shall be galvanised. Chain link fencing shall be fabricated in the form of panel 1300 X 2928 mm. An M.S. flat of at least 50x6 mm size shall be welded all-round fence fabric to form a panel. Four pairs of 13.5mm diameter holes on the vertical M S flat matching the spacing of holes in cleats fixed with pipe shall be provided to fix the fence panel with the tubular posts. A washer shall also be provided below each nut. The contractor, for fixing the panels, shall supply the 12mm diameter bolts including nuts and washers. All nuts, bolts and washers shall be hot dip galvanized.

The fence panel shall be provided with two or more coats of approved standard Zinc paint over approved standard steel primer.

12.6 **Installation**

1. Fence shall be installed along the switchyard line as shown in the approved drawings.
2. Post holes shall be excavated by approved method.
3. All posts shall be 3.0m apart measured parallel to ground surface.
4. Posts shall be set in 1:2:4 Plain Cement Concrete block of minimum 0.40x0.40x1.2m depth. 75mm thick plain cement concrete 1:4:8 shall be provided below concrete blocks. Posts shall be braced and held in plumb position and true alignment and elevation until concrete has set.
5. Fence fabric shall not be installed until concrete has cured a minimum of 7 days.
6. Fence fabric panel shall be fixed to the post at 4 nos. MS flat each of 50x6, 75 long through 2 nos. of bolts (12mm diameter) on each flat.

12.7 **Gate**

1. The gate shall be made of medium duty M.S. pipe conforming to relevant I.S. with welded joints. The main frame (outer frame) of the gate shall be made of 40mm dia. pipe and vertical pipes of 15mm dia. @ 125mm spacing (maximum) shall be welded with the main frame. Two number of 1.25 mm thick and 125 mm wide MS plates (Horizontal) @ 500 mm centre to centre distance shall be welded on each gate leaf. Gate leaves shall be fixed with a vertical post of 2700 mm long two steel channels-150 welded together. A 8 mm thick 200X 200 mm size MS plate shall be welded at the bottom of channel frame.
2. The gates shall be fabricated with welded joints to achieve rigid connections. The gate frames shall be painted with one coat of approved steel primer and two coats of synthetic enamel paint.
3. The gates shall be provided with suitable locking arrangement welded on 4 mm thick MS plate on the gate leaf.
4. The main gate shall be 5.0m wide and shall be of double leaf type (as shown in the drawing). Next to the main gate, a men gate (1.25m wide single leaf) shall also be provided.
5. Steel roller shall be provided with the gate.
6. Gate shall be installed in location as shown in approved G.A. drawing.
7. The vertical post of gate shall be embedded in PCC foundation of 500 X500X1250 mm deep size.

13.0 BUILDINGS

13.1 GENERAL

The scope includes the design, drawing, engineering and construction including anti-termite treatment, plinth protection, DPC of Building including sanitary, water supply, electrification, false ceiling etc as applicable, complete of control room building, fire fighting building, Auxiliary building and panel room. Electrification and air conditioning of

building shall be provided as detailed in other sections of electrical portion.

13.2 CONTROL ROOM CUM ADMINISTRATIVE BUILDING

GENERAL

The scope includes design, engineering and construction, including anti-termite treatment, plinth protection, DPC, peripheral drains, water supply, plumbing, sanitation, fire-fighting, electrification etc. of Control Room Building.

The Control Room Building shall be of size 20 m X 25 m approximately. It will be a double storeyed RCC Framed structure if constructed separately away from GIS hall. It shall be so designed that most of the area of switchyard is visible from the Control Room.

The building auxiliary services like air conditioning systems, fire protection and detection systems and all other miscellaneous services shall be designed in accordance with the requirements as specified in relevant section or elsewhere in this Specification. The building shall be constructed as per the design and drawings to be developed by the contractor. Tentative carpet area requirement for different rooms of control room cum administrative building is given as below for guidance to the contractor:

AREA REQUIREMENTS

• Control Room	37 sq.m.
• ACDB & DCDB Room	145 Sq.M or As per requirement.
• Battery Room	48 Sq. M or As per requirement.
• Electrical Lab	23 sq.m.
• Conference Room with attached Toilet	33 sq.m.
• Telecom Room	As per requirement
• S/S-In-charge office with attached Toilet	27 sq.m.
• Room for executives	55 sq.m.
• Room for non-executives	40 sq.m.
• Lobby -Reception	25 sq.m.
• Corridor width	Minimum width of corridor shall be 1800 mm.
• Portico	25 sq.m. (approx.).
• Common Toilet-Men	07 sq.m.
• Toilet for Women	4 sq.m.
• Janitor Room	3 sq.m.
• Pantry	7 sq.m.
• Provision of shaft for electrical, sanitary, water supply facilities shall also be kept.	

13.3 DESIGN CRITERIA

The Building shall be designed:

1. To the requirements of the International standards/British Standards.

2. for the specified climatic and loading conditions.

3. To adequately suit the requirements of the equipments and apparatus contained in the buildings and in all respects to be compatible with the intended use and occupancy.

4. with a functional and economical space arrangement.

5. To be aesthetically pleasing. Different buildings shall show a uniformity and consistency in architectural design, as far as possible.

6. To allow for easy access to the equipments as well as maintenance of the equipments.

7. Wherever access to the roof is required, RCC stair case shall be provided.

8. Fire retarding materials for walls, ceilings doors etc., which would prevent supporting or spreading of fire and wherever required, shall be decided by the bidder.

9. Suitable Expansion joints, wherever required, shall be provided as per Codal Provisions.
10. All the members of the buildings frame shall be designed for the worst combination of loads as per relevant British standard codes (B S Codes)/ equivalent International Standards.

11. Permissible stresses for different load combinations shall be taken as per relevant British standard codes (B S Codes)/ equivalent International Standards.

12. Seismic coefficient Method or Response spectrum method shall be used for seismic analysis of the building for Earthquake forces, as per relevant British standard codes (B S Codes)/ equivalent International Standards.

13.4 DESIGN LOADS

1. Building structure shall be designed for the most critical combinations of dead loads, super-imposed loads, equipment loads, erection loads, wind loads, seismic loads etc. Any other incidental load, if anticipated, shall be duly accounted for in the design, and shall be clearly mentioned by the bidder.

2. Dead loads shall include the weight of structures complete with finishes, fixtures and partitions, and shall be taken as per relevant British standard codes (B S Codes)/ equivalent International Standards.

3. Super-imposed loads in different areas shall include live loads, minor equipment loads, cable trays, small pipe racks/hangers and erection, operation and maintenance loads, wherever these loads are expected. Equipment loads shall constitute, if applicable, all load of equipments to be supported on the building frame.

AREA	**Load**
1. For Offices.	5.0 kN/m2
If higher than 5.0 kN/m2.	As per actual Requirement.
2. For Equipment Floors.	10.0 kN/m2
If higher than 10 kN/m2 (Based on Equipment weight and layout plans).	As per actual Requirement.
3. Staircases & Balconies.	5.0 kN/m2
4. Toilets.	2.0 kN/m2
5. Chequered Plate.	4.0 kN/m2
6. Cooridoors/Walkways.	3.0 kN/m2
7. Accessible Roofs.	1.5 kN/m2
8. Non-accessible Roofs.	0.75 kN/m2

4. Wind loads shall be calculated as per relevant British standard codes (B S Codes)/ equivalent

International Standards. The Factors affecting the wind speed shall be taken based on the site conditions.

5. Earthquake loads shall be calculated as per relevant British standard codes (B S Codes)/ equivalent International Standards.

6. Wind forces and Seismic forces shall not be considered to act simultaneously.

7. All the load combinations to create worst combinations of loads shall be as per relevant International standards/British Standards.

8. Floors/ Slabs shall be designed to carry loads imposed by equipments, cables, piping, movement of maintenance trucks (if required) and any other load associated with the building. In general, floors shall be designed for live loads as per relevant British standard codes (B S Codes)/ equivalent International Standards. Cable and piping loads shall also be considered in addition to the live loads for floors where these loads are expected.

13.5 FLOORS, WALLS & ROOFS

1. All walls shall be non-load bearing in filled panel walls, in brickwork as per the specification. Minimum thickness of external walls shall be 230 mm (one brick) with 1:6 cement sand mortar. Partition walls if any shall be of 115 mm thick brick masonry in cement sand mortar (1:4).

2. All Floor/Roof slabs shall be regular beam slab construction. However, sunken RCC slab shall be provided in toilet areas as per the requirement.

3. False ceiling as per requirement shall be provided as detailed in Table-1 (Detailed Finish Schedule).

4. Minimum height of skirting above finished floor level shall be 150 mm. The skirting material shall match with the floor finish.

5. Minimum height of the parapet walls shall be 750 mm.

6. Ground floor finish shall be laid over 20 mm thick cement sand mortar,100 mm thick plain cement concrete (PCC) 1:4:8 (1 cement: 4 sand : 8 stone aggregates),100 mm thick local sand filling. The earth below ground floor shall be well rammed before laying sand filling.

7. First floor details shall comprise of finish as per schedule, 20 mm cement sand mortar and 50 mm thick PCC(1:4:8) over RCC slab.

13.6 DETAILS OF ROOF

Roof of the Building shall consist of Cast-in-situ RCC slab treated with a water proofing system which shall be an integral cement based treatment conforming to relevant British standard codes (B S Codes)/ equivalent International Standards. The water proofing treatment shall be of following operations:

(a) Applying and grouting a slurry coat of neat cement using 2.75 kg/m2 of cement admixed with proprietary water proofing compounds conforming to relevant British standard codes (B S Codes)/ equivalent International Standards. Over the RCC slab including cleaning the surface before treatment.

(b) Laying cement concrete using broken stone of size from 25mm to 100mm size with 50% of cement mortar 1:5 (1 cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to relevant British standard codes (B S Codes)/ equivalent International Standards over 20mm thick layer of cement mortar of min 1:5 (Cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to relevant British standard codes (B S Codes)/ equivalent International Standards to required slope and treating similarly the adjoining walls up to 300mm height including rounding of junctions

of walls and slabs.

(c) After two days of proper curing applying a second coat of cement slurry admixed with proprietary water proofing compound conforming relevant British standard codes (B S Codes)/ equivalent International Standards.

(d) Finishing the surface with 20mm thick joint less cement mortar of mix 1:4 (1 cement: 4 course sand) admixed with proprietary water proofing compound conforming to relevant British standard codes (B S Codes)/ equivalent International Standards and finally finishing the surface with trowel with neat cement slurry and making of 300 x 300 mm square.

(e) The whole terrace so finished shall be flooded with water for a minimum period of two weeks for curing and for final test. All above operations to be done in order and as directed and specified by the Engineer-in-charge.

(f) Average thickness of water proofing shall be 120 mm and minimum thickness at khurra shall be 65 mm.

13.7 PARTITIONS

Partitions wherever provided, shall be made of powder coated aluminum frame provided with 5.5 mm thick clear glass or pre-laminated board depending upon the location of partition.

13.8 PLASTERING

External surfaces of buildings shall have 18 mm thick plaster in two layers, with the under layer 12mm thick 1:5 cement sand plaster and the top layer 6 mm thick 1:6 cement sand plaster. Inside wall surfaces shall have 12/15 mm thick 1:6 cement sand plaster. Rough surfaces shall have 15mm and smooth surface shall have 12 mm thick cement sand plaster.

All RCC ceilings shall be provided with 6 mm thick cement sand (fine) plaster (1:3) except for areas with false ceiling.

13.9 EXTERNAL PAINTING

External surfaces of the Control Room Building shall be painted with acrylic exterior flat paint as per manufacturer's specification and approval of NEA/Consultant.

13.10 DOORS, WINDOWS AND VENTILATORS

The schedule of doors, windows and ventilators of the Control Room Building shall be as per the detailed finish schedule given in Table-1 (Detailed Finish Schedule), and shall conform to the relevant British standard codes (B S Codes)/ equivalent International Standards. Rolling Steel shutters shall be provided as per the layout and requirements of the building. Main entrance door to control room building shall be made of powder coated aluminium frame with 5.5 mm thick glazing.

13.11 CABLE TRENCH INSIDE CONTROL ROOM BUILDING

All cable trenches inside the Control Room Building shall be covered with minimum 6mm thick steel chequered plate with suitable stiffeners.

13.12 PLINTH PROTECTION

750 mm wide and 50 mm thick plain cement concrete 1:2:4 (1 cement:2 sand:4 graded 20 mm nominal size stone aggregate) shall be laid over 75 mm thick drystone aggregates well rammed and consolidated with interstices filled with local sand including smooth finishing top.

13.13 PLUMBING & SANITATION

1. All plumbing and sanitation works shall be executed to comply with the requirements of the appropriate bye-laws, rules and regulations of the Local Authority having jurisdiction over such matters. The Contractor shall arrange for all necessary formalities to be met with regards to the inspection, testing, obtaining approval and giving notices etc.

2. 'SINTEX' or an equivalent make PVC Roof water tank(s) of adequate capacity depending on the number of users for 24 hours storage shall be provided. However, a minimum of 2 nos. 1500

litre capacity shall be provided.

3. Chlorinated Polyvinyl chloride (CPVC) pipes having thermal stability for hot and cold water supply including all CPVC plain and brass threading conforming to relevant British standard codes (B S Codes)/ equivalent International Standards shall be used for internal piping works for water supply.

4. Sand C.I. pipes with lead joints conforming to relevant British standard codes (B S Codes)/ equivalent International Standards shall be used for sanitary works above ground level and RCC pipes shall be used for sanitary works below ground.

5. Each toilet shall have the following minimum fittings:

(i) WC (Western type) 390 mm high along with toilet paper roll holder and all other fittings, in toilets attached to conference room and S/S In-charge office; and WC (Indian Type) Orissa Pattern (580 x 440 mm) with all fittings shall be provided in common toilets.

(ii) Urinal (430 x 260 x 350 mm size) with all fittings and built-in-sensor for automatic flush after use.

(iii) Wash basin (550 x 400 mm) with all fittings.

(iv) Bathroom mirror (600 x 450 x 6 mm thick) with hard board backing.

(v) CP brass towel rail (600 x 20 mm) with CP brass brackets.

(vi) Soap holder and liquid soap dispenser.

(vii) Automatic Hand Dryer.

6. Water cooler for drinking water with adequate water storage facility shall be provided which shall preferably be located near pantry and away from the toilet block.

7. One no. stainless steel kitchen sink with Drain board (510 x 1040 x 178 mm bowl depth) for pantry shall be provided.

8. All fittings, fasteners, gratings shall be chromium plated.

9. All sanitary fixtures and fittings shall be of approved quality and type, manufactured by reputed manufacturers. All items brought to site must bear identification marks of the Manufacturer.

10. Contractor shall provide necessary nos. of septic tank and soak pit of adequate capacity to treat the sewage/sullage from the buildings.

11. Contractor shall undertake all other activities required to complete and commission the building.

13.14 BUILDING STORM WATER DRAINAGE

1. The building design shall provide for the collection of storm water from the roof. This water shall be drained to the main drainage system of the Sub-station.
2. Cast Iron Rainwater down comer pipes conforming to relevant International standards/British Standards with water tight lead joints or medium class galvanized mild steel pipes conforms to relevant British standard codes (B S Codes)/ equivalent International Standards shall be provided to drain off the rain water from the roofs. These pipes shall be suitably concealed with masonry work or cement concrete or cladding material. The number and size of down comer pipes shall be governed by relevant British standard codes (B S Codes)/ equivalent International Standards.
3. All drains inside the buildings shall have minimum 40 mm thick grating covers; and in areas where heavy equipment loads are envisaged, Pre-Cast RCC covers shall be provided in place of steel grating.
4. Suitable arrangements for draining out water collected from equipment blow downs, leakages, floor washings, firefighting etc. shall be provided for each floor.

13.15 DETAILED FINISH SCHEDULE

The detailed finish schedule for Control Room Building Cum Administrative building is given below:

Table- 1: DETAILED FINISH SCHEDULE

Sl. No.	LOCATION	FLOORING & SKIRTING 150 MM HIGH	WALL(INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
1.	Control Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of 10mm thick toughened glass by using suitable patch fittings/spider fittings. The glass shall extend horizontally from column to column and vertically from sill level of 0.75 m to bottom of lintel/roof beam. All doors shall be glazed powder coated aluminium doors with 5.5.mm Thk. Glazing.
2.	Conference Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing
3.	S/S In-charge Room.	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
4	Office Rooms	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
5.	Electrical/Electronic Test Lab./Telecom Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
6.	ACDB & DCDB Room	62mm thick cement concrete flooring with metallic hardener topping. Skirting shall be of	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool. Windows/ventilator shall be of powder coated aluminium with 4mm glazing.

Sl. No.	LOCATION	FLOORING & SKIRTING 150 MM HIGH	WALL(INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
		cement sand plaster.			
7.	Battery Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool. Windows/ventilator shall be of powder coated aluminium with 4mm glazing.
8.	Reception/Lobby	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
9.	Corridor	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminum doors with 5.5.mm thk. Glazing.
10.	Portico	Cast-in-situ 52mm thk. Cement concrete with metallic hardener.	Granite cladding	Oil bound washable distemper on smooth surface applied with plaster of paris putty	All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
11.	Toilet	Ceramic tiles	DADO glazed tile 2100mm high, oil bound washable distemper above DADO	Oil bound washable distemper	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters made of pre-laminated particle board with powder coated aluminium frame.
12.	Janitor room	Ceramic tiles with white cement	Vitrified tiles 8mm thick size 600 x 600mm	Oil bound washable distemper	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters made of pre-laminated particle board with powder coated aluminium frame.

*Providing and fixing 15mm thick approximately 600 X 600mm Mineral fiber board panel false ceiling and making cut-outs for electrical fixtures, AC diffusers, openable access e.t.c complete

with silhouette profile system with 15mm wide flange incorporating 6mm central recess white / black main runners at 1200mm centre-centre and not greater than 600mm from the adjacent wall. The cross tees shall be provided to make a module of approximately 600mm X 600mm by fitting 600 mm long cross tees centrally placed between 1200 mm long cross tees. Cross tees also have 15mm wide flange incorporating 6mm central recess white/black. The module formed above shall be anchored to the slab with channels or angles, suspenders as per manufacturer's specifications.

13.16 **SUBMISSIONS**

The following information/documents/drawings shall be submitted for review and approval:

1. Structural design calculations, Structural drawings (including construction/ fabrication), both in hard and soft copies, for all reinforced concrete and structural steel structures.

2. Fully dimensioned and detailed floor plans, cross-sections, longitudinal sections and elevations identifying the major building components.

3. Product information of building components and materials, including walls, partitions, flooring, ceilings, roofing, doors, wall paneling and windows and building finishes along with BOQ.

5. A detailed schedule of building finishes including colors schemes along with item description.

6. A door & window schedule showing door & window types and locations, lock sets and latch sets and other door hardware along with item details.

Approval of the above information shall be obtained before ordering materials or starting construction/fabrication, as applicable.

13.17 **FALSE CEILING**

Providing and fixing seamless ceiling with Gypsum board of 12mm thick fixed to the underside of GI frame work. The GI is fixed to the roof Slab with metal expansion fastener. The joint shall be finished with joint paper tape by using jointing Compound recommended by manufacturer with the approval of NEA/Consultant. The rate includes for all necessary cutting of ceiling for the fixing of complete fixtures.

13.18 **Under deck Insulation**

The method of fixing shall consist of slotted M.S. angles of appropriate size (minimum 65x50x2mm) fixed to soffit of RCC roof slab at 600mm centres in both directions by Rawl plugs of adequate strength. The slots shall have 14g G.I. tie wire drawn through them.
50mm thick insulation mat Fibreglass Crown - 100 or equivalent shall, be made out of fibre-glass or approved equivalent conforming to IS: 8183, backed with 34g aluminium foil and 22g x 12mm mesh wire netting. The net shall be stretched tightly across the slotted angles or slotted plates holding it in place by means of wires. The joints of the wire netting shall be butted and tightly laced down with 14g G.I. wire. The system shall be got approved from NEA/Consultant.

13.19 **ELECTRIFICATION**

All electrification shall be executed as per details specified elsewhere in the technical specification. All details shall be as per relevant British standard codes (B S Codes)/ equivalent International Standards.

14.0 FIRE FIGHTING PUMP HOUSE BUILDING

GENERAL

The scope includes design, engineering and construction, including anti-termite treatment, plinth protection, DPC, peripheral drains, fire-fighting, electrification etc. of fire fighting pump house

building.

The firefighting pump house building shall be essentially single storied reinforced cement concrete (RCC) framed Building. The building auxiliary services like internal electrification, fire protection systems shall be designed in accordance with the requirements as specified in relevant section of technical Specification. The design and layout of foundation of various pumps and cable trenches inside building shall be prepared by the contractor as per requirement of proposed firefighting system.

AREA REQUIREMENTS

Dimensions of the Building shall be decided by the bidder depending upon the requirement. The approximate size of building is 12.3m X 7.9mX 4.3 m high. The height of building shall be measured from finished floor level to top of roof slab.

DESIGN CRITERIA

The Building shall be designed:

1. To the requirements of the relevant /British standards/ equivalent International standards quoted therein, and as specified in this specification.

2. for the specified climatic and loading conditions.

3. To adequately suit the requirements of the pumps and firefighting system contained in the buildings and in all respects to be compatible with the intended use and occupancy.

4. with a functional and economical space arrangement.

5. To be aesthetically pleasing. Different buildings shall show a uniformity and consistency in architectural design, as far as possible.

6. To allow for easy access to the equipments as well as maintenance of the equipments.

7. G.I. ladder with cage shall be provided for access to the roof.

8. With, wherever required, fire retarding materials for walls, ceilings doors etc., which would prevent supporting or spreading of fire and shall be decided by the bidder.

9. Suitable Expansion joints, wherever required, shall be provided as per Codal Provisions.

10. All the members of the buildings frame shall be designed for the worst combination of Loads as per relevant International standards/British Standards.

11. Permissible stresses for different load combinations shall be taken as per relevant International standards/British Standards.

12. Seismic analysis of the building for Earthquake forces shall be carried out as per relevant International standards/British Standards.

DESIGN LOADS

1. Building structure shall be designed for the most critical combinations of dead loads, super-imposed loads, equipment loads, wind loads, seismic loads etc. Any other incidental load, if anticipated, shall be duly accounted for in the design, and shall be clearly mentioned by the bidder.

2. Dead loads shall include the weight of structures complete with finishes, fixtures and partitions, and shall be taken as per relevant International standards/British Standards.

3. Super-imposed loads in different areas shall include live loads, cable trays, and small pipe racks/hangers, piping system and erection, operation and maintenance loads wherever these loads are expected.

1) Non-accessible Roof – 0.75 kN/m2.

2) Accessible Roof – 150 kN/m2

4. Wind loads shall be calculated as per relevant International standards/British Standards. The

Factors affecting the wind speed shall be taken based on the site conditions.

5. Earthquake loads shall be calculated as per relevant International standards/British Standards.

6. Wind forces and Seismic forces shall not be considered to act simultaneously.

7. All the load combinations to create worst combinations of loads shall be as per relevant International standards/British Standards.

7. Floors shall be designed to carry loads imposed by Pumps, cables, piping, movement of maintenance trucks (if required) and any other load associated with the building. In general, floors shall be designed for live loads as per relevant International standards/British Standards. Cable and piping loads shall also be considered in addition to the live loads for floors where these loads are expected.

FLOORS, WALLS & ROOFS

The floor shall be constructed with 52 mm thick cement concrete finished with metallic hardener topping. 150 mm thick base plain cement concrete layer,100 mm thick compacted local sand filling and 200 mm thick hard core of stone ballast with interstices filled with local sand shall be laid below cement concrete flooring top. The earth filling below floor shall be well rammed.

PLASTERING

External surfaces of building shall have 18 mm thick plaster in two layers, with the under layer 12mm thick 1:5 cement sand (coarse) plaster and the top layer 6 mm thick 1:6 cement sand (coarse) plaster. Inside wall surfaces shall have 12/15 mm thick 1:6 cement sand (coarse) plaster. Rough surfaces shall have 15mm and smooth surface shall have 12 mm thick cement sand plaster. Ceiling shall be plastered with 6 mm thick cement sand plaster (1 Cement: 3 Sand).

EXTERNAL PAINTING

External surfaces of the Building shall be painted with acrylic exterior flat paint as per manufacturer's specification and approval of NEA/Consultant.

DOORS, WINDOWS AND VENTILATORS

The schedule of doors, roller shutter, windows and ventilators of the Building shall be of steel as per relevant International standards/British Standards. Rolling Steel shutters shall be provided as per the layout and requirements of the building. Main entrance door to the Building shall be MS door frame with M.S. sheet double shutter. Windows and ventilators shall be of steel made of hot rolled sections windows and ventilators shall be provided with 5.5 mm thick glazing.

CABLE TRENCH INSIDE FIRE FIGHTING PUMP HOUSE BUILDING

All cable trenches inside the building shall be covered with minimum 6 mm thick steel chequered plate with suitable stiffeners. The structural steel used for cable tray support, earthing cleat, chequered plates for internal cable trenches of fire fighting pump house building shall be measured and paid under miscellaneous steel item of BPS

PLINTH PROTECTION

750 mm wide plinth protection all-around the building shall be provided. Plinth protection shall comprise of 50 mm thick PCC (1:2:4) laid over 75 mm thick well compacted stone aggregates with interstices filled with local sand including smooth finishing top.

PARAPET

230 mm thick and 500 mm high brick parapet shall be provided. The parapet shall be plastered with cement sand plaster (1:6).

BUILDING STORM WATER DRAINAGE

1. The building design shall provide for the collection of storm water from the roof. This water shall be drained to the main drainage system of the Sub-station.
2. Cast Iron Rainwater down comer pipes conforming to relevant International standards/British Standards with water tight lead joints or medium class galvanized mild steel pipes conforms to relevant International standards/British Standards shall be provided to drain off the rain water

from the roofs. These pipes shall be suitably concealed with masonry work or cement concrete or cladding material.
3. Suitable arrangements for draining out water collected from equipment blow downs, leakages, floor washings, fire fighting etc. shall be provided, if found necessary.

DETAILS OF ROOF

Roof of the Building shall consist of Cast-in-situ RCC slab treated with a water proofing system which shall be an integral cement-based treatment conforming to relevant International standards/British Standards. The water proofing treatment shall be of following operations:
(a) Applying and grouting a slurry coat of neat cement using 2.75 kg/m2 of cement admixed with proprietary water proofing compounds conforming to relevant International standards/British Standards over the RCC slab including cleaning the surface before treatment.
(b) Laying cement concrete using broken stones 25mm to 100mm size with 50% of cement mortar 1:5 (1 cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to relevant International standards/British Standards over 20mm thick layer of cement mortar of min 1:5 (Cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to relevant International standards/British Standards to required slope and treating similarly the adjoining walls up to 300mm height including rounding of junctions of walls and slabs.
(c) After two days of proper curing applying a second coat of cement slurry admixed with proprietary water proofing compound conforming to relevant British standard codes (B S Codes)/ equivalent International Standards. (d) Finishing the surface with 20mm thick joint less cement mortar of mix 1:4 (1 cement: 4 course sand) admixed with proprietary water proofing compound conforming to relevant International standards/British Standards and finally finishing the surface with trowel with neat cement slurry and making of 300 x 300 mm square.
(e) The whole terrace so finished shall be flooded with water for a minimum period of two weeks for curing and for final test. All above operations to be done in order and as directed and specified by the Engineer-in-charge.

(f) Average thickness of water proofing shall be 120 mm and minimum thickness at khurra shall be 65 mm.

DETAILED FINISH SCHEDULE

The detailed finish schedule for Fire Fighting Pump House Building is given below:

Table- 2 : DETAILED FINISH SCHEDULE

S.	LOCATION	FLOORING & SKIRTING 150 MM HIGH	WALL (INTERNAL)	CEILING	ROLLER SHUTTER, DOOR, WINDOWS & VENTILATOR
1.	Fire Fighting Pump House	62mm thick cement concrete flooring with metallic hardener topping. Skirting shall be of cement sand plaster.	Oil bound washable distemper on masonry portion.	As per Manufacturer details.	Windows/ ventilator shall be hot rolled steel section with 5.5mm thick glazing. Entry door shall be of M.S. Sheet double shutter and rolling shutter shall be of steel.

ELECTRIFICATION

All electrification shall be executed as per details specified elsewhere in the technical specification. All details shall be as per relevant British standard codes (B S Codes)/ equivalent International Standards.

15.0 AUXILLIARY BUILDING

Auxilliary building shall be single storeyed reinforced cement concrete framed structure building. The size of building shall be about 15 m X 20 m approximately. However, bidder may suggest suitable size as per his requirement. The building shall house 11 kV indoor switchgear.

The details like floor details, door, windows, ventilator, internal finish details etc shall match with respective room of RCC control room building. External finish shall also match with control room building.

1. Contractor shall develop the layout in such a way that its aesthetic look is pleasant. The design of Auxiliary building shall be carried out as per relevant International standard/British Standards.
2. The internal cable trenches, panel etc shall be designed by the contractor as per requirement. Layout of these cable trenches, panel layout shall also be prepared by the contractor as per requirement.

CABLE TRENCH INSIDE AUXILLIARY BUILDING

All cable trenches inside the building shall be covered with minimum 6 mm thick steel chequered plate with suitable stiffeners. The structural steel used for cable tray support, earthing cleat, chequered plates for internal cable trenches shall be measured and paid under miscellaneous steel item of BPS.

ELECTRIFICATION

All electrification shall be executed as per details specified elsewhere in the technical specification. All details shall be as per relevant British standard codes (B S Codes)/ equivalent International Standards.

16.0 FIRE FIGHTING WATER TANK

1. Reinforced cement concrete water tank with two compartments each of size 9.31 m X 9.31 m and capacity of 317 Cubic Meter shall be constructed. A sump of size 2.5 m X 2.5 m x 0.5 m deep shall be provided at one corner in each compartment. Finished floor level of water tank shall be about 200 mm above finished ground level of switch yard. Base slab of water tank shall rest on 75 mm thick plain cement concrete (1:3:6) laid over 800 mm thick well compacted stone packing (Stone Size from 25 mm to 150 mm) with interstices filled with local sand.

3. The roof of Water tank shall be of Asbestos-free Corrugated sheet. The sheet shall be

supported on suitable steel purlins etc. Suitable gutter shall be provided to drain off rain water.

4. A steel door of size 900 mm X 1850 mm with single shutter made of hot rolled steel section and MS steel door frame shall be provided at about (+) 4.5 m level for access inside water tank.

5. Suitable MS rungs of 20 mm diameter rod @ 300 mm centre to centre staggered on both faces (External and internal) of wall at suitable location shall be provided to act as ladder.

6. Integral water proofing compound of reputed brand shall be added to the concrete and plaster of water tank. Quantity of compound shall be as per manufacturer's recommendation.

7. All inserts, nozzles, pipe sleeves etc shall be provided during concreting at suitable locations as per fire fighting system. The size is to be decided by the contractor to meet the requirement.

8. Inside surfaces of water tank shall be plastered with cement sand plaster (1 Cement: 6 sand).

9. The outer surface of water tank shall be painted with the paint matching with Fire fighting pump house building.

10. P.V.C. water stopper shall be provided at all construction joints of water tank.

11. The design of water tank shall be carried out as per relevant British standard codes (B S Codes)/ equivalent International Standards.

17.0 SWITCH YARD PANEL ROOM

RCC switchyard panel room with the size as mentioned in bid price schedule shall be constructed. RCC sloped roof shall be provided. The sloped roof shall be covered with suitable tiles to enhance aesthetic look. The floor details (sand, PCC, cement mortar) shall match with that of other buildings. The floor finish shall be provided with vitrified tiles. Plinth protection as per other buildings. The finish details like painting, plaster shall match with other buildings. Doors shall be aluminium glazed.

All walls, floor and roof shall be provided with suitable chicken wire mesh which shall be connected with earthing system through 75 x 12 mm MS flat. Air conditioning and internal electrification of panel room shall be done as mentioned in respective technical specification and BPS in Electrical portion. The size and layout of internal cable trenches of panel room shall be decided by the contractor as per requirement. All cable trenches inside the panel room shall be covered with minimum 6 mm thick steel chequered plate with suitable stiffeners. The structural steel used for cable tray support, earthing cleat, chequered plates for internal cable trenches shall be measured and paid under miscellaneous steel item of BPS

The design shall conform to relevant British standard codes (B S Codes)/ equivalent International Standards.

18.0 CAR PARKING SHED

Aesthetically pleasant RCC car parking shed as per design and drawings as developed by the contractor and suitable to park 10 cars shall be constructed at suitable location to be decided during detailed engineering stage.

19.0 WATER SUPPLY

(i) Water shall be made available by NEA/consultant at any feasible point within

substation boundary at single point to the contractor. Contractor shall state the total water requirement both in terms of quantity and head to NEA/Consultant.

(ii) The contractor shall carry out all the plumbing/erection works required for supply of water in control room cum administrative building beyond the single point as at (i) above.

(iii) The contractor shall carry out all the plumbing/erection works required for supply of water to Fire Fighting pump house beyond the single point as at (i) above.

(iv) The details of tanks, pipes, fittings, fixtures etc for water supply are given elsewhere in the specification under respective sections.

(v) A scheme shall be prepared by the contractor indicating the layout and details of water supply which shall be got approved by NEA/Consultant before actual start of work including all other incidental items not shown or specified but as may be required for complete performance of the works. All drawings shall be prepared by the contractor for approval of NEA/Consultant.

(vi) Bore wells and pumps for water supply is not in the scope of contractor.

20.0 SEWERAGE SYSTEM

(i) Sewerage system shall be provided for all buildings wherever applicable.

(ii) The Contractor shall construct septic tank and soak pit suitable for 50 users each for control room building, transit camp and township buildings is constructed. If septic and soak pit system is not acceptable by local Nepal Authority, contractor will have to install suitable sewerage system as per local statutory requirement.

(iii) The system shall be designed as per relevant British standard codes (B S Codes)/ equivalent International Standards. All drawings shall be prepared by the contractor for approval of NEA/Consultant.

21.0 GIS HALL CUM CONTROL ROOM BUILDING

21.1 Control Room and GIS Hall

The GIS building shall be of pre-engineered steel structure. Control room building, if attached to GIS hall, shall be of pre-engineered steel structure similar to GIS hall and shall be RCC framed structure, if it is not connected with GIS hall. In case of steel control room building all walls shall be of brick masonry and roof of ground floor shall be of RCC. Internal access to the GIS hall from control room building shall be provided.

Material specification and other details for construction of Pre-engineered steel building shall be as described in subsequent paragraphs. The base plate of steel columns shall be mounted on the RCC foundation by means of hot dip galvanised foundation bolts (Galvanisation of 610 gms/Sq. M). In order to facilitate inspection and maintenance, the structures shall be provided with climbing devices. Separate fire escape doors shall also be provided in the GIS Building.

Panels shall be kept in an air-conditioned enclosure. A glazed partition made of aluminium frame and 5.5mm thick glass shall be provided between GIS hall and panel room. The glazing shall be kept at a sill level of 0.9 m above floor level. The height of glazing shall be minimum 2.1 m above sill level.

Walkway of width not less than 1.0m shall be provided at gantry girder level on the two longer side of GIS hall along with climbing arrangement to facilitate maintenance of crane.

All the material required for Pre-engineered (steel) building shall be procured from reputed manufacturer for which prior approval shall be obtained. Manufacturing of various parts of the building shall start only after approval of "Manufacturing Quality Plan to be prepared by the bidder during detailed engineering stage". Complete material shall be offered for inspection by QA&I department of Consultant/NEA before dispatch. Inspection shall be carried out based on assembly (fabrication) drawings approved by consultant/NEA and "BILL OF MATERIAL" & Shop drawing prepared by the Manufacturer and certified by the Contractor for its correctness. Approval of BOM and shop drawing from employer is not required.

21.2 **Material Specification**

21.2.1 Primary members fabricated from plates and sections with minimum yield strength of 345 MPa or to suit design by continuous welding.

21.2.2 Secondary members for Purlins and Grits shall conform to the physical specification of ASTM A570 (Grade 50) or equivalent BS/equivalent international standards having a minimum yield strength of 345 MPa. The minimum thickness of secondary members shall be 2.5mm.

21.2.3 Rod / ANGLE/pipe bracing shall conform to the physical specification of relevant BS/equivalent international standards of minimum 245 MPa Yield Strength

21.2.4 All hot rolled sections shall conform to the physical specifications of BS/equivalent international standards. All other miscellaneous secondary members shall have minimum yield strength of 250 MPa.

21.3 **DESCRIPTION**

21.3.1 **PRIMARY MEMBERS:**

Primary structural framing shall include the transverse rigid frames, columns, corner columns, end wall wind columns and crane gantry girders and Frames at Door openings.

21.3.2 **SECONDARY MEMBERS:**

Secondary structural framing shall include the purlins, girts, eave struts, wind bracing, flange bracing, base angles, clips, flashings and other miscellaneous structural parts. Suitable wind bracings sag rods to be reckoned while designing the structure.

21.3.3 **PURLINS, GIRTS, CLIPS:**

Purlins, girts and clips should be of Pre-Galvanised steel of 345 MPa having a coating thickness of 275 gms/sq. M inclusive of both sides.

21.3.4 ROOF SHEETING

Factory assembled 50mm thick puff (density 40kg/cu.m. +2 Kg/cu m as per BS/equivalent International Standards) sandwiched panels shall be provided. These panels shall be made of puff insulation sandwiched between two high tensile steel sheets each of 0.5 mm thickness. The material of sheets shall confirm to ASTM 792 M Grade 345B with minimum yield strength of 345 MPa. The steel sheets shall be provided with hot dip coating of Zinc aluminium alloy (approximately 55% Al , 43.5% Zn

and 1.5 % silicon) .Total mass of zinc aluminium alloy coating shall be minimum 200 gm/Sq. m inclusive of both sides. The tolerance of base metal thickness (BMT) of steel sheet shall be as per BS/equivalent International Standards. After hot dip coating of Zinc aluminium alloy, the sheet shall be provided with steel primer and silicon modified polyester (SMP) paint. The total thickness of primer and paint shall be 40 microns inclusive of both sides (TCT) comprising of 20 microns of SMP paint on top surface and 10 microns of backer coat (polyester coat) on back surface over 5 microns thick primer each on both surfaces with inorganic pigments coated free from heavy metals. Painting shall conform to BS/equivalent International Standards. In case SMP paint is not available, Super Durable Polyester paint (SDP) can also be used by the bidder without cost implication to POWERGRID.

21.3.5 **Wall Panels**

Wall panel material specifications shall be same as roof panels.

21.3.6 **SHEETING FASTENERS:**

Standard fasteners shall be self-tapping zinc plated metal screws with EPDM bonded zinc plated washers. All screws shall be colour coated to match roof and wall sheeting.

21.3.7 **SEALER**:

This is to be applied at all side laps and end laps of roof panels and around self-flashing windows. Sealer shall be pressure sensitive elastomeric Butyl tapes. The sealer shall be non-asphaltic, non-shrinking and non-toxic and shall be superior adhesive metals, plastics and painted at temperatures from 51°C to +104°C.

21.3.8 **CLOSURES**:

Solid or closed cell closures matching the profiles of the panel shall be installed along the eaves, rake and other locations specified on drawings.

21.3.9 **FLASHING AND TRIM:**

Flashing and / or trim shall be furnished at the rake, corners, eaves, and framed openings and wherever necessary to provide weather tightness and finished appearance. Colour shall be matching with the colour of wall. Material shall be 26 gauge thick conforming to the physical specifications of sheeting.

21.3.10 **WALL LIGHTS:**

For day lighting purpose of GIS hall, minimum 2 mm thick approved translucent polycarbonate sheet shall be provided for wall lighting in addition to windows for at least 10% of wall area on upper portion of both long walls. The polycarbonate sheet shall be fixed with necessary EPDM, rubber gasket, Silicon Sealant, cold forged fastener, aluminum profile etc. including MS supporting structural steel (conforming to relevant BS/equivalent International Standards) frame to ensure water tight arrangement.

21.3.11 **GUTTERS AND DOWN SPOUTS:**

Gutters and downspouts shall be adequately designed to ensure proper roof drainage system. Material shall be same as that of sheeting with matching colour.

21.3.12 PAINTING OF BUILT UP STEEL FRAMES, CRANE GANTRY GIRDERS and FRAMES AT DOOR OPENINGS, WALK WAY STEEL AND LADDER:

The built up frame, Crane gantry girders, frames for door openings and steel for walk

way shall be applied with a priming coat of standard steel primmer followed by one coat coating of epoxy paint and final coating of PU (Minimum 100 Micron). The steel work for aforesaid members shall be provided with suitable treatment of shot blasting before application of steel primer. The steel material of ladder shall be galvanized.

21.3.13 COLOUR SCHEME:

Colour Scheme matching with local aesthetic and best industry practices shall be submitted by vendors for approval of POWERGRID. Three alternatives of coloured isometric views with colour codes shall be submitted for approval. The monotony of external colour of sheet shall be avoided by providing vertical bands of different coloured sheet. The colour of roof sheet shall be light coloured to minimize heat absorption. External and internal masonry walls shall be painted with suitable colour matching with colour of steel sheet.

21.4 **CONNECTIONS:**

21.4.1 **SITE CONNECTIONS**

a) All primary bolted connections shall be provided with galvanized high strength bolts, washers, nuts conforming to specifications of relevant standard.

b) All secondary bolted connections shall be furnished with bolts, nuts, washers conforming to the specifications of grade 4.6 of relevant standard or ASTM-A307.

21.4.2 **SHOP CONNECTIONS**

All shop connections shall be welded with appropriate arc welding process and welding shall be in accordance with relevant standard, AWSD 1.1. as appropriate. The Webs should be welded on to the flanges at both the faces at top and bottom for columns, beams and crane girders. Weld material should have strength more than the parent metal.

21.4.3 **ROOF & WALL BRACINGS**

Roof and wall bracings shall have minimum yield strength of 250 MPa and shall conform to the specifications of relevant standard.

21.5 INTERNAL FINISH SCHEDULE

The finishing schedule is given in subsequent clauses and table-1. Areas not specified in finish schedule shall be provided with vitrified tile flooring, and Premium Acrylic emulsion paint oil bound washable distemper over two mm thick putty. Paints used in the work shall be of best quality specified in relevant standard.

21.5.1 FLOORING

Flooring in various rooms of control room building and GIS hall shall be as per detailed schedule given in Table -1.

21.5.2 WALLS

All walls of control room building shall be non-load bearing walls. Min. thickness of walls shall be 230 mm (one brick) with 1:6 cement sand mortar. Partition walls (115mm thick) in toilets and pantry can be half brick walls with 1:4 cement sand mortar and two nos. 6mm dia. MS bars at every third course.

In GIS building and the attached relay room 230mm thick brick wall shall be provided up to roof level of relay room attached to GIS hall. 50mm thick puff sandwiched panels as described above shall be provided above brick wall.

21.5.3 ROOF

(A) GIS Building and Control Room (if steel structure)

Roofing Panel: 50mm thick puff (density 40kg/cu. m.) sandwiched panels shall be provided as described in previous clauses.

21.6 CABLE TRENCH IN GIS HALL

All cable trenches in GIS hall shall be covered with minimum 6mm thick steel chequered plate with suitable stiffeners. Chequered plate shall be painted with two or more coats of Epoxy paint as per relevant standards.

21.7 EXTERNAL PLASTER AND PAINTING

External plaster 18mm thick shall be of 1:6 cement sand plaster in two layers. External surface of the control room building and GIS building (brick wall portion) shall be painted with Premium acrylic smooth exterior paint with silicon additives over and including priming coat of exterior primer as per relevant standards.

21.8 INTERNAL FINISH SCHEDULE

Internal finish Schedule for control room building and GIS hall is given in Table - 1 below:

Table -1

S.No.	LOCATION	FLOORING & SKIRTING 150MM HIGH	WALL (INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
1.	Control Room	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of 10mm thick toughened glass by using suitable patch fittings/spider fittings. The glass shall extend horizontally from column to column and vertically from sill level of 0.75 m to bottom of lintel/roof beam. All doors shall be glazed powder coated aluminium doors with 5.5.mm Thk. Glazing.
2.	Conference	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
3.	In-charge Room	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be

S.No.	LOCATION	FLOORING & SKIRTING 150MM HIGH	WALL (INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
			with plaster of paris (2 mm thick)		glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
4	Other Office Rooms	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
5.	Electronics Test Lab.	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
6.	ACDB & DCDB Room	62mm thick cement concrete flooring with metallic hardener topping	Oil bound washable distemper on smooth surface applied with plaster of paris putty as per relevant standards	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool. Windows/ventilator shall be of powder coated aluminium with 4mm glazing.
7.	Battery room	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool. Windows/ventilator shall be of powder coated aluminium with 4mm glazing.
8.	Lobby	18mm thick granite flooring	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.

S.No.	LOCATION	FLOORING & SKIRTING 150MM HIGH	WALL (INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
9.	Corridor	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
10.	Portico	18mm thick granite flooring	Granite cladding	Acrylic emulsion paint over a coat of cement primer on smooth surface applied with readymade putty 1 mm thick as per relevant standards	All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
11.	Toilet	Ceramic tiles	DADO glazed tile 2100mm high, oil bound washable distemper above DADO	Acrylic emulsion paint over a coat of cement primer on smooth surface applied with readymade putty 1 mm thick as per relevant standards	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters made of pre-laminated particle board (with powder coated aluminium frame.
12.	Janitor room	Ceramic tiles	DADO glazed tile 2100mm high, oil bound washable distemper above DADO	Acrylic emulsion paint over a coat of cement primer on smooth surface applied with readymade putty 1 mm thick as per relevant standards	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters made of pre-laminated particle board with powder coated aluminium frame.
13.	GIS Hall	62mm thick cement concrete flooring with metallic	Premium Acrylic emulsion paint having Volatile Organic	In case of RCC roof, ceiling shall be finished with Premium	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors

S.No.	LOCATION	FLOORING & SKIRTING 150MM HIGH	WALL (INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
		hardener topping (DSR item code 11.5). Two coats of PU coating over the metallic hardener shall be provided. The final coat of PU shall be applied after Installation of equipments. Total thickness of PU coats shall be minimum 300 microns.	Compound (VOC) content less than 50 gms per liter of approved brand and manufacturer on smooth surface applied with plaster of paris (2 mm thick) over approved primer coat.	Acrylic emulsion paint having Volatile Organic Compound (VOC) content less than 50 gms per liter of approved brand and manufacturer over approved primer coat	shall be flush door shutters with powder coated aluminium frame.
14.	Panel/Relay Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
15.	AHU Room	62mm thick cement concrete flooring with metallic hardener topping	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	Acrylic emulsion paint over a coat of cement primer on smooth surface applied with readymade putty 1 mm thick as per relevant standards	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters with powder coated aluminium frame.

21.9 Staircase shall be provided with stainless steel railing and 18mm thick granite slab in risers and treads.

21.10 DOORS AND WINDOWS

The details of doors and windows of the control room building shall be as per finish schedule Table-1 conforming to relevant BS/equivalent International Standards. Rolling steel shutters shall be provided as per layout and requirement of buildings. Main entrance door to control room building shall be made of powder coated aluminium frame with 5.5 mm thick glazing.

21.11 PARTITION

Partitions, if required, shall be made of powder coated aluminium frame provided with 5.5 mm thick clear glass or pre- laminated board depending upon the location of partition.

21.12 FALSE CEILING

Fifteen millimeter thick densified regular edged ecofriendly light weight calcium silicate false ceiling as per relevant standards shall be provided in the areas specified in Finish Schedule.

21.13 PLUMBING & SANITATION

(i) All plumbing and sanitation shall be executed to comply with the requirements of the appropriate bye-laws, rules and regulations of the Local Authority having jurisdiction over such matters. The Contractor shall arrange for all necessary formalities to be met in regard to inspection, testing, obtaining approval and giving notices etc.

(ii) PVC "SYNTEX" or equivalent make Roof water tank of adequate capacity depending on the number of users for 24 hours storage shall be provided. Minimum 2 nos. 1500 litre capacity shall be provided.

(iii) Galvanized MS pipe of medium class conforming to relevant standards shall be used for internal & external piping work for potable water supply.

(iv) Sand CI pipes with lead joints conforming to relevant standards shall be used for sanitary works above ground level and RCC pipe shall be used for works below ground.

(v) Each toilet shall have the following minimum fittings.

(a) WC (Western type) 390 mm high with toilet paper roll holder and all fittings in toilets attached to conference and sub-station in charge office.

and

WC (Indian Type) Orissa Pattern (580 x 440 mm) with all fittings shall be provided in common toilets.

(b) Urinal (430 x 260 x 350 mm size) with all fittings.

(c) Wash basin (550 x 400 mm) with all fittings.

(d) Bathroom mirror (600 x 450 x 6 mm thick) hard board backing

(e) CP brass towel rail (600 x 20 mm) with C.P. brass brackets

(f) CP Soap holder and CP liquid soap dispenser.

(g) All urinals and washbasins shall be provided with built in sensors.

(vi) Water cooler for drinking water with adequate water storage facility shall be provided and located near control room and not near toilet block.

(viii) 1 no. stainless steel kitchen sink with Drain board (510 x 1040 x 178 mm bowl depth) for pantry shall be provided.

(ix) All fittings, fastener, grating shall be chromium plated.

(x) All sanitary fixtures and fittings shall be of approved quality and type manufactured by well-known manufacturers. All items brought to site must bear identification marks of the type of the Manufacturer.

(xi) Stoneware pipes may be used for soil, waste and drain pipes in the areas not subjected to heavy loads otherwise Heavy duty cast iron pipes may be used.

(xii) Contractor shall provide septic tank and soak pit of adequate capacity to treat the sewage / sullage from the building.

(xiii) Contractor shall implement all other jobs required to complete and commission the building.

22.00 Residential and Non-Residential Buildings

All buildings shall be constructed as RCC Framed buildings. The architectural features shall match with local architecture. For preparation of architectural drawings of these buildings, the contractor shall depute local Architect of repute who must be well aware of local bye laws and statutory clearances required for residential and guest house/field hostel/Transit camp building from Nepal Authority. The buildings shall be designed for loads as applicable in accordance to relevant standards. The plumbing and sanitary works including overhead water tanks placed on terrace and for each building shall also be deemed to be included in the civil works of building. Construction of man holes/chambers, connection of internal plumbing and sanitary system with external sewerage and water supply system shall be considered as a part of civil works of buildings. These works will not be measured and paid separately.

The details and approximate size of various buildings are as below:

(a) Transit Camp: One number of size 15 m X 14 m (Double Storeyed with each floor of 15 m X 14 m).
(b) D-Type Quarter: One Number with size 15 m x 14 m-Single Storeyed.
(c) C-Type Quarters: Four Numbers: One Block of four quarters having two quarters on ground floor and two quarters on first floor. Block will have an area of about 12 m X 25 m on each floor.
(d) B-Type Quarters: Four Numbers: One Block of four quarters having two quarters on ground floor and two quarters on first floor. Block will have an area of about 10 m X 25 m on each floor.

The area for above buildings has been indicated as tentative. The Contractor shall adopt the suitable size to accommodate various rooms and services for each type of building. The size of various rooms shall be in accordance to local laws.

The finish schedule has been tabulated as below:

Schedule of Finishes for Quarters					
Floor	**Room Name**	**Flooring**	**Walls**	**Ceiling**	**Remarks**
Typical Flat	Living	Polished Vitrified Tiles	Plastered & Painted OBD Over 2mm POP Finish	Plastered & Painted with Wash Over 2MM POP	
	Living Balcony	Antiskid Vitrified Tiles	Plastered & Painted with Exterior Paint	DO	For Qrts. As applicable
	Kitchen	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M IS 15622	Plastered & Painted OBD Over 2mm POP Finish	DO	Ceramic Tiles UP to 0.6M Above Kitchen Platform
	Toilet	Do	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Above 2.1M Plaster & Painted OBD over 2MM POP Finish
	Bed Room	Vitrified Tiles	Plastered & Painted OBD Over 2mm POP Finish	DO	

	Bed Room Balcony	Antiskid Vitrified Tiles	Plastered & Painted with Exterior Paint	DO	
	Attached Toilet/ Bed Room Toilet	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M IS 15622	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Above 2.1M Plaster & Painted OBD over 2MM POP Finish
	Passage	Vitrified Tiles With Light Shade	Plastered & Painted OBD Over 2mm POP Finish	DO	
	Cupboard	1:2:4 Concrete with neat cement finish	Plastered & Painted OBD	DO	
	Staircase	Marble Stone Treads & Landings	Plastered & Painted OBD Over 2mm POP Finish	DO	Enamel Paint for M.S. Railing
	Car Parking	80mm Flexi Paver Blocks	Plastered & Painted with Exterior Paint	Plastered & Painted OBD over 2mm POP Finish	For D Type Qtrs. Only
Schedule of Finishes for Transit Camp					
Floor	Room Name	Flooring	Walls	Ceiling	Remarks
	Porch	60mm thk. Flexi Paver Blocks	Plastered & Painted with Exterior Paint	Plastered & Painted with OBD Over 2mm POP Finish	
	Drawing & Dining	Polished Vitrified Tiles 0.6x0.6M	Plastered & Painted Plastic Emulsion Paint over 2mm POP Finish	Mineral Fibre False Ceiling POP Cornice & Moulding Painted with Plastic Emulsion Paint	Vitrified Tiles Skirting of 150mm high to be Provided
	Lobby	DO	DO	Plastered & Painted OBD Over 2mm POP Finish	DO
	Kitchen	DO	DO	DO	Ceramic Tiles from Floor Level to 0.6M Above Kitchen Platform
	VIP Room & Lounge	DO	DO	DO	POP Cornice & Moulding shall be Provided for Ceiling

	Attached Toilet of VIP Room	Vitrified Tiles (Antiskid) 0.6x0.6M	Ceramic Tiles 0.3x0.45M (Minimum size)up to Ceiling	DO	
	Dormitory	22mm Thk.Terrazzo Tiles Light shade	Plastered & Painted OBD Over 2mm POP Finish	DO	
	Dormitory Toilet/Bath	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Area Above 2.1M Plaster & Painted OBD over 2MM POP Finish
	Staircase	18mm Thk. Udaipur Green Marble Stone	Plastered & Painted OBD Over 2mm POP Finish	DO	SS Hand Railing as per Drawing
	Bed Rooms	Polished Vitrified Tiles 0.6mx0.6m	Plastered & Painted with Plastic Emulsion Paint Over 2mm POP Finish	DO	
	Attached Toilets	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Area Above 2.1M Plaster & Painted OBD over 2MM Thk. POP Finish
	Care Taker Room	Vitrified Tiles With Light Shade	Plastered & Painted OBD Over 2mm POP Finish	DO	
	Common Toilet	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Area Above 2.1M Plaster & Painted OBD over 2MM Thk. POP Finish
	Store	Vitrified Tiles With Light Shade	Plastered & Painted OBD	DO	
	Balconies	Antiskid Vitrified Tiles Light Shade	Plastered & Painted with Exterior Paint	DO	
	Terrace	Brick Bat Coba Water Proofing	Plastered & Painted with Exterior Paint		

23.0 Boundary wall, Main Gate, Security Room and septic tank and soak pit

23.1 Boundary Wall:

RCC framed with brick masonry/concrete block/stone masonry in fill between columns shall be provided along periphery of substation. The brief description of boundary wall is given below:

(a) Height of boundary wall (Masonry portion) above ground = 2.5 m

(b) 0.5 m Height of Y shaped angle supports (50x50x6 mm) above each column with about 0.5 m deep grouted in column shall be provided as grill on the boundary wall
(c) C/c distance of RCC Column (230 X 230 mm size) = 2.5 m
(d) 8 rows of galvanised barbed wire with concertina coil a top of boundary wall shall be provided. 4 rows of barbed wire on each arm of Y-shaped angle is to be provided.
(e) Grade of Concrete for RCC works = M25
(f) Mix of masonry works = 1 Cement: 6 Sand
(g) 12 mm thick Cement sand plaster (1 cement: 6 Sand) over exposed portion of boundary wall along with 50mm thick CC (1:2:4) coping on the top of wall.
(h) Two coats of oil bound distemper with one coat of cement primer of approved make shall be applied over exposed portion of boundary wall.
(i) A RCC plinth beam (230 X 300 mm deep) shall be provided at ground level. A lintel beam of 230 X 230 mm shall be provided over gratings.
(j) Suitable steel grating made of 20 mm square bars shall be provided at suitable locations preferably @ 100 m to allow the flow of surface water.
(k) Suitable foundation of about 1.5 depth shall be provided for each RCC column. 75 mm thick PCC (1:4:8) layer shall be provided below all RCC works.
(l) All steel works shall be provided with two coats of synthetic enamel paint over a coat of steel primer of approved make.
(m) Twin columns with 25 mm expansion gap at every 45 meter length shall be provided.
(n) Suitable design of boundary wall shall be developed by the contractor.

The boundary wall shall be measured and paid on running meter length basis.

23.2 Main Gate

A steel gate of 2.1 m high and 6 m wide along with 1.5 m wide man gate shall be provided at entry location of substation. The gate shall be supported on steel columns. The steel support columns shall be encased with suitable RCC foundations. Suitable wheel mounting arrangement shall be provided at the bottom of gate for smooth opening of gate. All steel works shall be provided with two coats of synthetic enamel paint over a coat of steel primer of approved make.

The item shall be measured and paid on Lump sum basis.

23.3 Security Room:

A RCC framed room of size 3 m X 3m and 3 m high with 1.5 m wide veranda shall be provided near gate. An attached toilet of 1.5 m x 1.5 m size shall be provided. Suitable septic tank and soak pit for 10 users with cleaning interval of 3 years shall also be provided. A RCC platform (600 mm wide) at window sill level along with wardrobe shall be provided. All sanitary works and a PVC water tank of 1000 litre capacity shall also be provided. All finish details shall match with other buildings mentioned elsewhere in the technical specification.

The item shall be measured and paid on square meter area basis.

24.0 MODE OF MEASUREMENT

24.1 Geotechnical investigation

This shall include carrying out field tests, laboratory tests, compilation of results and preparation of soil report with recommendations for type of foundations shallow or pile type, suitability of soil for construction of substation etc. The geotechnical investigation work shall be measured on lump sum basis.

24.2 Contour survey and site leveling.

The Contour survey work shall not be measured and paid separately and shall be deemed to be included in the item of site levelling work.

Measurement of Earth work in all kind of soil including soft/disintegrated rock in the item of cutting and filling and item of earth work in the filling with borrowed earth shall be made in Cubic meters. No void deduction for 95% compaction.

24.3 Earthwork

This shall include excavation in all kinds of soil including rock, all leads and lifts including back filling with suitable earth, compacting, dewatering (if required) and disposal of surplus earth or rock to a suitable location within a lead up to 2 km. The surplus earth if disposed within substation boundary shall be spread in uniform layers each compacted with two passes of suitable compacting equipment. The quantity of excavation for foundations of towers, equipment supports structures, all transformers/Reactors, DG Set, firewall, cable trenches, fire fighting water tank, buildings and underground water tanks, covered car parking, External lighting poles, control cubicles, marshalling box shall only be measured. The quantity of excavation for roads, rail cum road, drains, culverts, rainwater harvesting, septic tank, soak pit, external water supply system, site surfacing, chain link fencing (including gate) shall not be measured separately and shall be deemed to be included in the composite rates quoted by the bidder for the respective works. All other excavation required for the completion of the work including plinth protection, flooring, sewerage system, manholes, pipes, earth mat etc. shall also not be paid for. The measurement of excavation of all concrete works shall be made considering dimension of the pit leaving 150mm gap around the base pad (lean concrete) or actually excavated pit, whichever is less. The quantity shall be measured in cubic metres.

24.4 PCC

Providing and laying Plain Cement Concrete of all types and at all locations including all leads and lifts. The quantity shall be measured in cubic meters as per lines and levels indicated in the drawings.

24.4.1 PCC 1:2:4 (1 cement: 2 sand: 4 coarse aggregate 20 mm nominal size) shall be measured in flooring of buildings, plinth protection, fencing, transformer/reactor foundation, rail track, drain, culverts, septic tank, chain link fencing, fencing gate ,external lighting poles etc. as indicated in the approved drawings.

24.4.2 PCC 1:4:8 (1 cement : 4 coarse sand : 8 stone aggregate, 40mm nominal size) shall be measured below all foundations of towers, equipment support structures, buildings, fire fighting water tanks, covered car parking, cable trench, roads, under flooring, rail-cum-road, transformer foundation, reactor foundation, drain, cable trench crossings, culverts, fence, gate etc. as indicated in the approved drawings.

24.4.3 PCC 1:5:10 (1 Cement: 5 sand: 10 Stone aggregate, 40mm nominal size) shall be provided for site surfacing in switchyard, roof water proofing etc.

All other PCC required for the completion of the work including hold fasts of doors/windows/rolling shutters, fixing of plumbing pipes, bedding concrete for sewer lines, embedment of electrical conduits etc. shall not be measured and deemed included in the composite rates quoted by the bidder for respective works. Water proofing compound wherever specified shall be added without any extra cost.

24.5 RCC

Measurement of reinforced cement concrete at all locations shall be made and shall include all leads, lifts, formwork, grouting of pockets and underpinning, (but shall exclude reinforcement & miscellaneous structural steel like inserts etc.), of M25 design mix (Minimum). This shall also

include pre-cast RCC work and addition of water proofing compound wherever required for which no additional payment shall be made. The quantity shall be measured in cubic meters as per lines and levels indicated in the drawings. No deduction shall be made for volume occupied by reinforcement/inserts/sleeves and for openings having cross-sectional area up to 0.1 Sq.M.

24.6 **Steel Reinforcement**

Reinforcement steel shall be measured in length (actual or theoretical as per drawing whichever is less) including hooks, if any, separately for different diameters as actually used in RCC work, excluding overlaps. From the length so measured, the weight of reinforcement shall be calculated in metric tonnes on the basis of sectional weights as adopted by British Standards/equivalent International standards. Wastage, overlaps, couplings, welded joints, spacer bars, chairs, stays, hangers and annealed steel wire or other methods for binding and placing shall not be measured and cost of these items shall be deemed to be included in the rates for reinforcement.

24.7 **Stone filling over grating in Transformer/Reactor foundation**

Measurement of stone (40mm nominal size) filling over gratings of transformer/reactor foundations shall be made as per theoretical volume of the space to be filled in the transformer foundation as per approved drawings. This shall be measured in Cu.M.

24.8 **Miscellaneous structural steel**

Measurement for Supply, fabrication, transportation and erection of all miscellaneous structural steel work for rails alongwith rail fixing details and gratings with supports for transformers/reactors, Cable trenches with covers (Chequered plate covers, cable supports, earthing cleats and edge protection angles etc), all other steel fittings and fixtures, inserts and embedment in concrete of transformer/reactor foundation and cable trenches shall be made as per approved drawings. The unit rate for this item shall be inclusive of cutting, grinding, drilling, bolting, welding, pre- heating of the welded joints, applying a priming coat of steel primer and anti-corrosive bitumastic paint/ synthetic enamel paint in general but with Zinc Phosphate Primer (Two packs) for grating and support for grating in Transformer foundation. (Wherever specified), setting of all types of embedment in concrete, etc. Steel required for foundation bolts, nuts and bolt, doors, windows, ventilators, louvers, rolling shutters, chain link fencing, gratings in drains, soil pipes, plumbing pipes, floor traps, embedment's required for rainwater harvesting, septic tank, soak pit, roof truss and purlins required for fire water tank, etc. shall not be considered for payment and measurements. Quantity shall be measured in metric tonnes.

24.9 **Roads**

A). The measurement for the concrete road shall be made on the basis of area in square meter (M2) of top concrete completed surface of the road and shall be deemed to include all items such as excavation, compaction, rolling, watering, WBM, shoulder, etc complete as per approved drawing but excluding concreting and reinforcement which shall be paid separately under respective items of BPS.

B) The measurement of bituminous road shall be made on the basis of area in square meter (M2), of the top bituminous completed surface of the road and shall include all items such as excavation, compaction, rolling, watering, sub base course, WBM, shoulder, premix carpet etc complete as per approved drawing.

C) The measurement of strengthening of existing road (bituminous road) shall be made on the basis of area in square meter (M2), of the top bituminous completed surface of the road including premix carpet etc but excluding item of granular sub base course which shall be paid separately under respective item of BPS.

24.10 Anti-weed Treatment and Stone Spreading

The measurement shall be done for the actual area in square metres of stone spreading provided in the switchyard. It includes providing and spreading of 100mm thickness of uncrushed/crushed/broken stone of 40mm nominal size as per relevant BS codes/equivalent International standards for the specified area. Application of anti-weed treatment including material shall not be measured separately and item would be deemed to be included in the quoted rate of stone spreading in switchyard.

24.11 Chain Link Fencing and gate

The measurement shall be made in running metres of the fence provided as per approved drawing. The rate shall be including the post, fencing, MS Flat, painting, brick work and plaster of toe wall etc. complete but excluding the concrete. The switch yard gate shall be measured in numbers.

24.12 Cable Trenches and Cable trench Crossings

Earthwork, PCC, RCC, reinforcement steel, RCC hume pipes and miscellaneous steel required for construction of Cable Trenches and cable trench crossings shall be measured under respective items of Bid price schedule (BPS) as described in clauses of aforesaid paras. No additional payment for brick work, plaster and PVC pipes used for cable trench crossings and sealing of trench mouth shall be admissible.

24.13 Drains & Culverts

PCC (1:2:4 and 1:4:8) for drains and culverts shall be measured under respective items of Bid price schedule (BPS) as described in clauses of aforesaid paras. All other items like excavation, brick work, plaster and stone pitching except RCC hume pipes required for completion of drains and culverts shall be deemed to be included in the quoted rate of drain. The quantity for each type of drain section shall be measured in running meters. However, RCC hume pipes used in culverts shall be measured under respective item of Bid price schedule (BPS) as described in clause of hume pipes.

24.14 External Finishing of RCC Framed Buildings/structures:

The item shall be measured per square meter area basis. Contractor has to assess the quantity as per requirement of Control room cum administrative building, Fire Fighting Pump House, fire fighting water tank, switchyard panel room, residential and non-residential buildings, covered car parking and quote for the same separately. This shall include following items.

1) External plastering/cement wash: 18mm Cement plaster in two coats under layer 12 mm thick cement plaster 1:5 (1 cement: 5 coarse Sand) finished with a top layer of 6 mm thick cement plaster 1:6 (1 cement: 6 fine Sand) for all buildings and fire fighting water tank.
2) Providing and applying two or more coats of Acrylic smooth exterior paint over an under coat of suitable primer on new cement plaster surfaces of the control room building, auxiliary building, fire fighting pump house building, fire fighting water tank, panel room, residential and non residential buildings and covered car parking. It shall be inclusive of required tools, scaffolding, materials and other painting accessories etc. as per recommendations of manufacturer.

24.15 Hume Pipe

Hume pipe shall be measured diameter-wise and laid as per approved drawings and shall be measured in running meters. The item shall be inclusive of excavation, laying, back filling, jointing etc. but excluding concrete and reinforcement (if any).

24.16 Building

The measurement of all items except excavation, concrete, reinforcement steel of each type of buildings shall be made on area in Square Meter basis. However, the quantity of excavation, concrete, reinforcement shall be measured in respective items of BPS and described in above paras. The structural steel used for cable tray support, earthing cleat, chequered plates for internal cable trenches of building and panel room wherever applicable shall be measured and paid under miscellaneous steel item of BPS and described above paras. The structural steel and foundation bolts for fixing equipments with foundations/raft within buildings shall not be measured separately which shall be deemed to be included in the quoted rates per square meter of buildings. External Finishing shall be measured and paid in respective items of BPS and described in above paras. The rest of the entire work required to complete the building in all respect as per drawings prepared by contractor and approved by NEA/Consultant shall be deemed to be included in this item rate per square meter area basis.

24.17 **Rain Water Harvesting**

This is a lump sum item. The contractor shall be required to complete the work in all respect as per drawings prepared by contractor and approved by NEA/Consultant. All the items including excavation, miscellaneous steel, brick work, fillings of boulders, gravel, sand, pipes etc. shall be deemed to be included in this lump sum rate. However, the concrete (all types) and the reinforcement shall be measured and paid under respective item of BPS and described in above paras.

24.18 Rail cum Road

The measurement for the rail cum road shall be made in square metres of top concrete completed surface of the rail cum road and shall include all items such as excavation, compaction, rolling, watering, WBM etc. complete as per approved drawing but excluding concrete, reinforcement, structural steel and rails with rail fixing details which shall be measured separately under respective item of BPS and described in above paras.

24.19 Septic Tank and Soak Pit

This is a lump sum item. The contractor shall be required to complete the work in all respect as per drawings furnished by the contractor and approved by NEA/Consultant. All the items including excavation, masonry work, all types of fillings, all types of pipes including plumbing and vent pipes, all type of fittings etc. shall be deemed to be included in this lump sum rate. However, the concrete (all types) and the reinforcement shall be measured and paid under the respective item mentioned above.

24.20 Fire Water Tank

This is a lump sum item. The contractor shall be required to complete the work in all respect as per approved drawings. The items including brick work if any, and miscellaneous steel including steel embedment Rungs, roof truss, corrugated AC Sheet roofing, door, pipe sleeves, internal finish, etc. shall be deemed to be included in this lump sum cost. However, the items like excavation, concrete (all types), reinforcement steel, external finish shall be measured and paid under the respective item of BPS and described in above paras.

24.21 External water supply from Bore-well/ other source of water supply arrangement to Fire water tank, Control Room building, Residential and non-residential buildings

The external water supply from Bore-well shall be measured diameter-wise in running meters. It shall include all the items such as excavation, piping, pipe fittings, painting, brickwork, sand filling, concrete, valves, chambers cutting chases in walls, openings in RCC and repairs, etc. required to complete the job.

24.22 External Sewage System of Control Room Building and other Buildings of Township.

It shall be measured diameter wise in running meters. It shall include all the items such as excavation, piping, pipe fittings, manholes, gali trap, gali chamber casing in concrete and repairs etc required to complete the job. Any modification in the existing sewage system, if required, shall be done by the Contractor without any extra cost implicated to NEA/Consultant.

25.0 MISCELLANEOUS GENERAL REQUIREMENTS

25.1 Dense concrete with controlled water cement ratio as per BS-code shall be used for all underground concrete structures such as pump-house, tanks, water retaining structures, cable and pipe trenches etc. for achieving water-tightness.

25.2 All joints including construction and expansion joints for the water retaining structures shall be made water tight by using PVC ribbed water stops with central bulb. However, kicker type (externally placed) PVC water stops shall be used for the base slab and in other areas where it is required to facilitate concreting. The minimum thickness of PVC water stops shall be 5 mm and minimum width shall be 230 mm.

25.3 All steel sections and fabricated structures which are required to be transported on sea shall be provided with anti-corrosive paint to take care of sea worthiness.

25.4 All mild steel parts used in the water retaining structures shall be hot-double dip galvanised. The minimum coating of the zinc shall be 750 gm/sq. m. for galvanised structures and shall comply with relevant BS. Galvanizing shall be checked and tested in accordance with relevant BS. The galvanizing shall be followed by the application of an etching primer and dipping in black bitumen in accordance with BS: 3416.

25.5 A screed concrete layer not less than 100 mm thick and of grade not weaker than M10 conforming to relevant BS shall be provided below all water retaining structures. A sliding layer of bitumen paper or craft paper shall be provided over the screed layer to destroy the bond between the screed and the base slab concrete of the water retaining structures.

25.6 Bricks having minimum 75 kg/cm2 compressive strength can only be used for masonry work. Contractor shall ascertain himself at site regarding the availability of bricks of minimum 75 kg/cm2 compressive strength before submitting his offer. The contractor may use concrete blocks of equivalent compressive strength in place of brick work.

25.7 Doors and windows on external walls of the buildings (other than areas provided, with insulated metal claddings) shall be provided with RCC sun-shade over the openings with 300 mm projection on either side of the openings. Projection of sunshade from the wall shall be minimum 450 mm over window openings and 750 mm over door openings.

25.8 All stairs shall have maximum riser height of 150 mm and a minimum tread width of 300 mm. Minimum width of stairs shall be 1500 mm. Service ladder shall be provided for access to all roofs. RCC fire escape staircase if required as per local bye laws, shall be provided in control buildings.

25.9 Angles 50x50x6 mm (minimum) with lugs shall be provided for edge protection all round cut outs/openings in floor slab, edges of drains supporting grating covers, edges of RCC cable/pipe trenches supporting covers, edges of manholes supporting covers, supporting edges of

manhole precast cover and any other place where breakage of corners of concrete is expected.

25.10 Anti termite chemical treatment for buildings shall be given to all column pits, wall trenches, foundations, filling below the floors etc. as per relevant International/BS.

25.11 Hand-railing minimum 900mm high shall be provided around all floor/roof openings, projections/balconies, walk ways, platforms, steel stairs etc. All handrails and ladder pipes shall be 32 mm nominal bore MS pipes (medium class) and shall be galvanised (medium-class as per relevant BS). All rungs for ladder shall also be galvanised as per relevant BS.

For RCC stairs, hand railing with 20 mm square MS bars, balustrades with suitable MS flats & aluminium handrails shall be provided.

25.12 For all civil works covered under this specification, design Mix of Minimum M25 grade as per relevant International /BS shall be used. Reinforcement steel shall be of minimum Fe 500 grade.

The material specification, workmanship and acceptance criteria shall be as per relevant clauses of applicable International/BS standard.

25.13 Items/components of buildings not explicitly covered in the specification and BPS but required for completion of the project shall be deemed to be included in the scope.

25.14 Requirement of sulphate resistant cement (SRC) for sub structural works shall be decided in accordance with the International/BS Standards based on the findings of the detailed soil investigation to be carried out by the Bidder.

25.15 Foundation system adopted by Bidder shall ensure that relative settlement and other criteria shall be as per provision in relevant BS and other International Standards.

25.16 All water retaining structures designed as uncracked section shall also be tested for water tightness at full water level in accordance with relevant international/ BS standards.

25.17 Construction joints shall be as per International/BS standard.

25.18 All underground concrete structures like basements, pumps houses, water retaining structures etc. shall have plasticizer cum water proofing cement additive conforming to relevant BS. The concrete surface of these structures in contact with earth shall also be provided with two coat of bituminous painting for water/damp proofing.

In case of water leakage in the above structures, The Method shall be applied as per relevant international standard/BS standard for repairing the leakage.

25.19 All building/construction materials shall conform to the best quality specified in relevant International /BS standard.

26.0 INTERFACING

The proper coordination & execution of all interfacing civil works activities like fixing of conduits in roofs/walls/floors, fixing of foundation bolts, fixing of lighting fixtures, fixing of supports/embedment's, provision of cut outs etc. shall be the sole responsibility of the Contractor. He shall plan all such activities in advance and execute in such a manner that interfacing activities do not become bottlenecks and dismantling, breakage etc. is reduced to minimum.

27.0 STATUTORY RULES

27.1 Contractor shall comply with all the applicable statutory rules pertaining to factories act (as applicable for the State). Fire Safety Rules of Tariff Advisory- Committee and Water and

sewerage Act for pollution control etc.

27.2 Provisions for fire proof doors, no. of staircases, fire escape stairs, fire separation wall, plastering on structural members (in fire prone areas) etc. shall be made according to the recommendations of Local Advisory Committee.

27.3 Statutory clearance and norms of Local Pollution Control Board shall be followed as per Water Act for effluent quality from plant.

28.0 FIELD QUALITY PLAN

All tests as required in accordance to BS codes or equivalent International standards have to be carried out. The contractor shall prepare field quality plan for civil works as per relevant /BS codes/equivalent International Standards during detailed engineering stage and submit to NEA/Consultant for approval within ONE month after award of work.

29.0 BRITISH STANDARD CODES

Major British standard Codes for civil work have been given in the following list. This list is illustrative but not exhaustive. However, for design and engineering relevant BS codes or equivalent International standards shall be referred by the contractor. Relevant portion of BS codes or equivalent international standards referred by the contractor for the design shall be made available to NEA/Consultant if necessary during detailed engineering stage.

Sr. No.	Standard No.	Title	Year
1	BS 41	Structural steel sections. Specification for hot-rolled sections	2005
2	BS 13771	Methods of test for soils for civil engineering purposes. General requirements and sample preparation	1990
3	BS 4449	Steel for the reinforcement of concrete. Weldable reinforcing steel. Bar, coil and decoiled product. Specification (with A2:2009)	2005
4	BS 4482	Steel fabric for the reinforcement of concrete. Specification	2005
5	BS 4483	Steel fabric for the reinforcement of concrete. Specification	2005
6	BS EN 102102	Hot finished structural hollow sections of non-alloy and fine grain steels. Tolerances, dimensions and sectional properties	2006
7	BS EN 100561	Specification for structural steel equal and unequal angles. Dimensions	1999
8	BS EN ISO 800001	Quantities and units. General	2013
9	BS 5930	Code of practice for site investigations (with A2:2010)	1999
10	BS EN 1993-11	Eurocode 3. Design of steel structures. General rules and rules for buildings	2005
11	NA to BS EN 199311	UK National Annex to Eurocode 3. Design of steel structures. General rules and rules for buildings	2008
12	BS EN 1993-15	Eurocode 3. Design of steel structures. Plated structural elements	2006
13	NA to BS EN 199315	UK National Annex to Eurocode 3. Design of steel structures. Plated structural elements	2008
14	BS EN 1993-18	Eurocode 3. Design of steel structures. Design of joints	2005

15	NA to BS EN 199318	UK National Annex to Eurocode 3. Design of steel structures. Design of joints	2008
16	BS 60732	Precast concrete masonry units. Guide for specifying precast concrete masonry units	2008
17	BS 7668	Weldable structural steels. Hot finished structural hollow sections in weather resistant steels. Specification	2004
18	BS EN 1997-1	Eurocode 7. Geotechnical design. General rules	2004
19	NA to BS EN 19971	UK National Annex to Eurocode 7. Geotechnical design. General rules	2007
20	BS EN 1992-3	Eurocode 2. Design of concrete structures. Liquid retaining and containing structures	2006
21	BS EN 1992-11	Eurocode 2. Design of concrete structures. General rules and rules for buildings	2004
22	NA to BS EN 199211	UK National Annex to Eurocode 2. Design of concrete structures. General rules and rules for buildings	2005
23	BS 75334	Pavements constructed with clay, natural stone or concrete pavers. Code of practice for the construction of pavements of precast concrete flags or natural stone slabs	2006
24	BS EN 1971	Cement. Composition, specifications and conformity criteria for common cements	2011
25	BS 743	Specification for materials for damp proof courses	1970
26	BS 8122	Testing aggregates. Methods for determination of density	1995
27	BS 952-1	Glass for glazing. Classification	1995
28	BS 952-2	Glass for glazing. Terminology for work on glass	1980
29	BS EN 12620	Aggregates for concrete	2013
30	BS 1125	Specification for WC flushing cisterns (including dual flush cisterns and flush pipes)	1987
31	BS 1188	Specification for ceramic wash basins and pedestals	1974
32	BS 1199 and 1200	Specifications for building sands from natural sources	1976
33	BS EN 13310	Kitchen sinks. Functional requirements and test methods	2003
34	BS 1245	Pedestrian doorsets and door frames made from steel sheet. Specification	2012
35	BS 1254	Specification for WC seats (plastics)	1981
36	BS 1370	Specification for low heat Portland cement	1979
37	BS EN 1008	Mixing water for concrete. Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete	2002
38	BS 3505	Specification for unplasticized polyvinyl chloride (PVC-U) pressure pipes for cold potable water	1986
39	BS EN 15743	Supersulfated cement. Composition, specifications and conformity criteria	2010
40	BS EN ISO 3766	Construction drawings. Simplified representation of concrete reinforcement	2003
41	BS 8666	Scheduling, dimensioning, bending and cutting of steel reinforcement for concrete. Specification	2005

42	BS 4514	Unplasticized PVC soil and ventilating pipes of 82.4 m m minimum mean outside diameter, and fittings and ac cessories of 82.4 mm and of other sizes. Specification	2001
43	BS 4551	Mortar. Methods of test for mortar and screed. Chemic al analysis and physical testing (with A2:2013)	2005
44	BS EN 1220 01	Plastics rainwater piping systems for above ground ext ernal use. Unplasticized poly (vinyl chloride) (PVC- U). Specifications for pipes, fittings and the system	2000
45	BS EN 1462	Brackets for eaves gutters. Requirements and testing	2004
46	BS EN 607	Eaves gutters and fittings made of PVC- U. Definitions, requirements and testing	2004
47	BS 6262	Code of practice for glazing for buildings	1982
48	BS EN 1441 1	Ceramic tiles. Definitions, classification, characteristics, evalua tion of conformity and marking	2012
49	BS 6510	Steel-framed windows and glazed doors. Specification	2010
50	BS EN 636	Plywood. Specifications	2012
51	NA to BS EN 19923	UK National Annex to Eurocode 2. Design of concrete structures. Liquid retaining and containment structures	2007
52	BS EN 1339	Concrete paving flags. Requirements and test methods	2003
53	BS EN 1340	Concrete kerb units. Requirements and test methods	2003

SECTION – 20

Inspection, Testing & Commissioning

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1.0 SCOPE OF WORK

The whole of the Works supplied under the Contract shall be subject to inspections and tests by the Employer or their Representatives during manufacture, erection and after completion. The inspections and tests shall include, but not be limited to, the requirements of this section of the Specifications.

The Contractor shall provide all costs, appliances, apparatus, supervision, labor and services necessary to carry out all tests, unless specifically stated otherwise.

The Contractor shall furnish the detailed schedule of his commissioning plan at least one month prior to the scheduled date. The schedule shall include the commissioning procedures, testing sequences and details of special testing equipment, tests and commissioning record formats, information about relevant standards etc.

The scope of the commissioning program includes the site testing and putting into successful operation of all the equipment supplied under the Contract, for 132kV, 33kV, 11kv, AC & DC plants and all secondary voltages systems. Testing of energy meters and certification of their accuracy shall also be included.

1.2 OBJECTIVE

The objectives of commissioning work, prior to the successful energization of Plant at full voltage and connection to the system, are the following:

- Confirm the integrity (correctness) of installation.
- Confirm the integrity of insulation, connections and phasing.
- Ensure proof of equipment characteristics.
- Review workmanship.
- Confirm the correct implementation of the design.
- Check equipment ratings.
- Check settings and operation of protective relays.
- Check and measure resistivity of earthing grid and earthing system.
- Confirm the proper functioning of SCADA system.

1.3 QUALITY ASSURANCE, INSPECTION AND TESTING

To assure that the supply and services under the scope of this Contract whether manufactured or performed within the Contractor's works or at his subcontractor's premises or at the Site or at any other place of work, are in accordance with the Specifications, the Contractor shall adopt suitable quality assurance program to control such activities at all points necessary. Such program shall be outlined by the Contractor and shall be finally accepted by the Employer after discussions before the award of the Contract. A quality assurance program of the Contractor shall generally cover, but not be limited to the following:

(a) His organization structure for the management and implementation of the proposed quality assurance program.

(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 materials inspection, and verification of materials purchases.

(e) System for shop manufacturing including process controls and fabrication and assembly controls.

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

(g) Control of calibration and testing of measuring and testing equipment.

(h) Inspection and test procedure for manufacture.

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

(j) System for quality audits.

(k) System for authorizing release of manufactured products to the Employer.

(l) System for maintenance of records.

(m) System for handling storage and delivery.

(n) A quality plan detailing out the specific quality control procedure adopting for controlling the quality characteristics relevant to each item of supply.

The quality plan shall be mutually discussed and approved by the Employer after incorporating necessary corrections by the Contractor as may be required.

- Quality Assurance Documents

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

  The Employer, through his duly authorized representatives, reserves the right to carry out Quality Audit and Quality Surveillance of the systems and the procedures of the Contractor's and the subcontractor's Quality Management and Control Activities.

- Inspection, Testing and Inspection Certificates

  The provisions of the clauses on Test and Inspection of the General Conditions of Contract and Special Conditions of Contract shall be applicable to the supply and erection portions of the Works. The Employer shall have the right to re-inspect at his expenses, any material though it would have been previously inspected and approved by him at the Contractor's works before, and if, after the same are inspected at Site following the latter, material is found defective, then the Contractor shall bear the cost of this inspection and reinstatement according to specification.

1.4 TESTS AT MANUFACTURERS WORKS

1.4.1 General

Where no specific test is specified, then the various items of materials and equipment shall be tested in accordance with the relevant British, IEC, or American Standards. Where no appropriate standard is available, tests shall be carried out in accordance with the maker's standard practice, which shall be subject to the Employer's approval.

Inspection of equipment will not be carried out unless the Employer has approved copies of the relevant sub-orders, drawings and test procedures.

No equipment shall be packed, prepared for shipment, or dismantled for the purpose of packing for shipment, unless it has been satisfactorily inspected, or inspection has been waived by the Employer.

Functional electrical and mechanical tests shall be carried out on the completed plant after assembly in the Works. The extent and method of recording the results shall be agreed by the Employer in sufficient time to enable the tests to be satisfactorily witnessed or to make any changes to the proposed program of tests.

All instruments and apparatus used in the performance of the tests shall be subject to the approval of the Employer and, if required by the Employer, shall be calibrated to an agreed standard at a laboratory of national standing to be nominated by the Contractor and approved by the Employer.

The costs of carrying out such calibration shall be borne by the Contractor in all cases.

The costs of making any test shall be borne by the Contractor. This shall apply to tests performed at the site or elsewhere.

After receiving the prior information about the completion of manufacturing at the factory, the Employer will depute his personnel to the Contractor's factory to witness the fabrication, assembly and testing of any or all parts of major equipment. The number of the Employer's personnel and equipment to be witnessed will be as listed below. The duration of such visits shall be as per inspection/ testing requirements.

- Power Transformer (220 kV)	
Core and Coil Inspection	2 persons, 1 visit
Final Inspection	2 persons, 1 visit
- Power Transformer (132 kV)	
Core and Coil Inspection	2 persons, 1 visit
Final Inspection	2 persons, 1 visit
- Power Transformer (33 kV)	
Core and Coil Inspection	2 persons, 1 visit
Final Inspection	2 persons, 1 visit
- 220 kV/132 kV Circuit Breakers	1 persons, 1 visit
- Control & Relay Panels including SAS	2 persons, 1 visit
- Disconnecting Switch	1 person, 1 visit
- Instrument transformers	1 person, 1 visit
- Lightning Arrestor	1 person, 1 visit
- 33kV/11 kV Switchgear System	2 persons, 1 visit
- 33 and 11 kV XLPE Power Cable	2 persons, 1 visit
- 132 kV/ 33 kV steel structures	1 person, 1 visit

Note:

The duration of Core and Coil Inspection of Power transformer shall be 10 days.

The duration of final factory testing & inspection of Control & Relay Panels of 220 kV, 132 kV and 33 kV system complete shall be 10 days.

Final Inspection for power transformer 220/132/11 kV 200 MVA, 132/33 kV 63 MVA, 33/11 kV 24 MVA shall be performed and total duration shall not be less than 14 days.

The duration of final factory testing & inspection all other equipments shall be seven (7) days.

1.4.2 Test Certificate

Within 30 days of the completion of any test, triplicate sets of all principal test records, test certificates and performance curves shall be supplied to the Employer.

These test records, certificates and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Employer or his representative. The information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificate refers and should also bear the Contract reference title. Specified requirements shall be shown on each certificate for comparison with actual test results.

When all equipment has been tested, test certificates of all factory and site tests shall be compiled by the Contractor into volumes and bound in an approved form complete with index. Two copies of each volume shall be supplied to the Consultant and five copies to the Employer.

1.4.3 Type Test

Type tests are required to prove the general design of the equipment and the Contractor may submit certificates of such design tests, which have been carried out on identical equipment. Notwithstanding any provision in BS, IEC or ANSI Standards, the Employer shall have the right to accept such certificates in lieu of the specified type tests or to reject them.

The type tests prescribed shall be carried out at the Contractor's cost in all cases, where either such certificates are not available or are rejected by the Employer.

1.5 RESPONSIBILITIES

To ensure that the test jurisdiction and transfer of responsibilities is regulated by strict safety and handover procedures, the Contractor agrees the interface with the Employer to establish and implement handover procedures consistent with the terms of these Specifications.

The Employer shall retain full jurisdiction over all commissioning activities, which may affect the operation of the existing system. In these circumstances and when so requested, shall provide technical advices and assistances.

The Contractor shall be responsible for technical guidance and assistance in establishing the scope and method of tests, witnessing of the testing, assessment of results, and re-negotiation of the changes in test schedules which may be necessary as a result of other circumstances, such as delays in the delivery, possible equipment failures.

1.6 SAFETY PROCEDURES

The Contractor shall share the responsibility for safety procedures with the Employer. The Contractor shall establish and implement a work permit and tagging system and

associated safety procedures (subject to the review of Employer) for all equipment, systems and areas not covered by the Employer's safety procedures.

The Employer will assume responsibility for the establishment and implementation of tagging, safety and work permit procedures for the protection of personnel and equipment, as soon as equipment and systems are connected to or are energizable from the existing system.

1.7 TRAINING OF THE EMPLOYER'S STAFF

The Contractor shall plan for the Employer's staffs' participation, either continuously or on a regularly recurring basis as specified in the BOQ.

Allow the Employer's staffs to become familiar with the operating and maintenance aspects of the new equipment supplied by him,

Maintain a continuing assessment with the Employer of the precautions required in or possible consequences of, initial energization of equipment, Allow for the above two necessary objectives in the preparation of schedules.

The Contractor shall have station at site, at least, one technical expert for a minimum of six months continuously after commissioning to rectify any problems, as well as train the Employer's attending staffs. If required, the length of his stay shall be extended as per requirement, which shall be at the Employer's discretion.

1.8 COMMISSIONING STAFF

The Contractor shall provide commissioning personnel including skilled and unskilled labor as required. Submit a list with names, experience and proposed duration of the stay of key personnel on site, consistent with the construction schedule, along with the commissioning program.

Ensure that only staffs assigned to commissioning fulfills that duty for the duration of the assignment.

Ensure that commissioning staffs have authorization, and the competence, to undertake minor repairs or to make temporary redesigns and to reconnect systems to meet the specified system performance to preclude delays in energization and putting into commercial service of any part of the works.

1.9 TEST EQUIPMENT

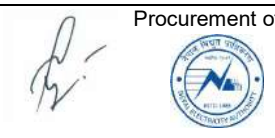
The Contractor shall ensure that all instruments, tools and other equipment required for testing and commissioning are available on site, ensure that the test equipment is of satisfactory quality and condition and, where necessary, is calibrated by an approved authority or standard.

Make arrangements for the provision of power supplies for testing with necessary vector configuration, voltage and current rating.

1.10 COMMISSIONING PROGRAM

Prepare a commissioning program for approval by the Employer and for incorporation into the Project master construction program. Allocate adequate time in this program to permit full commissioning of all components.

Carry out all testing during normal working hours as far as practicable. Tests, which involve existing apparatus and system outages, may be carried out outside normal working hours. Give the Employer sufficient notice to allow for the necessary outage arrangements to be made in conformity with the testing program.



Note that no tests listed in the agreed program will be waived except upon the instructions or consent of the Employer in writing.

1.10.1 Test Procedures

The following basic tests, in addition to others, shall be carried out:

- Measurement of insulation resistance.
- AC withstand voltage test

1.10.2 Requirements for Field Tests

The field tests shall be carried out in presence of Employer under the following conditions:

AC withstand test voltages for conductors and outdoor equipment shall be normal operation voltage of the transmission line and, withstand voltage test shall be carried out for ten (10) minutes by the normal voltage mentioned above. The field tests shall be carried out by the Contractor after adjustment of all the equipment have been completed.

Expandable and lead wires and other materials required for the field tests shall be arranged by the Contractor. The Contractor shall be responsible for providing all measuring instruments, test equipment and tools required for the tests.

Preparation of the test record sheets and test reports shall be the responsibility of the Contractor and the results of the field tests shall be submitted by the Contractor for Employer's approval.

Measurement of insulation resistance of the equipment shall be performed by at least 5000 V megger.

After completion of the measurement of insulation resistance mentioned above, ac withstand voltage test shall be performed by the normal operation voltage of the existing power system in accordance with the following procedure:

- 220 kV, 132 kV and 33 kV Main Circuit: The 33 kV and 132 kV and 220 kV circuit breakers and disconnecting switches, except for circuit breakers receiving power for the test from the existing power system through a transmission line, shall be closed, succeeding, normal operation voltage shall be charged on the equipment and bus conductors for ten (10) minutes for ac withstand voltage test. The indication value of meters mounted on the board during the ac withstand voltage test shall be recorded on the test record sheets prepared by the Contractor.

Submit test procedures, consisting of detailed test methods and samples of the related test record forms, for all equipment to be tested, to the Employer for approval along with the commissioning program. Strictly adhere to these procedures for the commissioning tests.

1.10.3 Records

Maintain an up-to-date record of all commissioning activities on site. Record the results of the tests clearly on forms and formats approved by the Employer and with clear references to the equipment and items tested, so that the record can be used as the basis for maintenance tests, in future. Submit the required number of site test records to the Employer as soon as possible after completion of the tests.

Record the details of the test equipment and instruments used in the test sheets, in those cases where the instrument or equipment characteristics can have a bearing on the test results.

1.10.4 "As-Built" Drawings

Keep an ongoing record of all changes on a master set of drawings. Produce and supply a minimum of five complete sets of marked-up "As Constructed/As-Built" drawings before leaving the Site. Correct and re-issue the original drawings as soon as possible as per this specification.

1.10.5 Test Methods

Carry out all necessary tests for commissioning the substations. The following clauses detail the tests which are considered to represent the minimum required in addition to those specified under the appropriate IEC Publications, other approved standards and the manufacturer's instructions for each item of equipment.

Strictly adhere to the methods of testing approved by the Employer.

A) Site and Commissioning Tests for Main and Auxiliary Equipment

General Checks:

Make a general check of all main and auxiliary equipment. Include a check of the completeness, correctness and condition of ground connections, labeling, arcing ring, paint surfaces, cables, wiring, pipe-work, valves, blanking plates and all other auxiliary and ancillary items.

Check for oil and gas leaks and that insulators are clean and free from external damage. Check that loose items, which are to be handed over to the Employer, e.g., blanking plates, tools, spares, etc. are in order and are correctly stored or handed over.

Power Transformers

Make all tests as per commissioning tests called for in the Manufacturers' instructions manual.

Record and submit to Employer in a hardcover binder, all test data obtained.

Circuit Breaker Tests

For the SF6 circuit breakers, test the gas system to prove the gas density, its dryness and its dielectric strength. Measure the gas leakage rate.

Check and set pressure switches settings when required. Also test mechanical operating systems.

Carry out contact resistance tests. In the case of multi-interrupter circuit breakers, perform resistance tests at each interrupter or pair of interrupters as well as through the series of interrupters on each pole.

Test local and remote trip/close operation and perform circuit breaker and auxiliary contact timing tests on all circuit breakers.

Control/ Relay Panels, energy meters and Switchboards

Carry out general testing and inspection, as referred to above. The Contractor shall also carry following tests: a) Carrier signal testing b) protective relay testing c) Instrument transformers testing c) Phase correcting testing. Functionally test and perform the timing tests on circuit breakers and AC and DC circuits, associated with stand-by auxiliary supplies and stand-by generating sets, particularly where automatic operation is defined.

Carry out insulation measurement tests of secondary circuits with a 1000 V DC megger before and after high voltage testing.

Check shutters, interlocking, earth procedures and the inter-changeability of components.

Carry out a high voltage 50 Hz dielectric test on each bus at 75% of the specified value for the equivalent factory test.

Disconnecting Switch and Earth Switches

Test all disconnecting switch and earth switches operationally to confirm contact pressures, contact resistance, simultaneous-operation of all phases and the ease of operation. Check the local and remote indications and the operation of auxiliary contacts. Check the earthing mat at the operating positions and check the availability of connecting points for maintenance earthing arrangements.

Test the earth switches and maintenance earthing devices to confirm the opening and closing sequences and check the ground mat connections, indications and manual locking devices.

Lightning Arresters

Inspect and verify the condition and satisfactory mounting of the arresters and their earth connections, electrodes and operation counters. Note the counter readings.

Bus bars and Connections

Test flexible bus bars and connections to ensure that the correct tensions, sags and clearances will be maintained over the range of environmental conditions and loads without stress to other equipment. If dynamometers are used to check the sags and tensions, check them before and after use.

Check rigid bus bars and connections to ensure that the bus bars will not cause overloading of the supporting insulators under load conditions and under the range of climatic variations applicable to the Site. Ensure that expansion and contraction of the equipment is fully accommodated by flexible connections.

Test conductivity on selected connections and joints.

Perform high voltage DC tests on all HV cables and isolated phase bus bars at 75% of the specified value for the equivalent factory test. Carry out with at least 1000 V DC megger the insulation measurement test, before and after high voltage tests.

Interlocking: Check all interlocking arrangements, both electrical and mechanical.

B) Earthing System

Carry out the tests and measurements in accordance with IEEE Standard 80. Test the effectiveness of the bonding and earthing and make conductivity tests on selected joints on the main earthing system and at the connections to equipment and structures. Check the precautions taken to avoid corrosion attack on the earthing system.

Measure the resistance of the earthing system to the remote earth indicating method and equipment used. Separate test probes of minimum 300 to 600 meters length to effectively test the earthing system.

Perform earthing resistance measurements with the transmission line earth wires disconnected from the grounding grid.

C) Area Lighting

Check all lighting circuits including the operation of relevant photoelectric cells and remote/local commands.

Measure the lighting levels throughout the substation on horizontal surface 800 mm above ground level and on all vertical surfaces of transformers, marshaling kiosks, etc. Measure the lighting levels in the area surrounding the substation up to 20 m from the fence.

D) Particular Constraints and Special Tests

The Contractor shall be prepared to cooperate with any special tests requested by the Employer.

SECTION-21-PAYMENT OF WORKS

Invoices of materials supplied and erection work shall be submitted separately for the purpose of accounting.

This section provides general guidelines for interim progress payment of different equipment and works covered under this contract.

Interim Certificates for site work shall be restricted in scope to the following items:

a. Substation equipment (transformers,220 kV, 132 kV & 33 kV equipment, 12 kV Switchgear, GIS etc)
b. Substation Auxiliaries (AC & DC Supply, earthing, cabling, illuminations, fire protection etc.)
c. Control & Relay Panels
d. Site Grading Works
e. Slope protection/ Retaining wall
f. Steel structure
g. Architectural & finishing works
h. Roads, Pavements & fencing
i. 33 kV overhead line
j. Spare Parts & Testing Equipment

The Contractor shall submit to the Employer for approval a draft blank printed Form of Measurement Certificate, for each line item at an early stage in the Contract.

All measurements for the purpose of payments shall be made jointly between representatives of the Contractor and the Employer.

No extra payments will be made for the followings, which are not mentioned in the price schedule and required for execution of the work:

- Design, Engineering and project management services.
- Supply of Construction power and water.
- Deployment of man powers required for construction, erection testing and commissioning.
- Providing tools & tackles, consumables, construction machineries, vehicles, testing equipment, spare parts required for construction, erection, testing and commissioning.
- Laptop, software, probes, cables etc. required for communication and protection system.
- Additional costs of access and transport of personnel, materials and erection equipment up to the substation.
- Pumping out of water and flooding conditions
- Shuttering, planking and close timbering of excavation, form of foundation, grouting, tests etc.
- Lean Concrete for foundation
- Scaffolding necessary if any.
- And other items specifically mentioned in the document.

Costs of all of the above items are deemed to be included in the quoted price in price schedule.

Payment for various items as per the Price Schedule shall be as follows:

Table 20.1: Schedule for Interim Payment

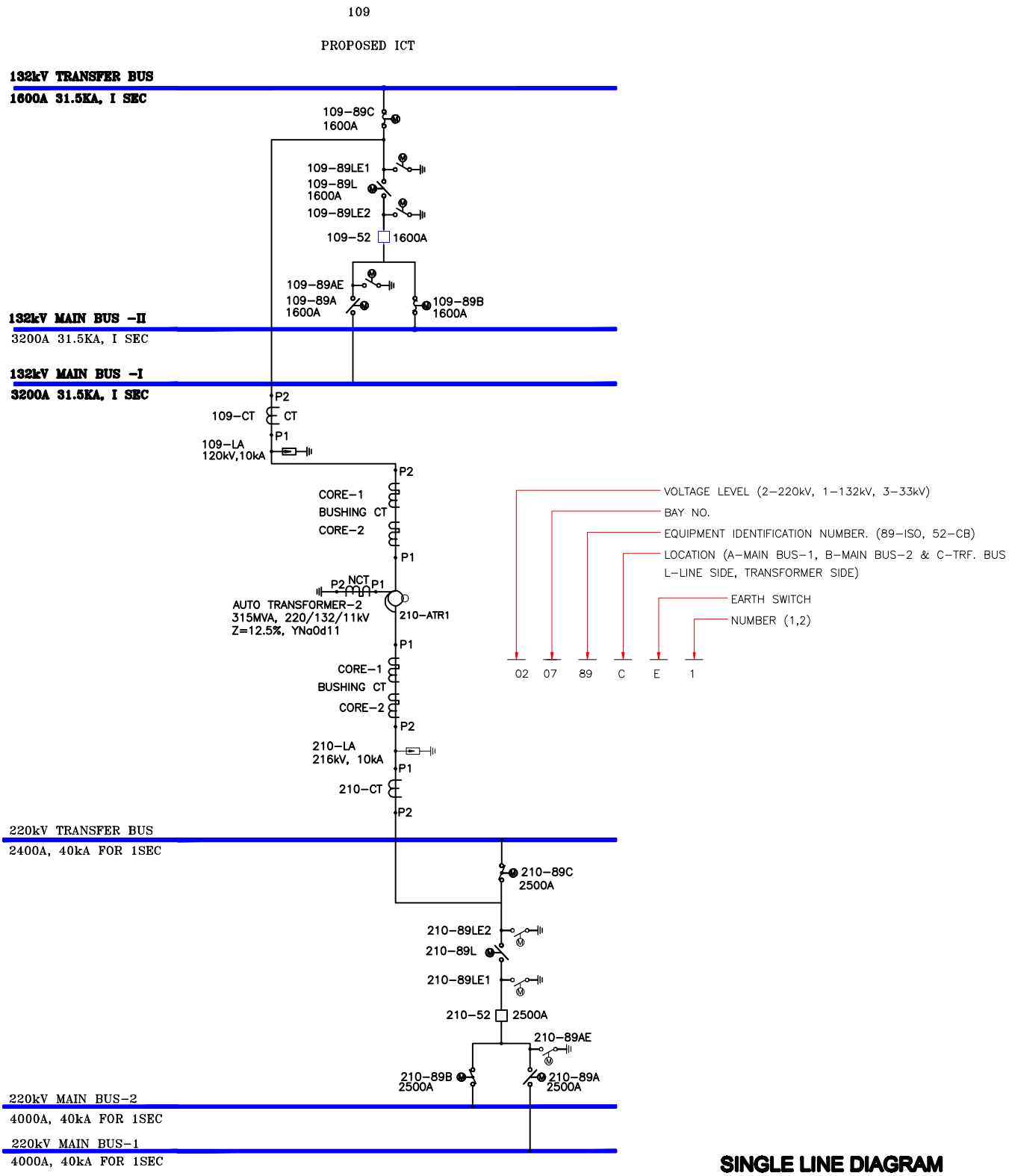
S.No.	Description	Unit	Basis of Payment
1	Transformer	No.	Based on no. of transformer
2	Circuit Breaker with support structure	No.	Based on no. of Circuit breaker with support structure
3	Current Transformer	No.	Based on no. of current transformer

S.No.	Description	Unit	Basis of Payment
4	Disconnecting Switch	No.	Based on no. of Disconnecting switch
5	Lightning Arrestor	No.	Based on no. of Lightning Arrestor
6	33/ 12 kV Switchgear	Set	Based on Set of 33/ 11kV switchgear
7	Battery and Battery Charger	No./ Sets	Based on no./sets of battery and battery charger
8	Illumination System	LS/ Sets	Based on measured value
9	Fire detection and alarm system		
9.1	Fire extinguisher	No.	Based on no. of extinguisher
9.2	Fire detection and alarm system	LS	Based on set measured value
9.3	Smoke detection system	LS	Based on set measured value
10	Cables along with clamps, glands, lugs and straight joints etc.		
10.1	11/33/132 kV Power Cable including termination joints etc	m	Based on measured value
10.2	LV Power and Control Cables	LS	Based on measured value
11	Erection Hardware	Lot/ LS	Based on measured value
12	Grounding		
12.1	Galvanised EHS for Lightning Shield Wire	LS	Based on measured value
12.2	Earthing of SS with Conductor, electrode	LS	Based on measured value
12.3	Lightning protection system with lightning mast, copper conductor, electrodes complete with all accessories for control building	LS	Based on measured value
13	Control and Relay panels	Sets	Based on sets of control and relay panel
14	Substation Automation System/Communication/SCADA	No	Based on no of bays
15	Integration of all bays at Substation With SIEMENS (Power 7) SCADA System at LDC	Lot/ LS	Based on measured value
16	Air Conditioning system	No	Based on no. of Air conditioner
17	Steel structures	LS/ Sets/ Nos/ MT	Based on measured value as applicable
18	Miscellaneous works		
18.1	Exploration Works	location	Based on measured value

S.No.	Description	Unit	Basis of Payment
18.2	Site Grading with earth filling by borrow pit earth Including compaction and leveling	Cu m	Based on measured value
19	Water Supply including testing	LS	Based on measured value
20	Crushed Rock Surfacing including Laying of Sand and Plastic	Cu m	Based on measured value
21	Foundation (Civil Works: Material plus Labor all included)	No./ LS/ sets	Based on measured value as applicable
22	Reinforcement bars applicable ONLY for miscellaneous civil works as per requirement	kg	Based on measured value
23	Gabion Box Protection/ Stone Masonary	Cu m	Based on measured value
24	Removing Roots of tree	LS	Based on number of trees
25	Control Building (Material plus Labor all included)	LS	Based on Building Progress
26	Switchyard fencing	Rm	Based on measured value
27	Asphalt Road	Sq. m	Based on measured value
28	Bus Post Insulator	No	Based on number
29	Tonge tester	No	Based on measured value
30	5 kV Insulation tester (Megger)	No	Based on measured value
31	Rail Structure for 220/132, 132/33 and 33/11 kV Power Transformer including access from inter road (For transformer shifting)	LS	Based on Progress/ measured value
32	Cable trench/ Conduit	LS	Based on Progress/ measured value
33	Complete Drains system including RCC slab cover	LS	Based on Progress/ measured value

SECTION-22-DRAWINGS

LIST OF DRAWINGS



SINGLE LINE DIAGRAM

(220 KV LINE & ICT BAY EXPANSION)

NEPAL ELECTRICITY AUTHORITY
(An Undertaking of Government of Nepal)
(NEW BUTWAL SUBSTATION EXPANSION)

Scope of Work

132kV BUTWAL LINE-1 SINGLE BEAR

220/132kV FUTURE ICT

132kV BUTWAL LINE-2 SINGLE BEAR

132kV TBC/BC BARDAGHAT LINE-1 SINGLE BEAR

ICT

132kV BARDAGHAT LINE-2 SINGLE BEAR

132/11kV, 45MVA TRANSFORMER FUTURE BAY

132/33kV, 63MVA TRANSFORMER FUTURE BAY

132 KV TRANSFER BUS (TWIN MOOSE ACSR)

3.75M WIDE ROAD

F.G.L-122.65 M

33KV

TRANSFORMER

MAIN BUS-1 (QUAD MOOSE ACSR)

MAIN BUS-2 (QUAD MOOSE ACSR)

LM-1

LM-2

LM-3

LM-4

LM-5

5.5 W

TWIN BISON 220kV (BARDAGHAT LINE-2)

TWIN BISON 220kV (BARDAGHAT LINE-1)

TWIN DRAKE HTLS 220kV KAWASOTI LINE-1

TWIN DRAKE HTLS 220kV KUSHMA LINE-2

220KV ICT

BUS COUPLER

TRANSFER BUS COUPLER

220KV ICT

220kV ICT-2 (FUTURE)

220kV ICT-1 (FUTURE)

TRANSFER BUS (TWIN BULL AAC)

MAIN BUS-1 (QUAD BERSIMIS ACSR)

MAIN BUS-2 (QUAD BERSIMIS ACSR)

3.75M WIDE ROAD

3.75M WIDE ℄ OF ROAD

℄ OF HBPI

℄ OF CVT

℄ OF LA

℄ OF CVT/BPI

℄ OF TOWER

℄ OF CT

℄ OF B PH.

℄ OF TAN.ISO/BPI

℄ OF PH.

℄ OF TAN.ISO

℄ OF PH.

℄ OF TAN.ISO/BPI

℄ OF ISO

℄ OF TOWER

℄ OF ISO/CT

℄ OF HBPI

℄ OF ROAD

℄ OF CB

℄ OF TOWER

℄ OF B PH.

℄ OF TAN.ISO/BPI

℄ OF PH.

℄ OF TAN.ISO

℄ OF PH.

℄ OF TAN.ISO/BPI

℄ OF TOWER

℄ OF ISO B PH.

℄ OF Y PH./BPI

℄ OF R PH.

℄ OF TOWER

℄ OF BPI

℄ OF ISO

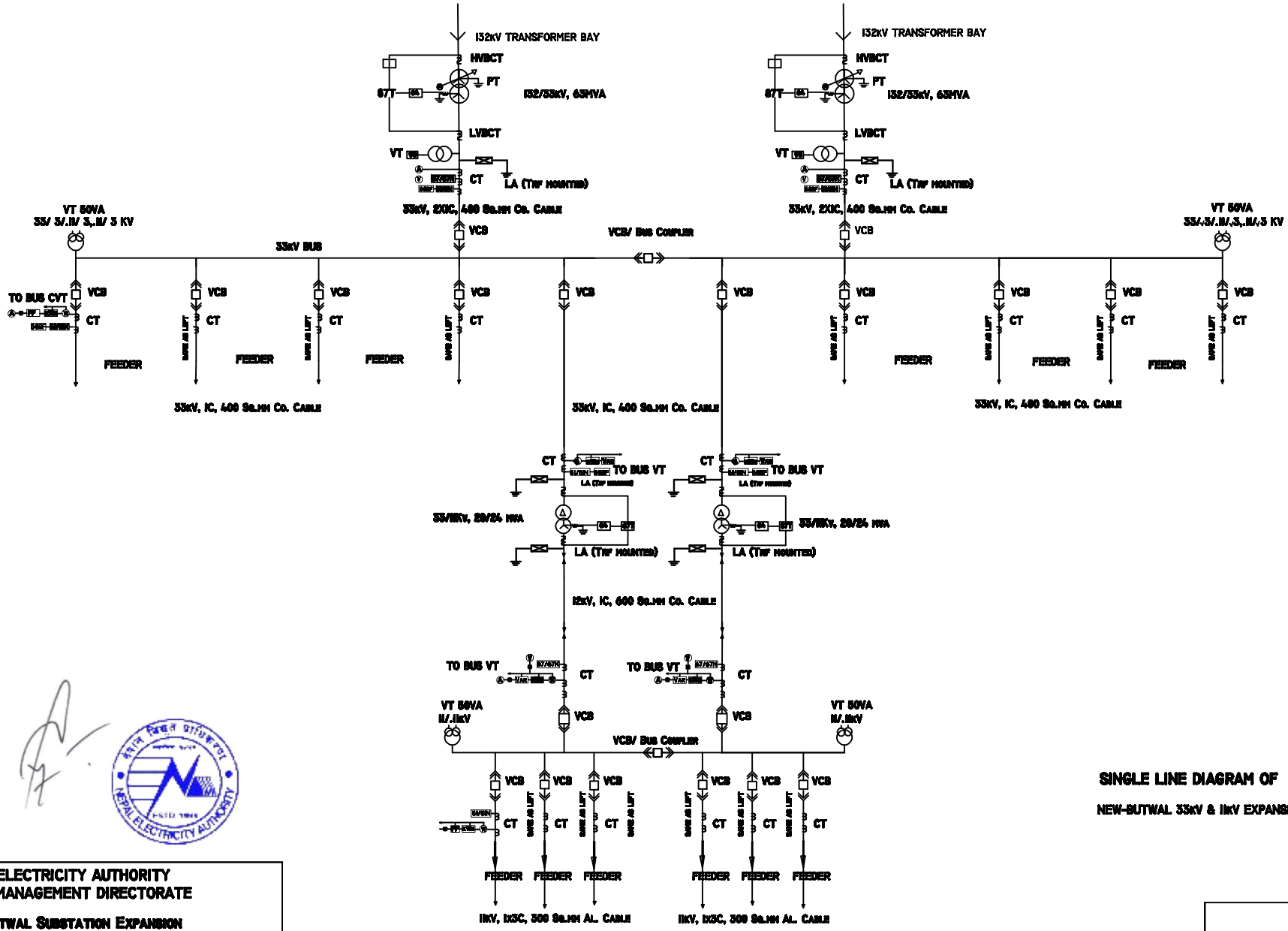
℄ OF CB

℄ OF PT

℄ OF LT TRANSFORMER

℄ OF CVT

NEPAL ELECTRICITY AUTHORITY



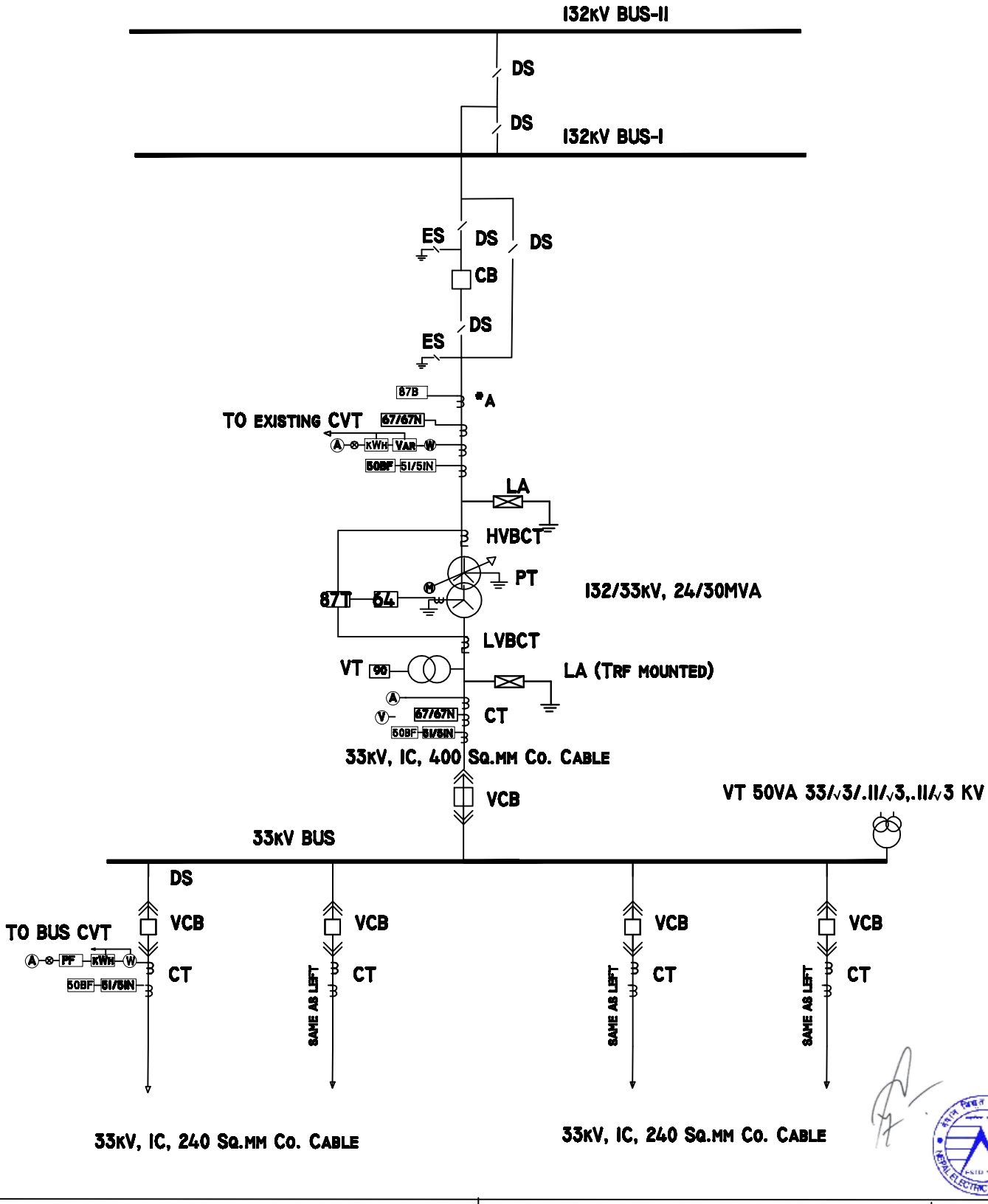
NEPAL ELECTRICITY AUTHORITY
PROJECT MANAGEMENT DIRECTORATE

NEW BUTWAL SUBSTATION EXPANSION

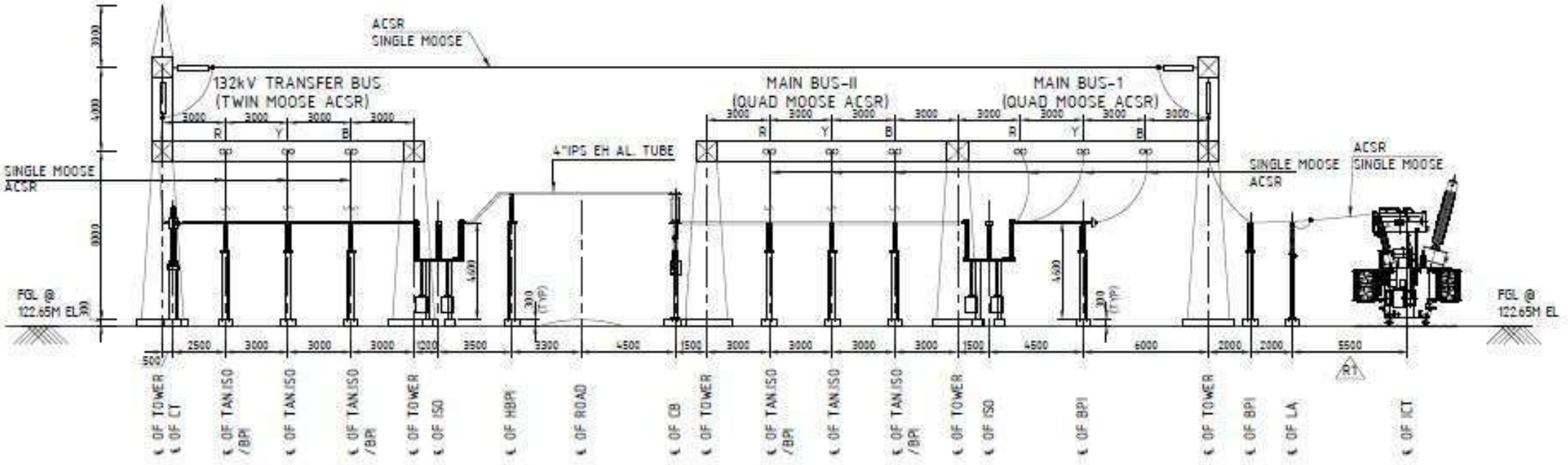
SINGLE LINE DIAGRAM OF

NEW-BUTWAL 33kV & 11kV EXPANSION

SCALE
NOT IN SCALE



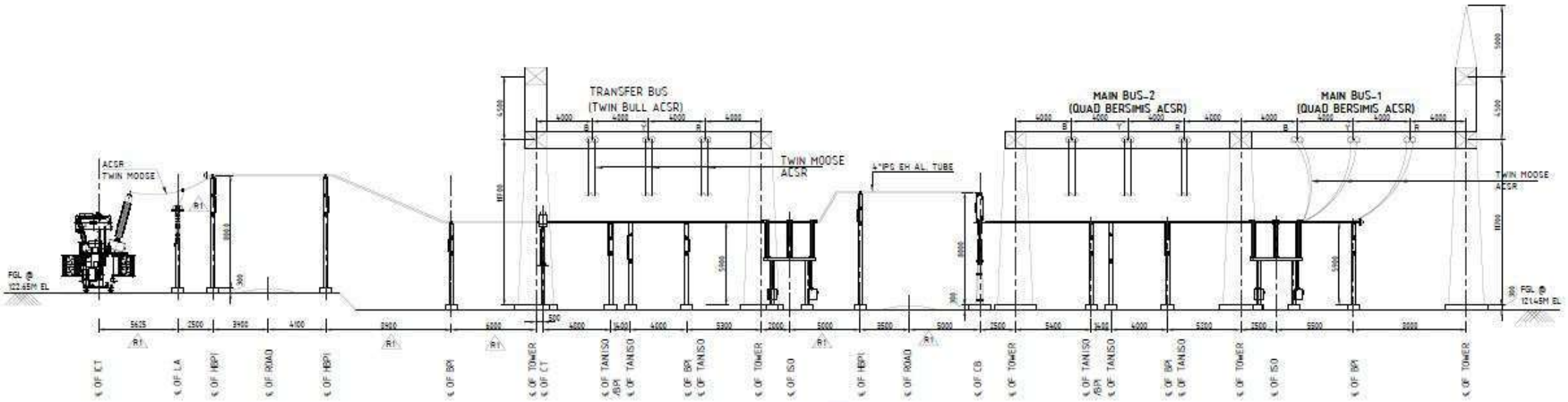
PROJECT MANAGEMENT DIRECTORATE NEPAL ELECTRICITY AUTHORITY PROJECT MANAGEMENT DEPARTMENT	SINGLE LINE DIAGRAM FOR KUSHMA SUBSTATION EXPANSION	SCALE NOT IN SCALE



SECTION B-B

132kV ICT BAY

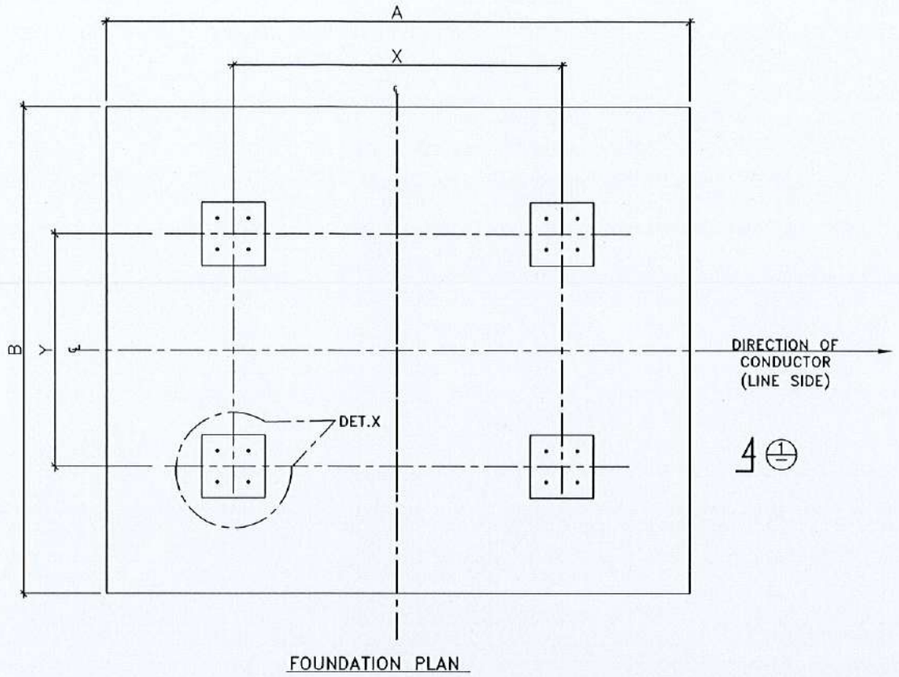
NEPAL ELECTRCITY AUTHORITY
NEW BUTWAL & kUSHMA SUBSTATION EXPANSION PROJECT
REFERENCE DRAWING



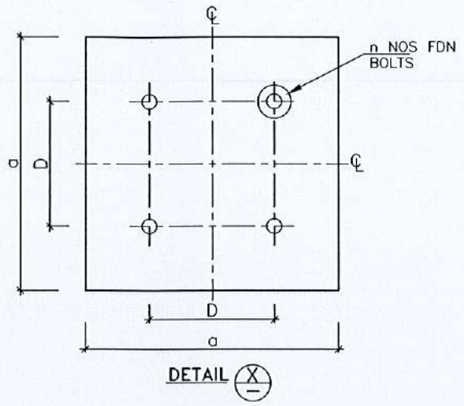
SECTION E-E
220kV ICT BAY (TRANSFORMER)

NEPAL ELECTRICITY AUTHORITY
NEW BUTWAL & KUSHMA SUBSTATION EXPANSION PROJECT
REFERENCE DRAWING

S.N.	TOWER	H	A	B	aXa	E	①	②	③	④	⑤	D	n	X	Y	ø
1	CB	2950	6000	5000	600X 600	550	Y16-175 C/C	Y16-175 C/C	4-Y28	8-Y25	Y8-250 C/C	320	4	~~2386~~	~~2386~~	56



FOUNDATION PLAN



DETAIL (X)

NOTES:-

1. ALL DIMENSIONS ARE IN MM. & ELEVATIONS ARE IN METER UNLESS NOTED OTHERWISE.
2. ALL STRUCTURAL CONC. SHALL BE 1:1:2 - M25 (1 CEMENT:1 COARSE SAND: 2 GRADED STONE AGGREGATE OF 20MM NOMINAL DIA SIZE)
3. ALL LEAN CONC. SHALL BE 75MM. THK. AND OF GRADE 1:4:8 (1 CEMENT:4 COARSE SAND: 8 GRADED STONE AGGREGATE OF 40MM NOMINAL SIZE)
4. ALL REINFORCEMENT STEEL BARS (DENOTED AS) SHALL CONFORM TO IS:1786-1985 OF GRADE Fe 500 OR TMT BARS OF EQUAL GRADE.
5. UNLESS NOTED OTHERWISE LAP/ANCHOR LENGTH SHALL BE 50 TIMES THE DIA. OF BARS.
6. CLEAR COVER TO MAIN REINF. SHALL BE 50 MM
7. FOR LOCATIONS OF TOWER FDNS REFER LAYOUTS OF RESPECTIVE SUBSTATIONS
8. ALL FOUNDATIONS SHALL REST MIN. 1000 MM BELOW VIRGIN SOIL
9. DEVELOPMENT LENGTH (Ld) SHALL BE 50 TIMES DIA OF THA BAR.
10. ORIENTATION OF FOUNDATION TO BE VERIFIED WITH FOUNDATION LAYOUT/GA DRAWING.

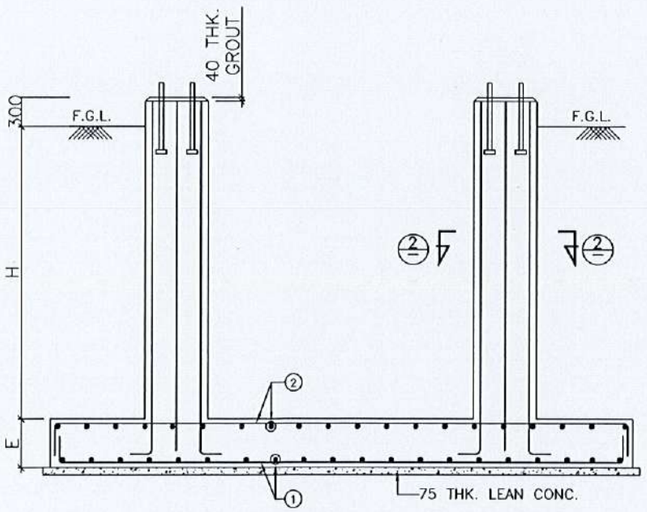
CAT-1*

EMPLOYER: NEPAL ELECTRICITY AUTHORITY (NEA)
SASEC : Power System Expansion Project
KALIGANDAKI TRANSMISSION CORRIDOR PROJECT
DANA- KUSHMA 220KV TRANSMISSION LINE & ASSOCIATED SUB STATIONS (Design, Supply & Install) - Contract - PMD-KGTCP

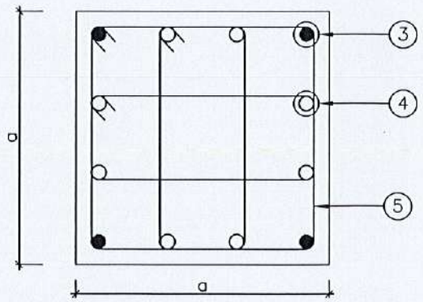
(Signature) (Designation) (Date)

I. Approved/ Released for Fabrication/ Co...
II. Approved/ Released for Fabrication/ Co... Subject to Incorporation of Comments, M... as Noted Revised Drawing Required.
III. To be Resubmitted for Approval after Incorporating the Comments.
IV. For Information & Record.
V. Not Approved.

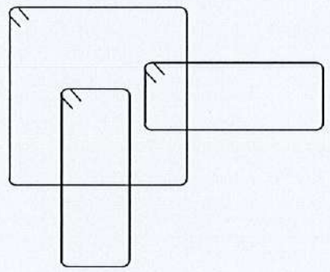
Consultant : Power Grid Corporation of India Ltd. Engg. (TL & S/S) Gurgaon (Haryana)



SECTION (1)



SECTION (2)



CAT 1*

Consultant: Power Grid Corporation of India Ltd. Engg. (S/S Civil) Gurgaon (Haryana).

(Signature) (Designation) (Date)

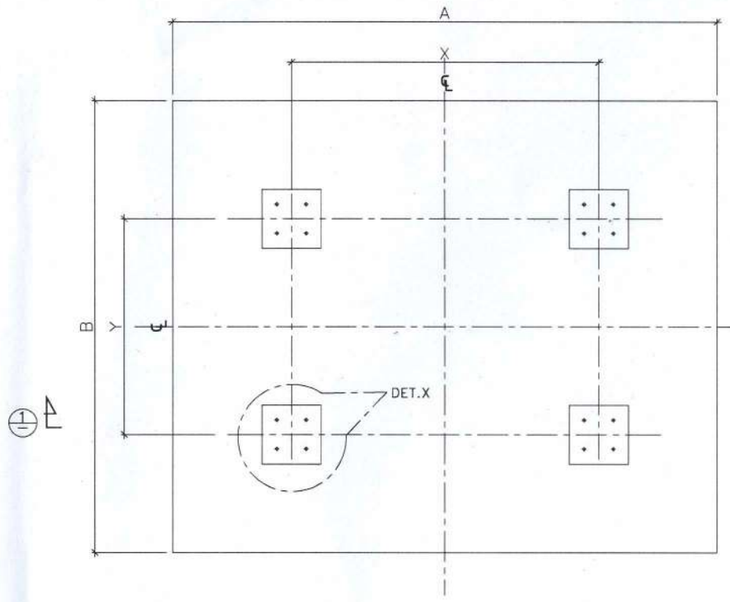
I. Recommended for Approval / Release for Fabrication / Construction.
II. Recommended for Approval / Release for Fabrication / Construction Subject to Incorporation of Comments Modification as Noted, Revised Drawing Required.
III. To be Resubmitted for Approval after Incorporating the Comments.
IV. For Information & Records.
V. Not recommended for approval.

KALIGANDAKI TRANSMISSION CORRIDOR PROJECT
Under SASEC : Power System Expansion Project
Owner : Nepal Electricity Authority (NEA).

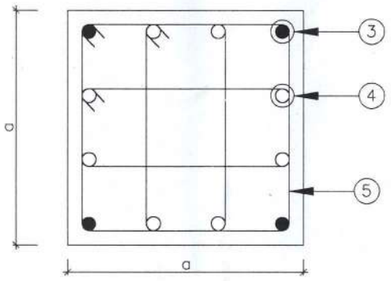
REV.	DATE	DESCRIPTION
R1	10.07.18	REVISED AS PER COMMENTS DT. 09.07.18
R0	28.06.18	FIRST SUBMISSION

CLIENT	NEPAL ELECTRICITY AUTHORITY (An Undertaking of Government of Nepal)			
CONSULTANT	POWER GRID CORPORATION OF INDIA LIMITED (PGCIL)			
CONTRACTOR				
PROJECT	KALIGANDAKI TRANSMISSION CORRIDOR PROJECT (KGTCP) : PROCUREMENT OF PLANT FOR 220/132 kV NEW BUTWAL SUBSTATION CONTRACT NO. ICB- PMD -KGTCP- 073/74-03			
DESCRIPTION	220 KV TOWER FOUNDATION (CB) OF 220/132KV NEW BUTWAL (RAMNAGAR) SUB STATION			
DRAWN BY.	M.H	DATE	10.07.2018	DRAWING No.
CHECKED BY.	AIK	SCALE	NTS	TPL-NEA-BTW-CL-0476
APPROVED BY.	VVS	SHEET NO.	1 OF 1	REV. R1

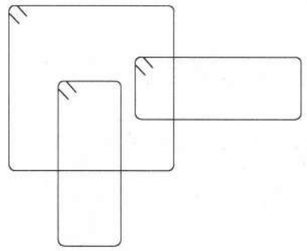
S.N.	TOWER	H	A	B	aXa	E	①	②	③	④	⑤	D	n	X	Y	ø
1	CTG	2400	6800	5800	600X 600	600	Y16-175 C/C	Y16-175 C/C	4-Y25	8-Y20	Y8-175 C/C	320	4	3386	2386	56



FOUNDATION PLAN

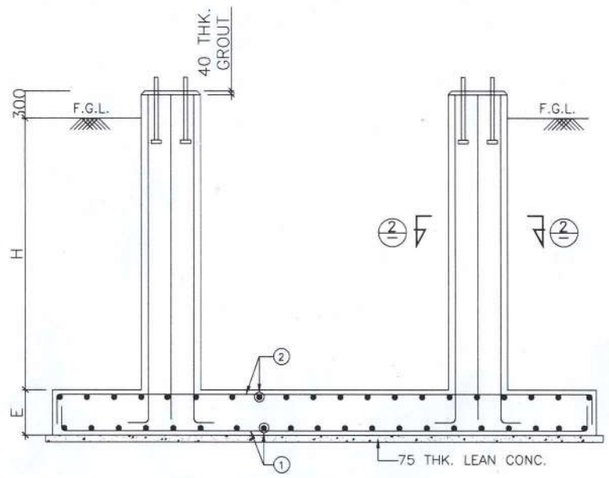


SECTION 2

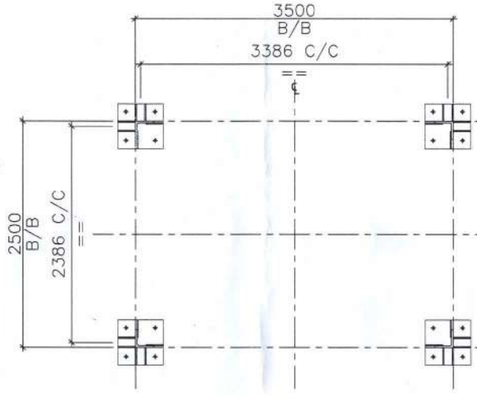


NOTES:-

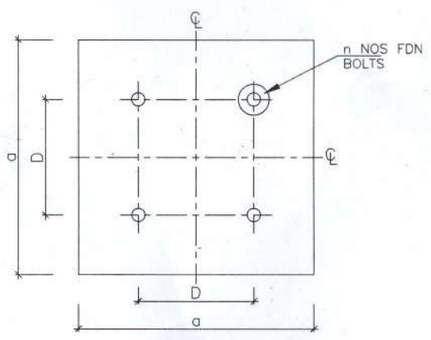
1. ALL DIMENSIONS ARE IN MM. & ELEVATIONS ARE IN METER, UNLESS NOTED OTHERWISE.
2. ALL STRUCTURAL CONC. SHALL BE 1:1:2 - M25 (1 CEMENT:1 COARSE SAND: 2 GRADED STONE AGGREGATE OF 20MM NOMINAL DIA SIZE)
3. ALL LEAN CONC. SHALL BE 75MM. THK. AND OF GRADE 1:4:8- M7.5 (1 CEMENT:4 COARSE SAND: 8 GRADED STONE AGGREGATE OF 40MM NOMINAL SIZE)
4. ALL REINFORCEMENT STEEL BARS (DENOTED AS) SHALL CONFORM TO IS:1786-1985 OF GRADE FE 500 OR TMT BARS OF EQUAL GRADE.
5. UNLESS NOTED OTHERWISE LAP/ANCHOR LENGTH SHALL BE 50 TIMES THE DIA. OF BARS.
6. CLEAR COVER TO MAIN REINF. SHALL BE 50 MM
7. FOR LOCATIONS OF TOWER FDNS REFER LAYOUTS OF RESPECTIVE SUBSTATIONS
8. ALL FOUNDATIONS SHALL REST MIN. 1000 MM BELOW VIRGIN SOIL.
9. DEVELOPMENT LENGTH (Ld) SHALL BE 50 TIMES DIA OF THA BAR.
10. ORIENTATION OF FOUNDATION TO BE VERIFIED WITH FOUNDATION LAYOUT/GA DRAWING.



SECTION 1



BASE PLATE PLAN



DETAIL X

CAT-I

Consultant: Power Grid Corporation of India Ltd. Engg. (S/S Civil) Gurgaon (Haryana).

(Signature) ✓

(Designation) ASTGM

(Date) 21/2/18

I. Recommended for Approval / Release for Fabrication / Construction.
II. Recommended for Approval / Release for Fabrication / Construction Subject to Incorporation of Comments Modification as Noted. Revised Drawing Required.
III. To be Resubmitted for Approval after Incorporating the Comments.
IV. For Information & Records.
V. Not recommended for approval.

KALIGANDAKI TRANSMISSION CORRIDOR PROJECT
Under SASEC : Power System Expansion Project
Owner : Nepal Electricity Authority (NEA).

EMPLOYER: NEPAL ELECTRICITY AUTHORITY(NEA)
SASEC : Power System Expansion Project
KALIGANDAKI TRANSMISSION CORRIDOR PROJECT
220/132 KV NEW BUTWAL SUBSTATION
(Design, Supply, Installation & Commissioning)
Contract To:- ICB-PMD-KGTCP-073/74-03

(Signature)

(Designation)

(Date) 21 Aug

I. Approved/ Realeased for Fabrication/ Construction
II. Approved/ Realeased for Fabrication/ Construction Subject to incorporation of Comments, Modification as Noted, Revised Drawing Required.
III. To be Resubmitted for Approval after Incorporating the Comments.
IV. For Information & Record.
V. Not Approved

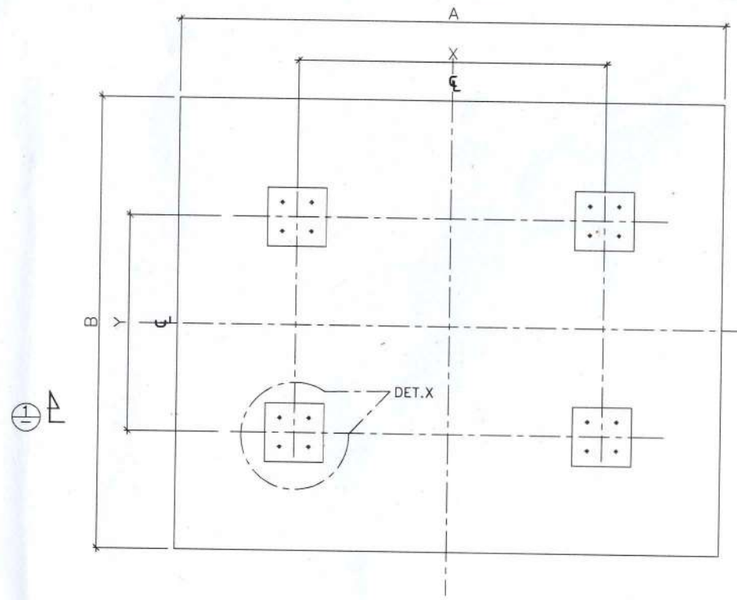
Consultant : Power Grid Corporation of India Ltd.
Engg. (TL & S/S) Gurgaon (Haryana)

REV.	DATE	DESCRIPTION
R1	20.08.18	SECOND SUBMISSION
R0	03.08.18	APPROVED IN CAT-III (18.08.18)

CLIENT	NEPAL ELECTRICITY AUTHORITY (An Undertaking of Government of Nepal)
CONSULTANT	POWER GRID CORPORATION OF INDIA LIMITED (PGCIL)
CONTRACTOR	
PROJECT.	KALIGANDAKI TRANSMISSION CORRIDOR PROJECT (KGTCP) : PROCUREMENT OF PLANT FOR 220/132 kV NEW BUTWAL SUBSTATION CONTRACT NO. ICB- PMD -KGTCP- 073/74-03
DESCRIPTION	220 KV TOWER FOUNDATION (CTG) NEW BUTWAL (RAMNAGAR) SUB STATION

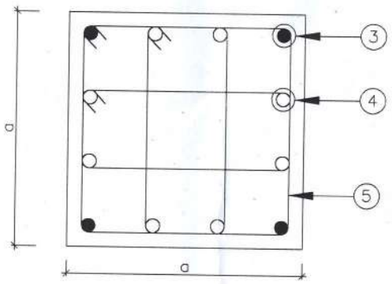
DRAWN BY.	M.H	DATE	20.08.2018	DRAWING No.	
CHECKED BY.	AIK	SCALE	NTS	TPL-NEA-BTW-CL-0499	
APPROVED BY.	VVS	SHEET NO.	1 OF 1	REV.	R1

S.N.	TOWER	H	A	B	aXa	E	①	②	③	④	⑤	D	n	X	Y	ø
1	CTH	2350	6500	5500	625X 625	650	Y16–150 C/C	Y12–125 C/C	4–Y25	8–Y20	Y8–175 C/C	320	4	3386	2386	56

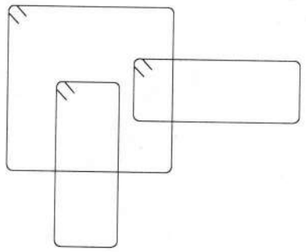


FOUNDATION PLAN

DIRECTION OF CONDUCTOR (LINE SIDE)

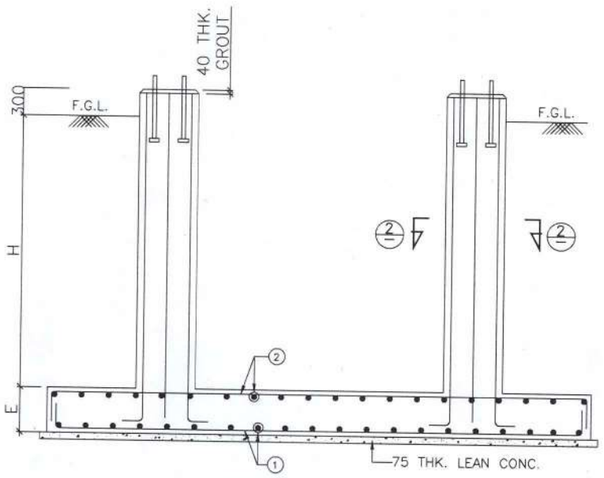


SECTION ②

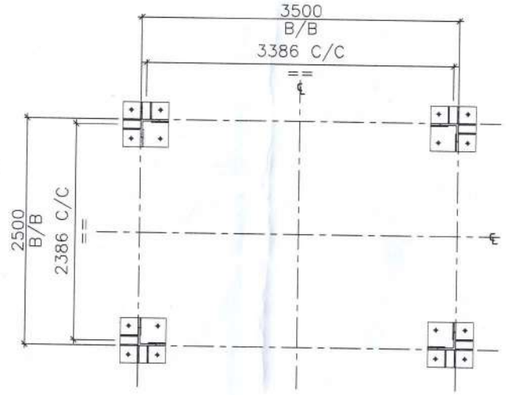


NOTES:–

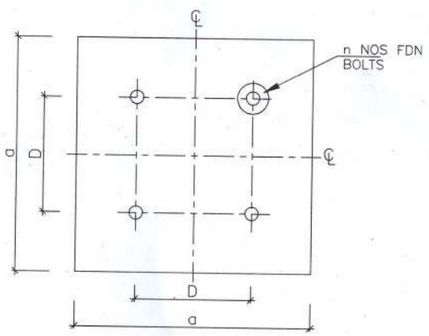
1. ALL DIMENSIONS ARE IN MM. & ELEVATIONS ARE IN METER, UNLESS NOTED OTHERWISE.
2. ALL STRUCTURAL CONC. SHALL BE 1:1:2 - M25 (1 CEMENT:1 COARSE SAND: 2 GRADED STONE AGGREGATE OF 20MM NOMINAL DIA SIZE)
3. ALL LEAN CONC. SHALL BE 75MM. THK. AND OF GRADE 1:4:8- M7.5 (1 CEMENT:4 COARSE SAND: 8 GRADED STONE AGGREGATE OF 40MM NOMINAL SIZE)
4. ALL REINFORCEMENT STEEL BARS (DENOTED AS) SHALL CONFORM TO IS:1786-1985 OF GRADE FE 500 OR TMT BARS OF EQUAL GRADE.
5. UNLESS NOTED OTHERWISE LAP/ANCHOR LENGTH SHALL BE 50 TIMES THE DIA. OF BARS.
6. CLEAR COVER TO MAIN REINF. SHALL BE 50 MM
7. FOR LOCATIONS OF TOWER FDNS REFER LAYOUTS OF RESPECTIVE SUBSTATIONS
8. ALL FOUNDATIONS SHALL REST MIN. 1000 MM BELOW VIRGIN SOIL.
9. DEVELOPMENT LENGTH (Ld) SHALL BE 50 TIMES DIA OF THA BAR.
10. ORIENTATION OF FOUNDATION TO BE VERIFIED WITH FOUNDATION LAYOUT/GA DRAWING.



SECTION ①



BASE PLATE PLAN



DETAIL X

CAT-I

Consultant: Power Grid Corporation of India Ltd. Engg. (S/S Civil) Gurgaon (Haryana).

(Signature) ATTEM

(Designation)

21/8/18 (Date)

I. Recommended for Approval / Release for Fabrication / Construction.
II. Recommended for Approval / Release for Fabrication / Construction Subject to Incorporation of Comments Modification as Noted. Revised Drawing Required.
III. To be Resubmitted for Approval after Incorporating the Comments.
IV. For Information & Records.
V. Not recommended for approval.

KALIGANDAKI TRANSMISSION CORRIDOR PROJECT
Under SASEC : Power System Expansion Project
Owner : Nepal Electricity Authority (NEA).

EMPLOYER: NEPAL ELECTRICITY AUTHORITY(NEA)
SASEC : Power System Expansion Project
KALIGANDAKI TRANSMISSION CORRIDOR PROJECT
220/132 KV NEW BUTWAL SUBSTATION
(Design, Supply, Installation & Commissioning)
Contract To:- ICB-PMD-KGTCP-073/74-03

(Signature) Laxman Poudyal

(Designation)

21-Aug (Date)

I. Approved/ Realeased for Fabrication/ Construction
II. Approved/ Realeased for Fabrication/ Construction Subject to incorporation of Comments, Modification as Noted, Revised Drawing Required.
III. To be Resubmitted for Approval after Incorporating the Comments.
IV. For Information & Record.
V. Not Approved

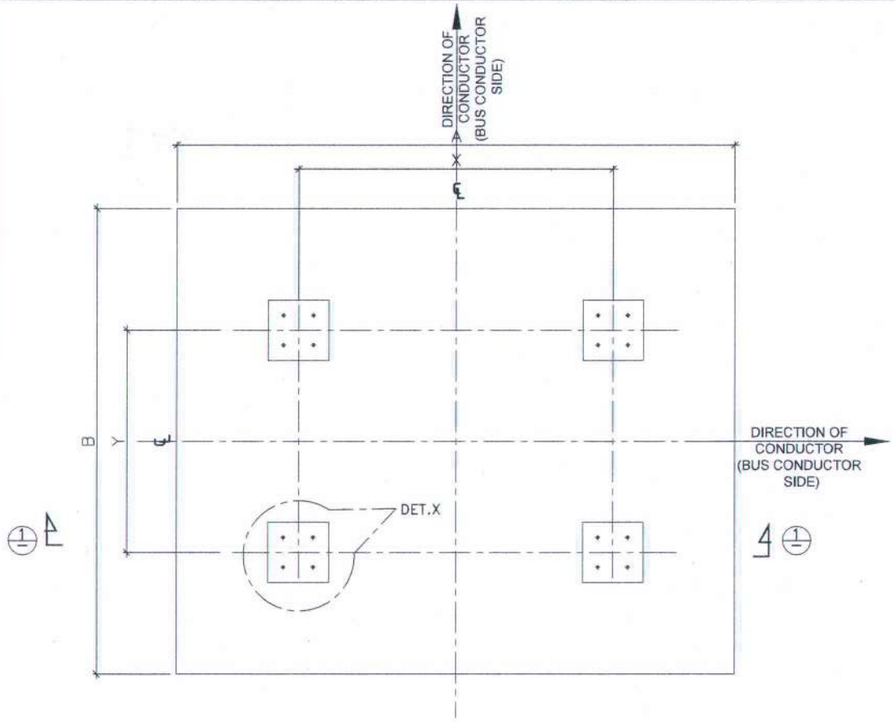
Consultant : Power Grid Corporation of India Ltd.
Engg. (TL & S/S) Gurgaon (Haryana)

REV.	DATE	DESCRIPTION
R1	20.08.18	SECOND SUBMISSION
R0	03.08.18	APPROVED IN CAT–III (18.08.18)

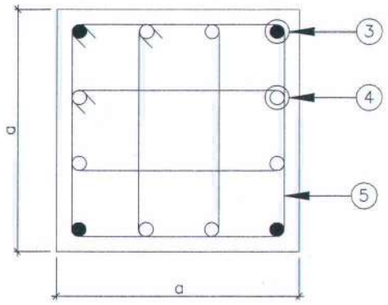
CLIENT	NEPAL ELECTRICITY AUTHORITY (An Undertaking of Government of Nepal)
CONSULTANT	POWER GRID CORPORATION OF INDIA LIMITED (PGCIL)
CONTRACTOR	
PROJECT.	KALIGANDAKI TRANSMISSION CORRIDOR PROJECT (KGTCP) : PROCUREMENT OF PLANT FOR 220/132 kV NEW BUTWAL SUBSTATION CONTRACT NO. ICB- PMD -KGTCP- 073/74-03
DESCRIPTION	220 KV TOWER FOUNDATION (CTH) NEW BUTWAL (RAMNAGAR) SUB STATION

DRAWN BY.	M.H	DATE	20.08.2018
CHECKED BY.	AIK	SCALE	NTS
APPROVED BY.	VVS	SHEET NO.	1 OF 1
DRAWING No.	TPL–NEA–BTW–CL–0374		
REV.	R1		

S.N.	TOWER	H	A	B	aXa	E	①	②	③	④	⑤	D	n	X	Y	ø
1	CTI	2450	6000	5000	600X 600	550	Y16-175 C/C	Y16-175 C/C	4-Y25	8-Y20	Y8-175 C/C	320	4	3382	2382	56



FOUNDATION PLAN



SECTION (2)

NOTES:-

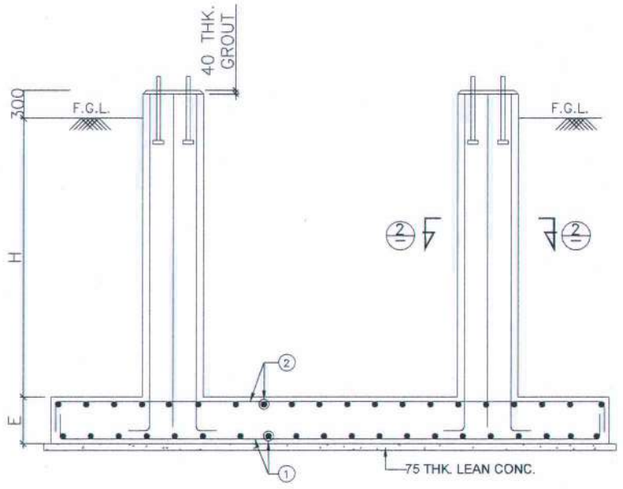
1. ALL DIMENSIONS ARE IN MM. & ELEVATIONS ARE IN METER, UNLESS NOTED OTHERWISE.
2. ALL STRUCTURAL CONC. SHALL BE 1:1:2 - M25 (1 CEMENT:1 COARSE SAND: 2 GRADED STONE AGGREGATE OF 20MM NOMINAL DIA SIZE)
3. ALL LEAN CONC. SHALL BE 75MM. THK. AND OF GRADE 1:4:8- M7.5 (1 CEMENT:4 COARSE SAND: 8 GRADED STONE AGGREGATE OF 40MM NOMINAL SIZE)
4. ALL REINFORCEMENT STEEL BARS (DENOTED AS) SHALL CONFORM TO IS:1786-1985 OF GRADE FE 500 OR TMT BARS OF EQUAL GRADE.
5. UNLESS NOTED OTHERWISE LAP/ANCHOR LENGTH SHALL BE 50 TIMES THE DIA. OF BARS.
6. CLEAR COVER TO MAIN REINF. SHALL BE 50 MM
7. FOR LOCATIONS OF TOWER FDNS REFER LAYOUTS OF RESPECTIVE SUBSTATIONS
8. ALL FOUNDATIONS SHALL REST MIN. 1000 MM BELOW VIRGIN SOIL.
9. DEVELOPMENT LENGTH (Ld) SHALL BE 50 TIMES DIA OF THA BAR.
10. **ORIENTATION OF FOUNDATION TO BE VERIFIED WITH FOUNDATION LAYOUT/GA DRAWING.**

CAT-T

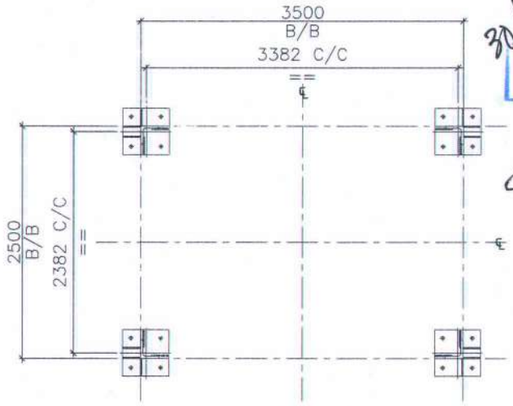
EMPLOYER: NEPAL ELECTRICITY AUTHORITY (NEA)
SASEC : Power System Expansion Project
KALIGANDAKI TRANSMISSION CORRIDOR PROJECT
220/132 KV NEW BUTWAL SUBSTATION
(Design, Supply, Installation & Commissioning)
Contract To:- ICB-PMD-KGTCP-073/74-03
Approved/ Realeased for Fabrication/ Construction
Approved/ Realeased for Fabrication/ Construction
Subject to Incorporation of Comments, Mo
as Noted, Revised Drawing Required.
To be Resubmitted for Approval after Incorp
the Comments.
For Information & Record.
Not Approved
Consultant : Power Grid Corporation of India Ltd.
Engg. (TL & S/S) Gurgaon (Haryana)

30/NOV/18

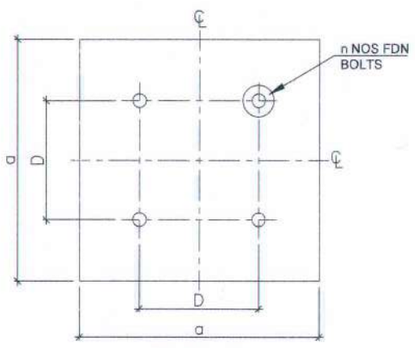
CAT-I



SECTION (1)



BASE PLATE PLAN

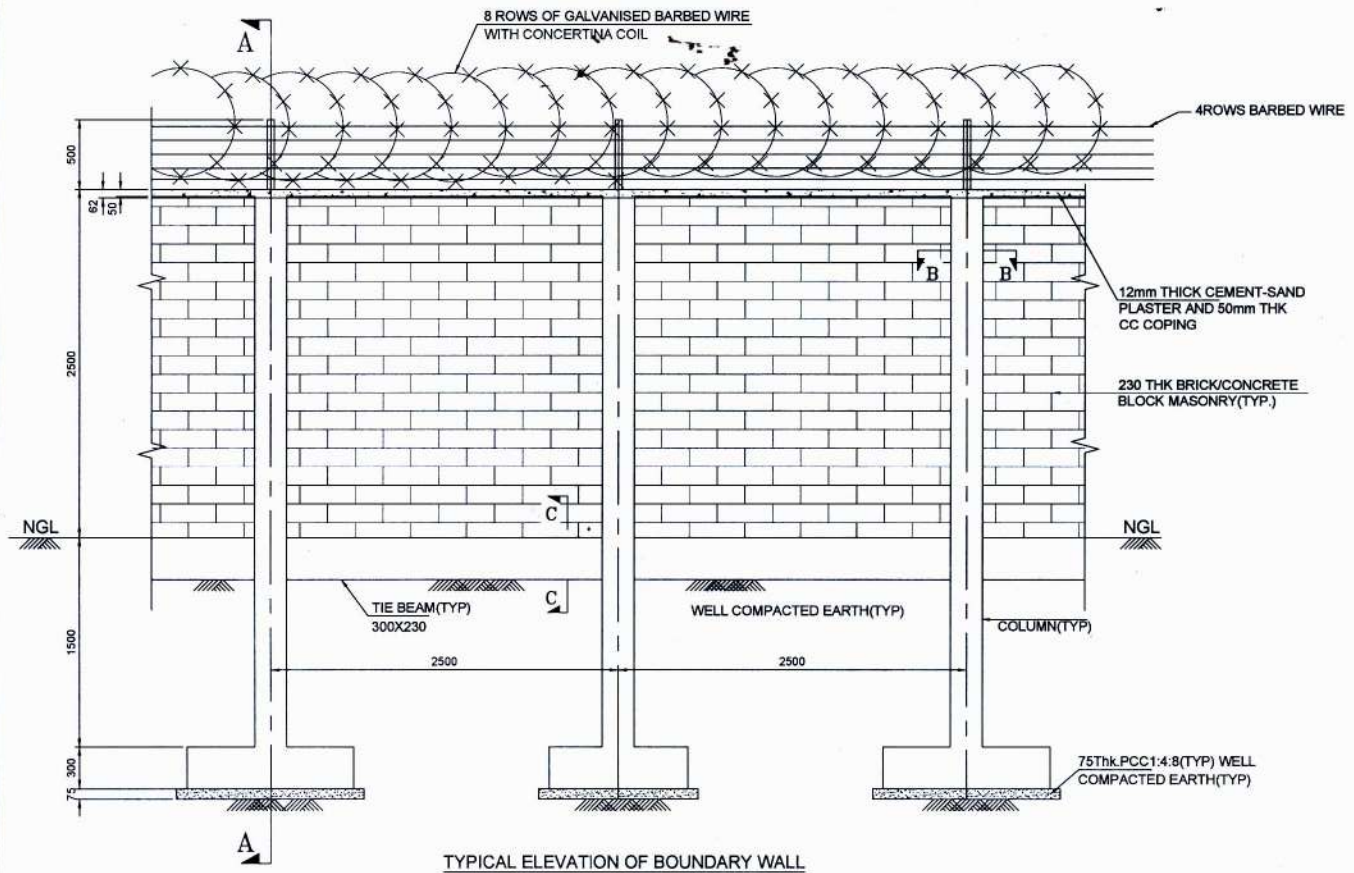


DETAIL (X)

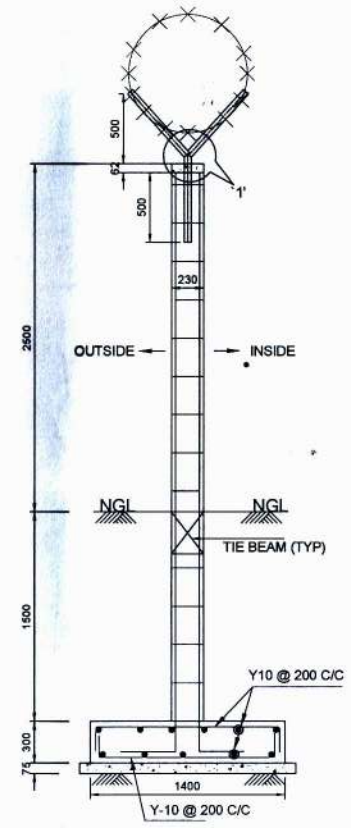
Consultant: Power Grid Corporation of India Ltd.
Engg. (S/S Civil) Gurgaon (Haryana).
I. Recommended for Approval / Release for Fabrication / Construction.
II. Recommended for Approval / Release for Fabrication / Construction Subject to Incorporation of Comments Modification as Noted. Revised Drawing Required.
III. To be Resubmitted for Approval after Incorporating the Comments.
IV. For Information & Records.
V. Not recommended for approval.
(Signature)
SRDGM
(Designation)
22/11/18
(Date)
KALIGANDAKI TRANSMISSION CORRIDOR PROJECT
Under SASEC : Power System Expansion Project
Owner : Nepal Electricity Authority (NEA).

REV.	DATE	DESCRIPTION
R1	21.11.18	SECOND SUBMISSION
R0	29.09.18	APPROVED IN CAT-III (07.10.18)

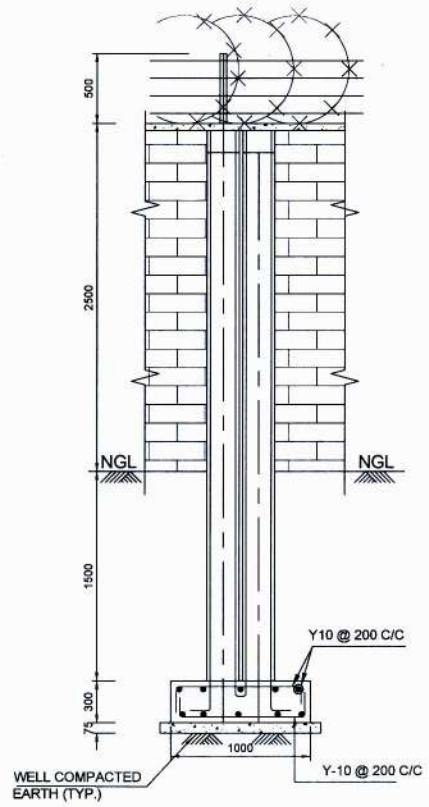
CLIENT	NEPAL ELECTRICITY AUTHORITY (An Undertaking of Government of Nepal)			
CONSULTANT	POWER GRID CORPORATION OF INDIA LIMITED (PGCIL)			
CONTRACTOR				
PROJECT.	KALIGANDAKI TRANSMISSION CORRIDOR PROJECT (KGTCP) : PROCUREMENT OF PLANT FOR 220/132 kV NEW BUTWAL SUBSTATION CONTRACT NO. ICB- PMD -KGTCP- 073/74-03			
DESCRIPTION	220 KV TOWER FOUNDATION (CTI) NEW BUTWAL (RAMNAGAR) SUB STATION			
DRAWN BY.	M.H	DATE	21.11.18	DRAWING No.
CHECKED BY.	AIK	SCALE	NTS	TPL-NEA-BTW-CL-0440
APPROVED BY.	VVS	SHEET NO.	1 OF 1	REV. R1



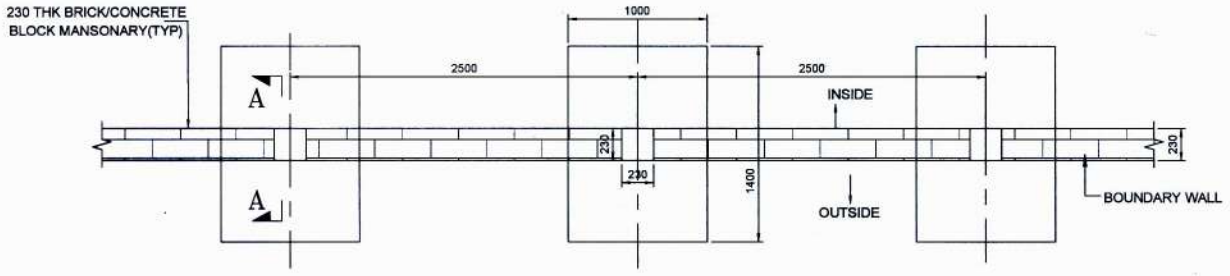
TYPICAL ELEVATION OF BOUNDARY WALL



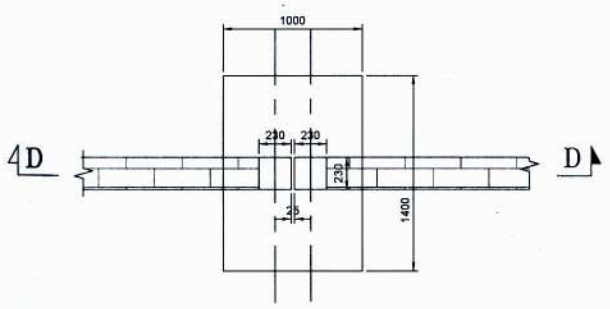
SECTION A-A



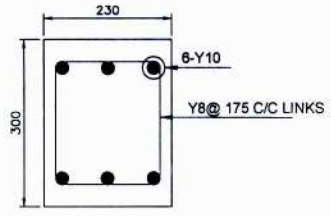
SECTION D-D



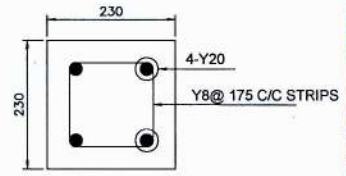
TYPICAL PLAN OF BOUNDARY WALL FOUNDATION



PLAN OF TWIN COLUMN WITH 25MM EXPANSION GAP AT EVERY 45M



TYPICAL DETAIL OF TIE BEAM
SECTION C-C
SECLE –1:2



TYPICAL DETAIL OF COLUMN
SECLE –1:2

CAT-I

EMPLOYER: NEPAL ELECTRICITY AUTHORITY(NEA)
SASEC : Power System Expansion Project
KALIGANDAKI TRANSMISSION CORRIDOR PROJECT
220/132 KV NEW BUTWAL SUBSTATION
(Design, Supply, Installation & Commissioning)
Contract To:- ICB-PMD-KGTCP-073/74-03

(Signature)
(Designation)
(Date)

I. Approved/ Realeased for Fabrication/ Construction
II. Approved/ Realeased for Fabrication/ Construction Subject to Incorporation of Comments, Modification as Noted, Revised Drawing Required.
III. To be Resubmitted for Approval after Incorporating the Comments.
IV. For Information & Record.
V. Not Approved

Consultant : Power Grid Corporation of India Ltd.
Engg. (TL & S/S) Gurgaon (Haryana)

CAT-I

Consultant: Power Grid Corporation of India Ltd.
Engg. (S/S Civil) Gurgaon (Haryana).

(Signature)
ASST GM
(Designation)
09/10/18
(Date)

I. Recommended for Approval / Release for Fabrication / Construction.
II. Recommended for Approval / Release for Fabrication / Construction Subject to Incorporation of Comments, Modification as Noted, Revised Drawing Required.
III. To be Resubmitted for Approval after Incorporating the Comments.
IV. For Information & Records.
V. Not recommended for approval.

KALIGANDAKI TRANSMISSION CORRIDOR PROJECT
Under SASEC : Power System Expansion Project
Owner : Nepal Electricity Authority (NEA).

LEGEND:-

NGL— NATURAL GROUND LEVEL

CONSTRUCTION NOTES :-

1. ALL DIMENSIONS ARE IN MM UNLESS NOTED OTHERWISE.
2. ALL STEEL WORKS SHALL BE PROVIDED WITH TWO COATS OF SYNTHETIC ENAMEL POINT OVER A COAT OF STEEL PRIMER OF APPROVED MAKE.
3. ALL WELDS ARE 6mm THK. CONTINUOUS FILLET WELD UNLESS OTHERWISE SPECIFIED.
4. ALL REINFORCED CONCRETE SHALL BE M25 GRADE.
5. 75 MM THICK PCC (1:4:8) LAYER SHALL BE PROVIDED BELOW ALL RCC WORKS WITH 40MM NOMINAL SIZE AGGREGATE.
6. ALL REINFORCEMENTS SHALL BE HIGH YIELD STRENGTH DEFORMED BARS (HYSD), Fe 500.
7. UNLESS NOTED OTHERWISE THE MINIMUM CLEAR COVER SHALL BE AS FOLLOWS :-

	TOP	BOTTOM	SIDE.
a) FOUNDATION ————	50	50	50
b) COLUMN, THE BEAM, ——	40	40	40

NOTES:-

1. HEIGHT OF BOUNDARY WALL ABOVE THE GROUND SHALL BE 2.5M.
2. GRADE OF CONCRETE FOR RCC WORKS SHALL BE M25.
3. TWIN COLUMNS WITH 25MM EXPANSION GAP AT EVERY 45M LENGTH SHALL BE PROVIDED.
4. RCC FRAMED WITH BRICK MASONRY IN FILL BETWEEN COLUMNS SHALL BE PROVIDED ALONG PERIPHERY OF SUB STATION.
5. 0.5 HEIGHT OF Y SHAPED ANGLE SUPPORTS 50X50X6 MM ABOVE EACH COLUMN WITH ABOUT 0.5M DEEP GROUTED IN COLUMN SHALL BE PROVIDED AS GRIL ON THE BOUNDARY WALL.
6. 8 ROWS OF GALVANIZED BARBED WIRE WITH CONCERTINA COIL AT TOP OF BOUNDARY WALL SHALL BE PROVIDED. 4 ROWS OF BARBED WIRE ON EACH ARM OF Y-SHAPED ANGLE IS TO BE PROVIDED.
7. SUITABLE STEEL GRATING MADE OF 20MM SQUARE BARS SHALL BE PROVIDED AT SUITABLE LOCATIONS PREFERABLY @ 100M TO ALLOW THE FLOW OF SURFACE WATER.
8. ALLOWABLE SAFE BEARING CAPACITY OF SOIL = 9.3 T/SQ.M FOUNDING LEVEL.
9. PROVIDE BRICK WORK IN ENGLISH BOND WITH 12MM THICK CEMENT SAND PLASTER (1 CEMENT : 6 SAND) OVER EXPOSED PROVISION OF BOUNDARY WALL ALONG WITH 50MM THICK 1:2:4 COPING ON TOP OF WALL.
10. STEPPING OF WALL SHALL BE CONSIDERED AS PER SITE CONDITIONS.
11. MIX OF MASONRY WORKS = 1 CEMENT : 6 SAND
12. TWO COATS OF OIL-BOUND DISTEMPER WITH ONE COAT OF CEMENT PRIMER OF APPROVED MAKE SHALL BE APPLIED OVER EXPOSED PORTION OF BOUNDARY WALL.
13. THE SPECIFICATIONS OF BRICK/CONCRETE BLOCK & BARBED WIRE SHALL BS AS PER SPECIFICATIONS.
14. IN CASE OF BOUNDARY WALL PANEL COMING AT SLOPE, THE HIGHER G.L. 2.5M HEIGHT TO BE MAINTAINED FOR BOUNDARY WALL.
15. BARBED WIRE SHALL BE GALVANIZED STEEL BARBED WIRE AND SHALL BE IN AS A-4-IS:278 CONFORMING TO IS:278.
16. a). BRICK TO BE DONE WITH BRICK OF FIRST CLASS DESIGNATION-75.
    b). PLASTER WORK SHALL BE IN CEMENT MORTAR 1:6 (1CEMENT : 6 FINE SAND) THICKNESS OF PLASTER SHALL BE AS PER BOQ.
17. THE EXCAVATION IN SOIL SHALL BE DONE AS PER THE SIZE OF FOOTING.
18. STRUCTURAL STEEL FOR ANGLE POST SHALL CONFORM TO IS:2062, ANGLE POST SHALL BE PAINTED WITH TWO OR MORE COATS OF ENAMEL PAINTS OF APPROVED BRAND AND MANUFACTURE OVER A PRIMING COAT OF APPROVED STEEL PRIMER.
19. THE RISE/ FALL IN BOUNDARY WALL FOUNDATION SHALL BE PROVIDED WHEREVER THE DIFFERENCE IN GROUND LEVEL IS MORE THAN 500mm.
20. LAP/ANCHORAGE SHALL BE 50xDIA OF BAR.
21. INCASE BLACK COTTON SOIL IS ENCOUNTERED SUITABLE TREATMENT IN FOUNDATION SHALL BE PROVIDED.
22. BACKFILL SOIL SHALL BE WELL COMPACTED TO AVOID THE SETTLEMENT OF EARTH.
23. THE SURPLUS EARTH GENERATED FROM FOUNDATION SHALL BE DISPOSED ALONG THE BOUNDARY WALL AND THE SAME SHALL BE ROUGHLY GRADED.
24. STONE BLANKET, IF ANY, SHALL BE PROVIDED AS PER RECOMMENDATION OF SOIL INVESTIGATION REPORT.
25. ALL EXPOSED PLASTER SURFACES ARE TO BE PAINTED AS PER B.O.Q.
26. THE HEIGHT OF BOUNDARY WALL EXCLUDING FENCE A TOP SHALL NOT BE MORE THAN 2500mm, ABOVE LEVEL OR FORMATION LEVEL.
27. NO. OF M.S. GRATING AND THEIR LOCATION TO BE INSTALLED IN BOUNDARY WALL ALONG WITH THE LEVELS SHALL BE DECIDED BY THE SITE AS/ THE SITE CONDITION KEEPING IN VIEW THE MAX. POSSIBLE CATCHMENT AREA FOR EACH GRATING.
28. ALL M.S. SECTION USED FOR GRATING SHALL BE PAINTED WITH TWO OR MORE COATS OF BLACK ANTICORROSIVE BITUMASTIC PAINT OF APPROVED BRAND AND MANUFACTURE OVER A PRIMING COAT OF APPROVED STEEL PRIMER.
29. TOP OF PLINTH BEAM SHALL BE REDUCED BY 100mm WHEREVER MS GRATING IS TO BE PROVIDED.

REF. DWG:-

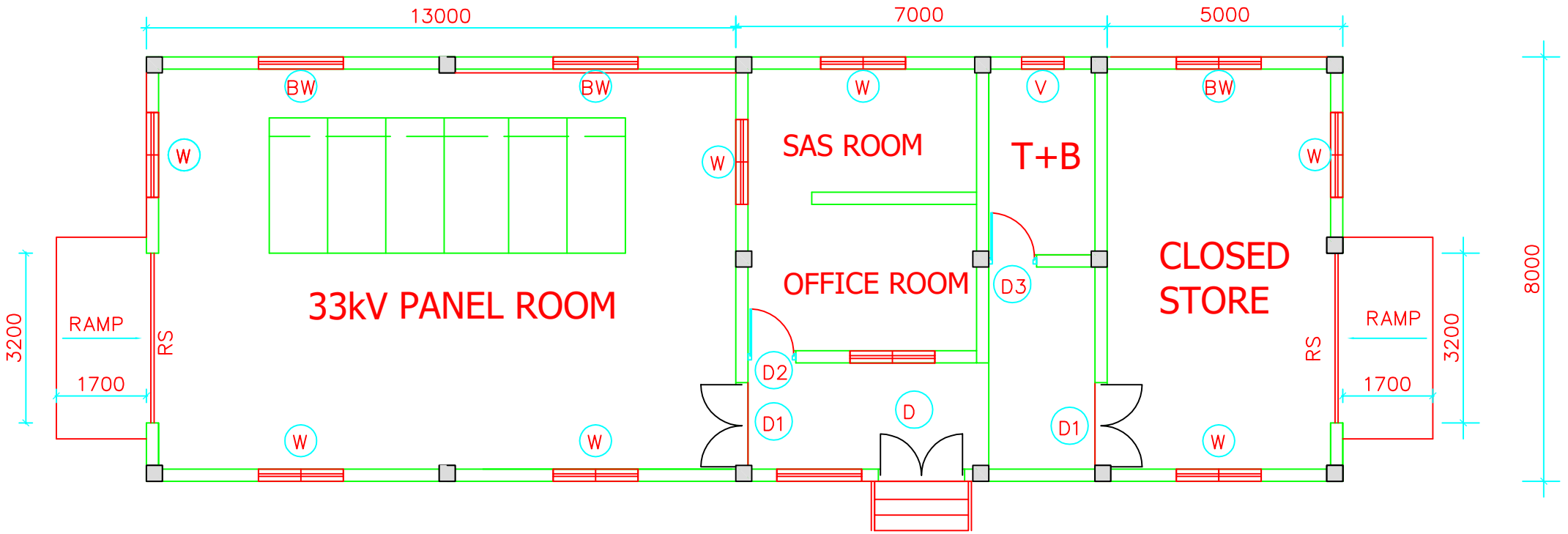
BOUNDARY WALL LAYOUT

TATA PROJECTS LIMITED

REV.	DATE	DESCRIPTION
R1	08.10.18	SECOND SUBMISSION
R0	04.10.18	APPROVED IN CAT-II (08.10.18)

CLIENT	NEPAL ELECTRICITY AUTHORITY (An Undertaking of Government of Nepal)
CONSULTANT	POWER GRID CORPORATION OF INDIA LIMITED (PGCIL)
CONTRACTOR	
PROJECT.	KALIGANDAKI TRANSMISSION CORRIDOR PROJECT (KGTCP) : PROCUREMENT OF PLANT FOR 220/132 kV NEW BUTWAL SUBSTATION CONTRACT NO. ICB- PMD -KGTCP- 073/74-03
DESCRIPTION	DETAIL OF BOUNDARY WALL WITH BARBED WIRE OF 220/132KV NEW BUTWAL (RAMNAGAR) SUB STATION

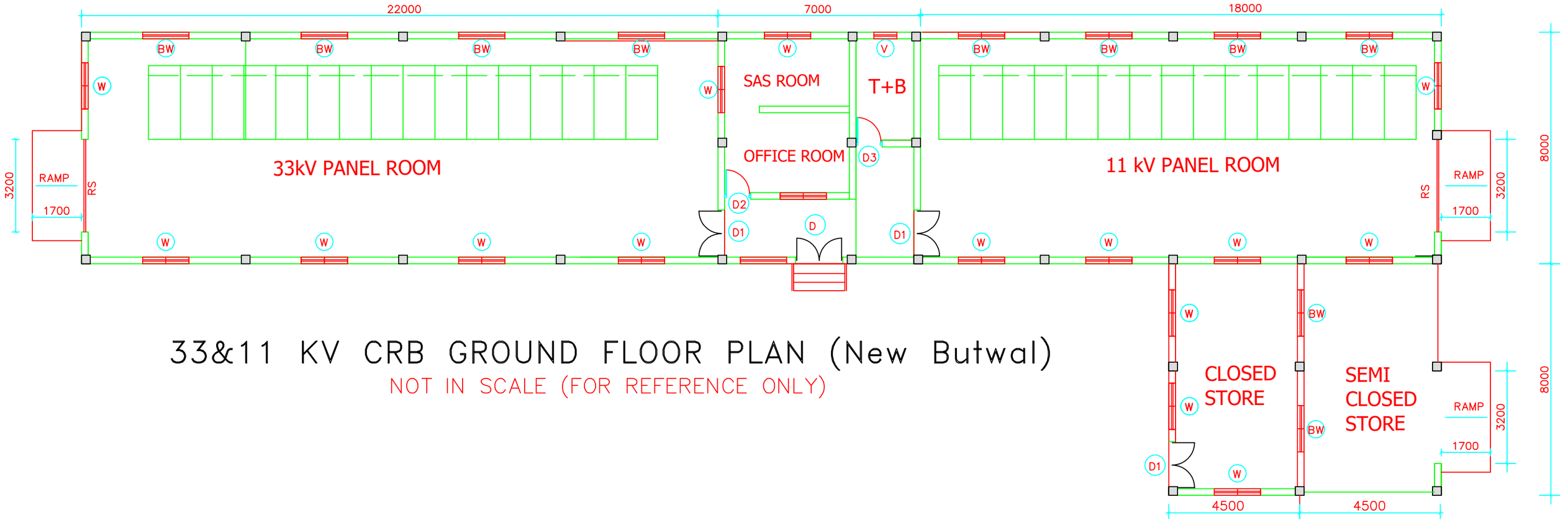
DRAWN BY.	S.K	DATE	08.10.2018	DRAWING No.	
CHECKED BY.	AIK	SCALE	NTS	TPL-NEA-BTW-CL-0521	
APPROVED BY.	VVS	SHEET NO.	1 OF 1	REV.	R1



33 kV CRB GROUND FLOOR PLAN (Kushma SS)

NOT IN SCALE (FOR REFERENCE ONLY)

NEPAL ELECTRICITY AUTHORITY
NEW BUTWAL & KUSHMA SUBSTATION EXPANSION PROJECT
33 KV SWITCHGEAR PANEL ROOM (CONTROL ROOM)
REFERENCE DRAWING

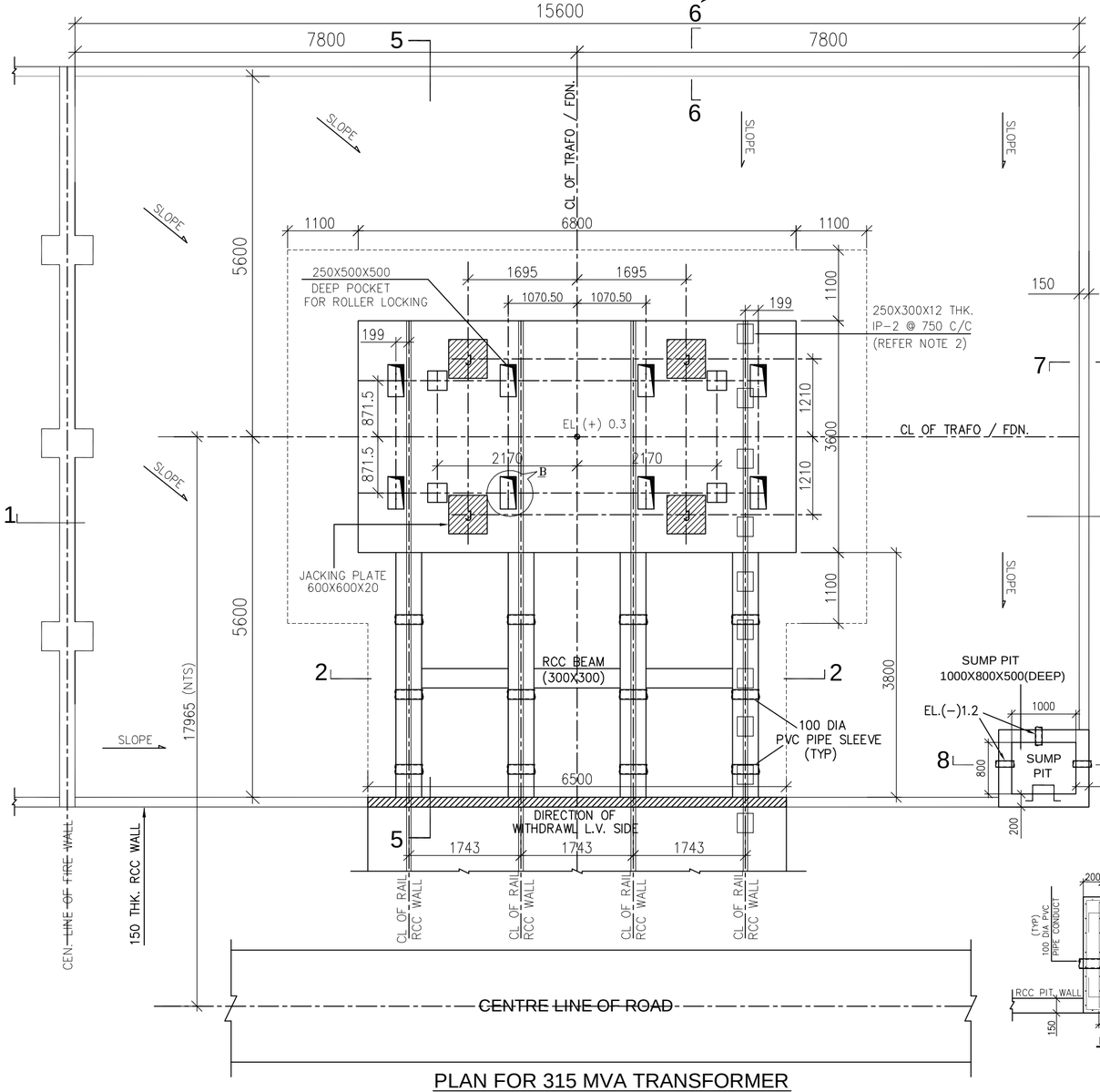


33&11 KV CRB GROUND FLOOR PLAN (New Butwal)

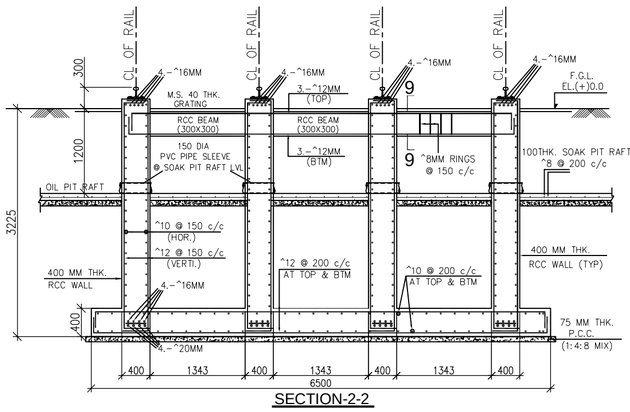
NOT IN SCALE (FOR REFERENCE ONLY)

NEPAL ELECTRICTY AUTHORITY
NEW BUTWAL & KUSHMA SUBSTATION PROJECT
33 & 11 KV SWITCHGEAR PANEL ROOM (CONTROL ROOM BUILDING)
REFERENCE DRAWING ONLY

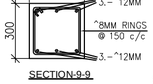
FOR SECTION 6-6 REFER DRG NO:-1TEIEA181160101



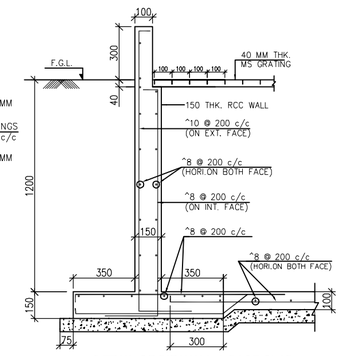
PLAN FOR 315 MVA TRANSFORMER



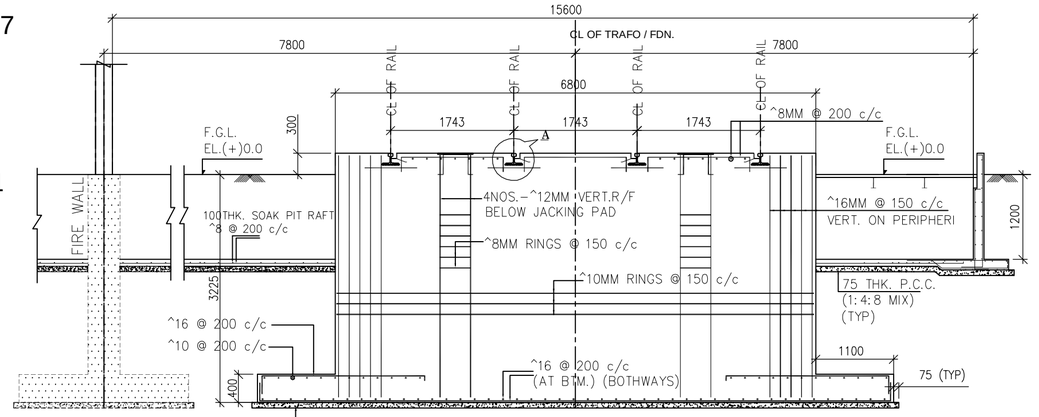
SECTION-2-2



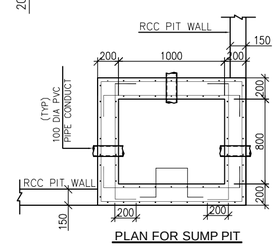
SECTION-9-9



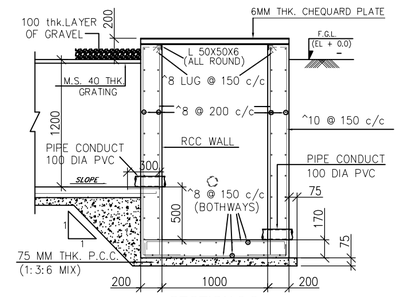
DETAIL OF PIT WALL & BASE SLAB
(SECTION-7-7)



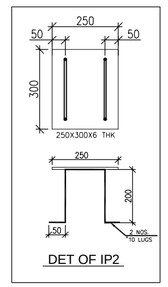
SECTION-1-1



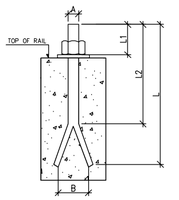
PLAN FOR SUMP PIT

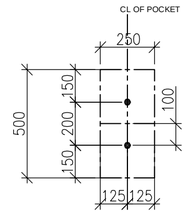


SECTION 8-8



DET OF IP2

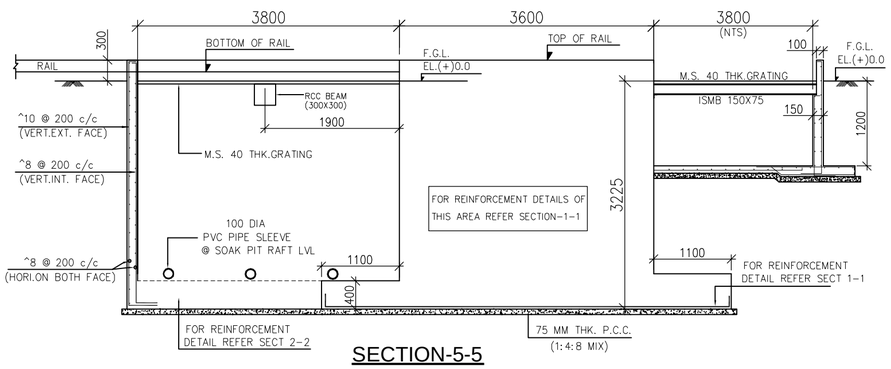




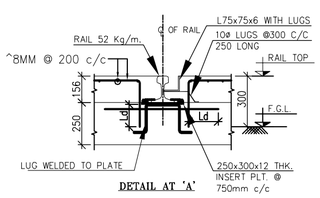
DETAIL -B
ROLLER LOCKING ARRANGEMENT

FOUNDATION BOLT DETAILS

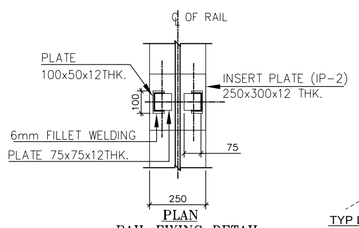
SR.NO	USED FOR	QTY	DIMENSIONS				
			A	B	L	L1	L2
A	ROLLER LOCKING	16	M24	70	380	70	280



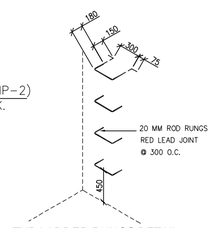
SECTION-5-5



DETAIL AT 'A'



PLAN
RAIL FIXING DETAIL



TYP LADDER RUNGS DETAIL

CK.

FOR TENDER PURPOSE ONLY

नेपाल विद्युत प्राधिकरण
NEPAL ELECTRICITY AUTHORITY
ESTD 1985

TABLE OF CONTENTS

TECHNICAL SCHEDULE FOR SUBSTATION EXPANSION

1.1 General

The bidder shall submit three (3) sets [One (1) original + Two (2) Copies] of filled up Technical Schedule along with the bid. Any alterations necessary due to errors etc. in the filled-up data shall be initiated by the bidder.

1.1.1 Type Test Report

Type test Reports, as specified in section-3 (Evaluation and Qualification Criteria) of Volume-I, shall be submitted along with the technical schedules.

1.2 Guaranteed Technical Particular for Power Transformer

1.2.1 Technical Particulars for 220/132/11 kV Power Transformer

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
Manufacturer's name			
Country of Origin			
Applicable Standard			
Years of Manufacturing Experience	Years	Minimum 7	
ISO Certificate Submitted			
Manufacturer's sales record submitted	Yes/No	Yes	
1. Service		Outdoor	
2. Type (Core or Shell)		Core	
3. Applicable Standard		IEC	
4. Number of winding per phase	No.	2	
5. Type of cooling		*ONAN/ONAF1*	
6. Rating			
a) Rated capacity			
- ONAN	MVA	189	
- ONAF1		315	
b) Rated voltage			
- Primary	kV	*220*	
- Secondary		*132*	
- Tertiary		*11*	

c) Rated frequency	Hz	50	
7. Noise level			
a) On ONAN rating	dB	*<73*	
c) On ONAF- rating	dB	*<75*	
8. Temperature rise			
a) Temperature rise above 40°C ambient			
-In oil by thermometer	deg.C	50	
-In winding by resistance	deg.C	55	
b) Hottest spot temperature in winding limited to	deg.C	55	
9. Connection			
a) High voltage		*star*	
b) Low voltage		*star*	
c) Tertiary Voltage		*Ungrounded delta*	
d) Vector group reference in accordance with IEC 60076		*YNaOd11*	
10. Magnitude of 3rd harmonics voltage as of fundamental frequency	%	*<2*	
11. Taps			
a) Type of tap changer		*ON-LOAD*	
b) Tap steps	No.	*12*	
c) Tap range	%	*+/- 10%*	
12. Cooling equipment (for ONAF1/ONAF2)			
a) Manufacturer and type			
b) Number of Fans	Nos.		
c) Rated power	kW		
d) Rated voltage	V, AC	230/400	
13. Cooling equipment (for ONAF2)			
a) Manufacturer and type			
b) Number of Fans	Nos.		
c) Rated power	kW		
d) Rated voltage	V, AC	230/400	
14. On-load tap changing gear & control-system			

a) Manufacturer and type		*MR Germany* *ABB Sweden or equivalent*	
b) Rating			
-Rated voltage	kV	*72*	
-Step voltage	V		
-Rated current (normal)	A	*150*	
-Number of steps	Nos.	*17*	
c) Control suitable for:			
-Remote/local operation		*Remote & local*	
-Auto/manual operation		*Auto & manual*	
-Parallel operation	Yes/No	*Yes*	
d) Rated voltage of drive motor	V, AC	*400/230*	
15. Guaranteed losses			
a) No-load loss at rated voltage and frequency on maximum MVA base	kW		
b) Load loss at rated current and 75 deg C on maximum MVA base	kW		
c) Cooler loss for full load operation on maximum MVA base	kW		
d) Total losses	kW		
16. Impedance at rated current and frequency at 75 deg.C winding temperature and normal tapping			
a) on maximum MVA base in ONAN	%	11.7	
b) on maximum MVA base in ONAF	%	11.7	
17. Efficiency at 75 deg.C winding Temperature at PF=0.9			
a) At 100 % load	%		
b) At 75 % load	%		
c) At 50 % load	%	Above 99%	
18. No load current in % of rated current referred to HV side & 50Hz			
a) At 90 % rated voltage	%		
b) At 100 % rated voltage	%		

c) At 110 % rated voltage	%		
19. Minimum clearance in air HV/LV			
-Between phases	mm		
-Between phase and ground	mm		
20. Insulation level			
a) Power frequency withstand voltage (1 min. rms)			
-Primary	kV	*395*	
-Secondary	kV	*230*	
-Tertiary	kV	*95*	
b) Impulse withstand			
-Primary	kV	*950 (crest)*	
-Secondary	kV	*550 (crest)*	
-Tertiary	kV	*250 (crest)*	
22. Detail of oil preservation system			
a) Type of oil preservation system furnished	type	Conservator type	
b) If conservator type, urethane air cell provided	Yes/No	Yes	
21. Minimum pressure of pressure relief device set to operate at	kg/cm2		
22. Details of bushings HV/LV/HV neutral			
a) Manufacturer / Model No.			
b) Type			
c) Voltage class	kV	*245/145/12*	
d) Creepage distance	mm	4650/1300/1300	
e) Reference standard		*IEC*	
f) Dry flash over voltage	kV		
g) Wet flash over voltage	kV		
h) Impulse withstand voltage	kV peak	*1050/650*	
23. Insulating oil			

a) Approximate volume of oil	liter		
b) Whether first fill of oil with 5 % excess furnished	Yes/No	Yes	
24. Bushing current transformer			
a) Type			
b) Voltage class (HV/LV)	kV/kV	*245/145*	
c) Number of cores			
-HV	No.	*1*	
-LV	No.	*1*	
-HV Neutral	No.	*1*	
-LV Neutral	No.	*2*	
d) Ratio			
-HV (phase)	A		
-HV (Neutral)	A		
-LV (phase)	A		
- LV (Neutral)	A		
e) Accuracy class		5P20	
25.Lightning arresters mounted on			
a) HV side	Yes/No	*No*	
b) LV side	Yes/No	Yes	
26. Approximate overall dimension (L * W * H)	mm		
27. Approximate weight			
a) Core and coils	kg		
b) Tank and fittings	kg		
c) Oil	kg		
d) Total weight	kg		
28. Delivery of equipment in month following award of contract (Allowing time for approval of drawings)	months		

1.2.2 Technical Particular for 132/33kV Power Transformer

DESCRIPTION	UNIT	REQUIREMENT		OFFERED DATA
Manufacturer's name				
Country of Origin				
Applicable Standard				
Years of Manufacturing Experience	Years	Minimum 7		
ISO Certificate Submitted				
Manufacturer's sales record submitted	Yes/No	Yes		
1. Service		Outdoor		
2. Type (Core or Shell)		Core		
3. Applicable Standard		IEC		
4. Number of winding per phase	No.	2		
5. Type of cooling		*ONAN/ONAF1/ONAF2*		
6. Rating				
a) Rated capacity				
- ONAN		40	20	
- ONAF1	MVA	51.5	24	
- ONAF2		63	30	
b) Rated voltage				
- Primary	kV	*132*		
-Secondary		*33*		
c) Rated frequency	Hz	50		
7. Noise level				
a) On ONAN rating	dB	*<73*		
c) On ONAF- rating	dB	*<75*		
8. Temperature rise				
a) Temperature rise above 40^{o}C ambient				
-In oil by thermometer	deg.C	50		
-In winding by resistance	deg.C	55		

b) Hottest spot temperature in winding limited to	deg.C	55	
9. Connection			
a) High voltage		*star*	
b) Low voltage		*star*	
c) Vector group reference in accordance with IEC 60076		*YNyn0*	
10. Magnitude of 3rd harmonics voltage as of fundamental frequency	%	<2	
11. Taps			
a) Type of tap changer		*ON-LOAD*	
b) Tap steps	No.	*17*	
c) Tap range	%	*+/- 10%*	
12. Cooling equipment (for ONAF1)			
a) Manufacturer and type			
b) Number of Fans	Nos.		
c) Rated power	kW		
d) Rated voltage	V, AC	230/400	
13. Cooling equipment (for ONAF2)			
a) Manufacturer and type			
b) Number of Fans	Nos.		
c) Rated power	kW		
d) Rated voltage	V, AC	230/400	
14. On-load tap changing gear & control-system			
b) Manufacturer and type		*MR Germany* *ABB Sweden or equivalent*	
b) Rating			
-Rated voltage	kV	*72*	
-Step voltage	V		
-Rated current (normal)	A	*150*	
-Number of steps	Nos.	*17*	
c) Control suitable for:			
-Remote/local operation		*Remote & local*	

-Auto/manual operation		*Auto & manual*	
-Parallel operation	Yes/No	*Yes*	
d) Rated voltage of drive motor	V, AC	*400/230*	
15. Guaranteed losses			
c) No-load loss at rated voltage and frequency on maximum MVA base d) Load loss at rated current and 75 deg C on maximum MVA base c) Cooler loss for full load operation on maximum MVA base	kW kW kW		
d) Total losses	kW		
16. Impedance at rated current and frequency at 75 deg.C winding temperature and normal tapping			
a) on maximum MVA base in ONAN	%		
b) on maximum MVA base in ONAF	%	11	
17. Efficiency at 75 deg.C winding Temperature at PF=0.9			
a) At 100 % load	%		
b) At 75 % load	%		
c) At 50 % load	%	Above 99%	
18. No load current in % of rated current referred to HV side & 50Hz			
a) At 90 % rated voltage	%		
b) At 100 % rated voltage	%		
c) At 110 % rated voltage	%		
19. Minimum clearance in air HV/LV			
-Between phases	mm		
-Between phase and ground	mm		
20. Insulation level			
a) Power frequency withstand voltage (1 min. rms)			
-Primary	kV	*325*	
-Secondary	kV	*95*	

b) Impulse withstand			
-Primary	kV	*750 (crest)*	
-Secondary	kV	*250 (crest)*	
22. Detail of oil preservation system			
a) Type of oil preservation system furnished	type	Conservator type	
b) If conservator type, urethane air cell provided	Yes/No	Yes	
21. Minimum pressure of pressure relief device set to operate at	kg/cm2		
22. Details of bushings HV/LV/ HV neutral			
a) Manufacturer / Model No.			
b) Type			
c) Voltage class	kV	*145/36/36*	
d) Creepage distance	mm	4650/1300/1300	
e) Reference standard		*IEC*	
f) Dry flash over voltage	kV		
g) Wet flash over voltage	kV		
h) Impulse withstand voltage	kV peak	*750/250*	
23. Insulating oil			
a) Approximate volume of oil	liter		
b) Whether first fill of oil with 5 % excess furnished	Yes/No	Yes	
24. Bushing current transformer			
a) Type			
b) Voltage class (HV/LV)	kV/kV	*132/33*	
c) Number of cores			
-HV	No.	*1*	
-LV	No.	*1*	
-HV Neutral	No.	*1*	
-LV Neutral	No.	*2*	

d) Ratio			
-HV (phase)	A		
-HV (Neutral)	A		
-LV (phase)	A		
- LV (Neutral)	A		
e) Accuracy class		5P20	
25.Lightning arresters mounted on			
a) HV side	Yes/No	*No*	
b) LV side	Yes/No	Yes	
26. Approximate overall dimension (L * W * H)	mm		
27. Approximate weight			
a) Core and coils	kg		
b) Tank and fittings	kg		
c) Oil	kg		
d) Total weight	kg		
28. Delivery of equipment in month following award of contract (Allowing time for approval of drawings)	months		

1.2.3 Technical Particular for 33/11kV Distribution Transformer

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
Manufacturer's name			
Country of Origin			
Applicable Standard		IEC	
Years of Manufacturing Experience	Years	Minimum 7	
ISO Certificate Submitted			
Manufacturer's sales record submitted	Yes/No	Yes	
1. Service		Outdoor	
2. Type (Core or Shell)		Core	
3. Applicable Standard		IEC	
4. Number of winding per phase	No.	2	
5. Type of cooling		*ONAN/ONAF*	
6. Rating			
a) Rated capacity			
- ONAN	MVA	20	
- ONAF		24	
b) Rated voltage			
- Primary	kV	*33*	
- Secondary		*11*	
c) Rated frequency	Hz	50	
7. Noise level			
a) On ONAN rating	dB	*<73*	
c) On ONAF- rating	dB	*<75*	
8. Temperature rise			
a) Temperature rise above 50°C ambient			
- Top oil measured by thermometer	deg.C	50	
- Average winding measured by	deg.C	55	

resistance method			
b) Hottest spot temperature in winding limited to	deg.C	55	
9. Connection			
a) High voltage		*delta*	
b) Low voltage		*star*	
c) Vector group reference in accordance with IEC 60076		*Dyn11*	
10. Magnitude of 3rd harmonics voltage as of fundamental frequency	%	<2	
11. Taps			
a) Type of tap changer		*ON-LOAD*	
b) Tap steps	No.	*17*	
c) Tap range	%	*+/- 10%*	
12. Cooling equipment (for ONAF)			
a) Manufacturer and type			
b) Number of Fans	Nos.		
c) Rated power	kW		
d) Rated voltage	V, AC	230/400	
15. On-load tap changing gear & control-system			
c) Manufacturer and type		*MR Germany* *ABB Sweden or Equivalent*	
b) Rating			
-Rated voltage	kV		
-Step voltage	V		
-Rated current (normal)	A		
-Number of steps	Nos.		
c) Control suitable for:			
-Remote/local operation		*Remote & local*	
-Auto/manual operation		*Auto & manual*	
-Parallel operation	Yes/No	*Yes*	

d) Rated voltage of drive motor	V, AC	*400/230*	
16. Guaranteed losses			
e) No-load loss at rated voltage and frequency on maximum MVA base	kW		
f) Load loss at rated current and 75 deg.C on maximum MVA base	kW		
c) Cooler loss for full load operation on maximum MVA base	kW		
d) Total losses	kW		
17. Impedance at rated current and frequency at 75 deg.C winding temperature and normal tapping			
a) on maximum MVA base in ONAN	%		
b) on maximum MVA base in ONAF	%	8	
18. Efficiency at 75 deg.C winding Temperature at PF=0.9			
a) At 100 % load	%		
b) At 75 % load	%		
c) At 50 % load	%	Above 99%	
19. No load current in % of rated current referred to HV side & 50Hz			
a) At 90 % rated voltage	%		
b) At 100 % rated voltage	%	<1	
c) At 110 % rated voltage	%		
20. Minimum clearance in air HV/LV			
-Between phases	mm		
-Between phase and ground	mm		
21. Insulation level			
a) Power frequency withstand voltage (1 min. rms)			
-Primary	kV	*95*	
-Secondary	kV	*28*	
b) Impulse withstand			
-Primary	kV	*250 (crest)*	

-Secondary	kV	*95 (crest)*	
22. Detail of oil preservation system			
a) Type of oil preservation system furnished	type	Conservator type	
b) If conservator type, urethane air cell provided	Yes/No	Yes	
23. Minimum pressure of pressure relief device set to operate at	kg/cm2		
24. Details of bushings HV/LV/LV HV neutral			
a) Manufacturer / Model No.			
b) Type			
c) Voltage class	kV	*36/12/36*	
d) Creepage distance	mm	900/900	
e) Reference standard		*IEC*	
f) Dry flash over voltage	kV		
g) Wet flash over voltage	kV		
h) Impulse withstand voltage	kV peak		
25. Insulating oil			
a) Approximate volume of oil	liter		
b) Whether first fill of oil with 5 % excess furnished	Yes/No	Yes	
26. Bushing current transformer			
a) Type			
b) Voltage class (HV/LV)	kV/kV	*33/11*	
c) Number of cores			
-HV	No.	*1*	
-LV	No.	*1*	
-HV Neutral	No.	*1*	
-LV Neutral	No.	*2*	
d) Ratio			
-HV (phase)	A		

-HV (Neutral) -LV (phase) - LV (Neutral)	A A A		
e) Accuracy class		5P20	
27.Lightning arresters mounted on			
a) HV side	Yes/No	*No*	
b) LV side	Yes/No	Yes	
28. Approximate overall dimension (L * W * H)	mm		
29. Approximate weight			
a) Core and coils	kg		
b) Tank and fittings	kg		
c) Oil	kg		
d) Total weight	kg		
30.Delivery of equipment in month following award of contract (Allowing time for approval of drawings)	months		

1.2.4 Technical Particulars of Insulating oil for Transformers

Sr. No.	Characteristics	Specification	*To be filled by bidder*
1.	Electric Strength (BDV)	60 kV (min)	
2.	Dielectric dissipation factor	0.01 (Max.) (Ten Delta)	
3.	Specific resistance (Resistivity)	1500x10*12 (Min.) at 27^0C (ohm-cm)	
4.	Flash point Pensky-Mortion	1400C (Min.) (Closed)	
5.	Inter facial tension at 270C	0.04 N/m (Min.)	
6.	Total activity	0.04 mg koh/gm (Max.)	
7.	Water Content	50 (Max)	

Deviations from technical requirements and reasons for such deviations:

Signed: .....

As Representative for: .....

Address: .....

Date: .....

1.3 Guaranteed technical particular for circuit breakers

1.3.1 Technical Particulars of 245 kV SF6 Circuit Breaker

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
Manufacturer's name			
Country of Origin			
Applicable Standard			
Years of Manufacturing Experience	Years	Minimum 7	
ISO Certificate Submitted			
Manufacturer's sales record submitted	Yes/No	Yes	
1. Manufacturer's designation as per submitted catalogue/ Model No.		To be furnished	
2. Applicable standard		IEC	
3. Type / Class		SF6 / outdoor	
4. Poles	No.	3	
5. Local and remote operations		Both Required	
6. Rated maximum voltage	kV	245	
7. Rated current	A		
a) Normal current	A	3150	
b) Short time for 1 sec	kA	*40*	
8. Frequency	Hz	50	
9. Insulation level			
a) Impulse withstand voltage	kV	1050(crest)	
b) Power frequency withstand Voltage (1 min, rms)	kV	460	
10. Rated short circuit breaking current	kA	40/50	
11.Rated short circuit making current	kAp	100/125	
12.Interrupting time at 100% capacity			
a) Max. opening time	ms		
b) Total interrupting time	ms	60	
13. Closing time	ms		
14. Make Time	ms	120	
15. Rated a. Line-charging breaking current	A		

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
16. First pole to clear factor		1.3	
17. Operating mechanism			
a) Type		Spring operated	
b) Number of mechanisms per breaker set		3 for Line CB 1 for BC & Transformer CB	
c) single/three phase auto reclosure			
d) enclosure protection		IP55W	
e) Nominal Operating voltage of Closing/ Tripping coil	V, DC	220	
f) Operating voltage range	% of rated voltage		
- Closing		85-110%	
- Tripping		70-110%	
g) Spring charging Motor rating			
- Capacity	kW		
- Rated voltage	V	220 V, DC	
h) Time required by motor to charge the spring completely	Sec	30	
18. Push button for local operation	Yes/No	Yes	
19. Selection switch for local/ remote control	Yes/No	Yes	
20. Anti-pumping device provided	Yes/No	Yes	
21. Trip-free feature provided	Yes/No	Yes	
22. Gas density detector provided	Yes/No	Yes	
23. Operation counter provided	Yes/No	Yes	
24. Space heater provided for cubicle	Yes/No	Yes	
25. Operating duty cycle		O-0.3 sec-CO-3 min-CO	
26.Thickness of sheet steel of cubicle	mm	min 2	
27. Number of Auxiliary Contacts	No.	5 NO, 5 NC	

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
28. Number of possible operations without maintenance :			
for contacts			
- Rated short circuit breaking current	No.	Not less than 10	
- Rated normal current	No.	Not less than 2,000	
- for mechanism	No.	Not less than 2,000	
29. Rated SF6 gas pressure	kgf/cm^2		
30. Guaranteed SF6 gas loss per annum	% / annum	<0.1	
31. Porcelain insulator			
a) Manufacturer			
b) Creepage distance	mm	6125	
32. Padlocking provision for local cubicle	Yes/No	Yes	
33. Gas pressure gauge provided	Yes/No	Yes	
34. Total weight of circuit breaker	kg		

1.3.2 Technical Particulars of 132 kV SF6 Circuit Breaker

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
Manufacturer's name			
Country of Origin			
Applicable Standard			
Years of Manufacturing Experience	Years	Minimum 7	
ISO Certificate Submitted			
Manufacturer's sales record submitted	Yes/No	Yes	
1. Manufacturer's designation as per submitted catalogue/ Model No.		To be furnished	
2. Applicable standard		IEC	
3. Type / Class		SF6 / outdoor	
4. Poles	No.	3	
5. Local and remote operations		Both Required	
6. Rated maximum voltage	kV	145	
7. Rated current	A		
a) Normal current	A	1600/2500	
b) Short time for 1 sec	kA	*31.5*	
8. Frequency	Hz	50	
9. Insulation level			
a) Impulse withstand voltage	kV	650(crest)	
b) Power frequency withstand voltage (1 min, rms)	kV	275	
10. Rated short circuit breaking current	kA	31.5	
11.Rated short circuit making current	kAp		
12.Interrupting time at 100% capacity			
a) Max. opening time	ms		
b) Total interrupting time	ms	60	
13. Closing time	ms		
14. Make Time	ms	120	
15. Rated a. Line-charging breaking current	A		
16. First pole to clear factor		1.3	

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
17. Operating mechanism			
a) Type		Spring operated	
b) Number of mechanisms per breaker set		3 for Line CB 1 for BC & Transformer CB	
c) single/three phase auto reclosure		*Single for 132 kV line*	
d) enclosure protection		IP55W	
e) Nominal Operating voltage of Closing/ Tripping coil	V, DC	110	
f) Operating voltage range - Closing - Tripping	% of rated voltage	 85-110% 70-110%	
g) Spring charging Motor rating			
- Capacity	kW		
- Rated voltage	V	220 V, DC	
h) Time required by motor to charge the spring completely	Sec	30	
18. Push button for local operation	Yes/No	Yes	
19. Selection switch for local/ remote control	Yes/No	Yes	
20. Anti-pumping device provided	Yes/No	Yes	
21. Trip-free feature provided	Yes/No	Yes	
22. Gas density detector provided	Yes/No	Yes	
23. Operation counter provided	Yes/No	Yes	
24. Space heater provided for cubicle	Yes/No	Yes	
25. Operating duty cycle		O-0.3 sec-CO-3 min-CO	
26.Thickness of sheet steel of cubicle	mm	min 2	
27. Number of Auxiliary Contacts	No.	5NO, 5NC	

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
28. Number of possible operations without maintenance :			
for contacts			
- Rated short circuit breaking current	No.	Not less than 10	
- Rated normal current	No.	Not less than 2,000	
- for mechanism	No.	Not less than 2,000	
29. Rated SF6 gas pressure	kgf/cm^2		
30. Guaranteed SF6 gas loss per annum	% / annum	<0.1	
31. Porcelain insulator			
a) Manufacturer			
b) Creepage distance	mm	3625	
32. Padlocking provision for local cubicle	Yes/No	Yes	
33. Gas pressure gauge provided	Yes/No	Yes	
34. Total weight of circuit breaker	kg		

Deviations from technical requirements and reasons for such deviations:

Signed: .....

As Representative for: .....

Address: .....

Date: .....

1.4 Guaranteed Technical particular for disconnecting switches

1.4.1 Technical Particulars of 245 kV Disconnecting Switch with & Without Grounding Switch

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
Manufacturer's name			
Country of Origin			
Applicable Standard			
Years of Manufacturing Experience	Years	Minimum 7	
ISO Certificate Submitted			
Manufacturer's sales record submitted	Yes/No	Yes	
1. Manufacturer's designation as per submitted catalogue / Model no.		To be furnished	
2. Applicable standard		IEC	
3. Type		3-Pole; Double break	
4. Local and remote both operations		Required	
5. Frequency	Hz	50	
6. Rated maximum voltage	kV	*245*	
7. Rated current			
a) Normal current	A	*1600*	
b) Short time for 1 sec	kA	*40*	
8. Insulation level			
a) Impulse withstand voltage	kV crest	1050	
b) Power frequency withstand voltage (1 min, rms)	kV	460	
9. Maximum current the switch can safely interrupt			
a. Bus/line charging current	A	0.5 min	
b. Potential transformer magnetizing current	A	0.5 min	
10. Clearance			
a. Between live parts and ground	mm		
b. Between fixed contact and blade in open position	mm		
11. Main contacts			
- Material of contacts		copper alloy	

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
- Coating of contacts		Silver plated	
- Material of the contacts of the earthing switch		copper alloy	
- Coating of the contacts of the earthing switch		silver plated	
12. Material of terminals			
13. Coating of terminals			
14. Operating mechanism		*Electrical & Manual*	
15. Local operating device provided	Yes/No	Yes	
16. Auxiliary contacts			
a) Type (convertible or fixed)		convertible	
b) Continuous current rating at 110V DC	A		
c) Material		Copper	
d) Contacts silver-plated?	Yes/No	Yes	
17. No of operations switch can withstand without deterioration of contacts	Nos.		
18. Type of interlocks furnished:		Electrical & Mechanical	
19. Are the disconnectors and the earthing switches mechanically interlocked to each other	Yes/No	Yes	
20. Weight of disconnecting switch	kg		
21. Auxiliary power supply			
a) DS operating motor supply voltage	V/ Phase	400V / 3Ph	
b) DS operating motor power	WT		
c) Space heater and cubicle	V/ Phase	230V / 1Ph	
d) Control circuit	V	220V, DC	
22. Insulator			
a) Manufacturer			
b) Creepage distance in air	mm	6125	
23. Number of NC. Contacts (minimum)	No.	8	

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
24. Number of NO. contacts (minimum)	No.	8	
25. Enclosure protection		IP-55W	
26. Thickness of sheet (minimum)	mm	2	
27. Earthing switch			
a) Operating mechanism		Manual	
b) Type of interlocks furnished		Electrical & Mechanical	
28. Number of NC. Contacts (minimum)	No.	3	
29. Number of NO. contacts (minimum)	No.	3	
30. Weight of earthing switch	kg		
31. Delivery of equipment in months following award of contract. (Allowing time for approval of drawing.)	month		

1.4.2 Technical Particulars of 132 kV Disconnecting Switch with & Without Grounding Switch

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
Manufacturer's name			
Country of Origin			
Applicable Standard			
Years of Manufacturing Experience	Years	Minimum 7	
ISO Certificate Submitted			
Manufacturer's sales record submitted	Yes/No	Yes	
1. Manufacturer's designation as per submitted catalogue / Model no.		To be furnished	
2. Applicable standard		IEC	
3. Type		3-Pole; Double break	
4. Local and remote both operations		Required	
5. Frequency	Hz	50	
6. Rated maximum voltage	kV	*145*	
7. Rated current			
a) Normal current	A	*1600/2500*	
b) Short time for 1 sec	kA	*31.5*	
8. Insulation level			
a) Impulse withstand voltage	kV crest	650	
b) Power frequency withstand voltage (1 min, rms)	kV	275	
9. Maximum current the switch can safely interrupt			
a. Bus/line charging current	A	0.5 min	
b. Potential transformer magnetizing current	A	0.5 min	
10. Clearance			
a. Between live parts and ground	mm		
b. Between fixed contact and blade in open position	mm		
11. Main contacts			
- Material of contacts		copper alloy	
- Coating of contacts		Silver plated	

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
- Material of the contacts of the earthing switch		copper alloy	
- Coating of the contacts of the earthing switch		silver plated	
12. Material of terminals			
13. Coating of terminals			
14. Operating mechanism		*Electrical & Manual*	
15. Local operating device provided	Yes/No	Yes	
16. Auxiliary contacts			
a) Type (convertible or fixed)		convertible	
b) Continuous current rating at 110V DC	A		
c) Material		Copper	
d) Contacts silver-plated?	Yes/No	Yes	
17. No of operations switch can withstand without deterioration of contacts	Nos.		
18. Type of interlocks furnished:		Electrical & Mechanical	
19. Are the disconnectors and the earthing switches mechanically interlocked to each other	Yes/No	Yes	
20. Weight of disconnecting switch	kg		
21. Auxiliary power supply			
a) DS operating motor supply voltage	V/ Phase	400V / 3Ph	
b) DS operating motor power	WT		
c) Space heater and cubicle	V/ Phase	230V / 1Ph	
d) Control circuit	V	220V, DC	
22. Insulator			
a) Manufacturer			
b) Creepage distance in air	mm	3625	
23. Number of NC. Contacts (minimum)	No.	8	
24. Number of NO. contacts (minimum)	No.	8	

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
25. Enclosure protection		IP-55W	
26. Thickness of sheet (minimum)	mm	2	
27. Earthing switch			
a) Operating mechanism		Manual	
b) Type of interlocks furnished		Electrical & Mechanical	
28. Number of NC. Contacts (minimum)	No.	3	
29. Number of NO. contacts (minimum)	No.	3	
30. Weight of earthing switch	kg		
31. Delivery of equipment in months following award of contract. (Allowing time for approval of drawing.)	month		

1.5 Guaranteed Technical Particular For instrument transformer

1.5.1 Technical Particulars of 245 kV Current Transformer

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
Manufacturer's name			
Country of Origin			
Applicable Standard			
Years of Manufacturing Experience	Years	Minimum 7	
ISO Certificate Submitted			
Manufacturer's sales record submitted	Yes/No	Yes	
1. Manufacturer's designation as per submitted catalogue / Model No.		To be furnished	
2. Applicable standard		IEC	
3. Type		*outdoor* *oil immersed*	
4. Number of phases	No.	single	
5. Number of cores in each CT	No.	*5*	
6. Frequency	Hz	50	
7. Rated Primary Voltage	kV	220	
8. Insulation level			
a) Impulse withstand voltage	kV,(crest)	650	
b) Power frequency withstand voltage (1 min. rms)	kV	275	
19. Rated peak withstand current	kA		
10. Creepage distance	mm		
11. Short time thermal rating (1 Sec)	kA	40	
12. Ratings			
13. Current ratio	A	*1600 A with 120 % extended current rating*	
14. Rated VA burden for each core	VA	30	
15. Accuracy class / No. of Cores		5P20 – 2 Nos. *CL:X – 2 Nos.* for protection & CL:0.2 - 1 Nos. for metering	
16. Dimension (L x W x H)	mm		

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
17. Weight	kg		
18. Delivery of equipment in months following award of contract (Allowing time for approval of drawings.)	month		

1.5.2 Technical Particulars of 145 kV Current Transformer

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
Manufacturer's name			
Country of Origin			
Applicable Standard			
Years of Manufacturing Experience	Years	Minimum 7	
ISO Certificate Submitted			
Manufacturer's sales record submitted	Yes/No	Yes	
1. Manufacturer's designation as per submitted catalogue / Model No.		To be furnished	
2. Applicable standard		IEC	
3. Type		*outdoor* *oil immersed*	
4. Number of phases	No.	single	
5. Number of cores in each CT	No.	*5*	
6. Frequency	Hz	50	
7. Rated Primary Voltage	kV	145	
8. Insulation level			
a) Impulse withstand voltage	kV,(crest)	650	
b) Power frequency withstand voltage (1 min. rms)	kV	275	
19. Rated peak withstand current	kA		
10. Creepage distance	mm		
11. Short time thermal rating (1 Sec)	kA	25	
12. Ratings			
13. Current ratio	A	*800/1600 A with 120 % extended current rating*	
14. Rated VA burden for each core	VA	30	
15. Accuracy class / No. of Cores		5P20 – 2 Nos. *CL:X – 2 Nos.* for protection & CL:0.2 - 1 Nos. for metering	
16. Dimension (L x W x H)	mm		
17. Weight	kg		

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
18. Delivery of equipment in months following award of contract (Allowing time for approval of drawings.)	month		

1.6 Guaranteed Technical Particular for Lightning Arresters

1.6.1 Technical Particulars of 216 kV Lightning Arrester

DESCRIPTION	UNIT	REQUIREMENT	OFFERED DATA
Manufacturer's name			
Country of Origin			
Applicable Standard			
Years of Manufacturing Experience	Years	Minimum 7	
ISO Certificate Submitted			
Manufacturer's sales record submitted	Yes/No	Yes	
1. Manufacturer's designation as per submitted catalogue / Model No.		To be furnished	
2. Applicable standard		IEC	
3. Type		Gap less metal – oxide / Outdoor	
4. Rated voltage rating of L.A.	kV	216	
5. Impulse withstand voltage, (crest)	kV	1050	
6. Power frequency withstand voltage	kV	460	
7. Rated frequency	Hz	50	
8. Nominal discharge current	kA	10	
9. Surge counter with insulating base furnished?	Yes/No	Yes	
10. Leakage current measuring instrument furnished?	Yes/No	Yes	
11. Porcelain creepage distance	mm	6125	
12. Line terminal with accessories provided	Yes/No	Yes	
13. Earth terminal with accessories provided	Yes/No	Yes	
14. Has manufacturer exported such units?	Yes/No	Yes	

1.7 Technical particular for 220 kV Transformer Control & Relay Panels with SAS

DESCRIPTION	UNIT	REQD. Transformer Panel	Offered Transformer Panel
Manufacturer's name			
Country of Origin			
Applicable Standard			
Years of Manufacturing Experience	Years	Minimum 7	
ISO Certificate Submitted			
Manufacturer's sales record submitted	Yes/No	Yes	
1. Type (simplex/duplex)			
2. Applicable standard		IEC	
3. Control panels furnished as per specification?	Yes/No	Yes	
4. Enclosure protection class	IP	IP 43	
5. Thickness of sheet metal used			
a)Front and rear portion	mm	>=3	
b) Side, top & bottom covers	mm	>=2	
c) Doors	mm	>=3	
6. All instruments, meters, relays and control switches flush or semi-flush type?		flush type	
7. Ground bus			
a)Material		copper	
b) Size	mm x mm	25 x 6	
8. Overall dimension of control boards (LxWxH)	mm		
9. Shipping data			
a)Size of the large package (LxWxH)	mm		
b) Weight of the heaviest package	Kg		
10. Delivery of equipment in months following award of contract. (Allowing time for approval of drawing)	month		
11.Indicating Instruments			
a) Ammeter			
Manufacturer's designation / Model No.			
Type			

DESCRIPTION	UNIT	REQD. Transformer Panel	Offered Transformer Panel
Accuracy class		0.5	
Scale			
- Type of scale	linear / non-linear		
- Range of indication (...../1 A CT operated)	A		
b) Voltmeter			
Manufacturer's designation / Model No.			
Type			
Accuracy class			
Scale			
- Range of indication	kV		
- Linear / non-linear			
c) Active power meter			
Manufacturer's designation / Model No.			
Type			
Manufacturer's type designation			
Applicable standard		IEC	
Rated voltage	kV	*220/√3:* *0.11/√3*	
Rated current	A		
Current range (Transducer operation)	mA		
Accuracy class			
Scale			
- Type		*Digital*	
- Range of indication	MW	*0-30* *0-60*	
- Linear / non-linear			
d) Frequency meter		-	
Manufacturer's designation / Model No.		-	

DESCRIPTION	UNIT	REQD. Transformer Panel	Offered Transformer Panel
Range of indication	Hz	-	
e) Energy Meter			
Manufacturer / Model No.			
Type		electronic 3- ph, 4 wire	
Applicable standard		IEC	
Class of accuracy		*0.2*	
Import and export meter provided	Yes/No	*Yes*	
Rated voltage	kV	*220/√3:* *0.11/√3*	
Rated current	A		
VA burden	VA		
f) ANNUNCIATORS			
Manufacturer's designation / Model No.			
Type		numeric	
Number of inputs (annunciator /event)			
Number of active points	No.	24	
Number of rows	No.	3	
Number of columns	No.	8	
Type of mounting		flush	
Replacement of individual inscription plates and lamps from front panel possible?	Yes/No	Yes	
Sequence of operation as per specifications	Yes/No	Yes	
g) PHASE OVERCURRENT RELAYS: (Directional & Non-directional)			
Manufacturer's designation / Model No.			
Type		*numeric*	
Applicable standards		*IEC*	
Triple pole or single pole		*Triple pole*	
Continuous overload capacity	x In		

DESCRIPTION	UNIT	REQD. Transformer Panel	Offered Transformer Panel
Current setting range	% of rated current	*20 - 200%*	
Operating time at 10 times current setting	sec	3	
Reset time	ms		
Characteristics - IDMT(standard inverse) - IDMT(very inverse) - IDMT(extremely inverse) - Definite time			
Instantaneous unit provided	Yes/No	Yes	
- Current setting range	% of rated current		
Operating time	ms		
h) GROUND OVER CURRENT RELAYS (Directional & Non-directional)			
Manufacturer's designation / Model No.			
Type		numeric	
Applicable standards		IEC	
Single pole/Triple pole		three pole	
Continuous overload capacity	x In		
Current setting range	% of rated current	10 - 80%	
Operating time at 10 times current setting	sec	3	
Reset time	ms		
Characteristics - IDMT(standard inverse) - IDMT(very inverse) - IDMT(extremely inverse) Definite time		IDMT (standard inverse)	
Instantaneous unit provided	Yes/No	Yes	

DESCRIPTION	UNIT	REQD. Transformer Panel	Offered Transformer Panel
- Current setting range	% of rated current		
Operating time	ms		
i) BUS / TRANSFORMER DIFFERENTIAL RELAY			
Manufacturer's designation / Model No.			
Applied standards		IEC	
Type		numeric	
Current magnitude difference setting range	% of rated secondary current		
j) SYNCHRO-CHECK RELAY			
Manufacturer's designation / Model No.			
Applied standards			
Type			
Rated input measuring voltage	V		
Voltage magnitude difference setting range	% of Vn		
Phase angle difference setting range	Degrees		
Frequency difference setting range	Hz		
Operating time	ms		
Reset time	ms		
Specify whether each relay incorporate with the following options of reclosing on:			
- Dead bus-live line	Yes/No		
- Dead line - live bus	Yes/No		
If the options of reclosing on dead bus- live line and dead line- live bus are separately furnished and mounted, specify:			
- type.			

DESCRIPTION	UNIT	REQD. Transformer Panel	Offered Transformer Panel
-Voltage rating	V		
k) AUXILIARY TRIPPING & LOCKOUT RELAYS			
Manufacturer's designation / Model No.			
Applicable standards		IEC	
Type		numeric	
Operating time	ms		
l) BREAKER FAILURE RELAY			
Manufacturer's designation / Model No.			
Applicable standards		IEC	
Type		numeric	
Setting range	A		
- number of trip steps	No.		
- adjustable time of 1st step	ms		
- adjustable time of 2nd step	ms		
- both in steps	ms		
Operating times			
- maximum operating time	ms		
- reset time	ms		
m) DISTANCE RELAY			
Manufacturer's designation / Model No.			
Applicable standards			
Type			
No of zones		-	
- forward direction			
- reverse direction			
- Zone reach setting ranges including steps		-	
- Zone 1	Ω/phase	-	
- Zone 2	Ω/phase	-	

DESCRIPTION	UNIT	REQD. Transformer Panel	Offered Transformer Panel
- Zone3	Ω/phase	-	
- Reverse Zone	Ω/phase	-	
Zone timer setting ranges including steps		-	
- Zone 2	sec	-	
- Zone 3	sec	-	
- Reverse Zone	sec	-	
Directional sensitivity		-	
- Single phase and phase to phase faults		-	
- Three phase faults		-	
Are the following features incorporated in each distance relay?		-	
Instantaneous tripping when closing on three phase zero volt bolted fault	Yes/No	-	
Carrier auxiliary relays for additional following carrier transfer trip schemes		-	
- Zone acceleration	Yes/No	-	
- Permissive under reaching	Yes/No	-	
- Permissive overreaching	Yes/No	-	
Auxiliary tripping relays	Yes/No	-	
Single pole tripping and reclosing scheme	Yes/No	-	
Operation indicators for each function	Yes/No	-	
Alarm for auxiliary DC voltage failure	Yes/No	-	
Built-in test facilities	Yes/No	-	
Power swing blocking facility	Yes/No	-	
VT supply supervision facility	Yes/No	-	
Specify whether the distance relay is insensitive to:		-	
-Frequency changes	Yes/No	-	
-Power swing (Hunting)	Yes/No	-	
-Capacitive loading	Yes/No	-	
FAULT LOCATOR		-	
(inbuilt / seperate)			

DESCRIPTION	UNIT	REQD. Transformer Panel	Offered Transformer Panel
Accuracy	%	-	
Calculating time	ms	-	
Does the fault locator incorporate following features:		-	
- Independent of the fault type	Yes/No	-	
- phase selection indication	Yes/No	-	
Mis-operation protection for loss-of-potential due to short circuit in the secondary of CVT	Yes/No	-	
m) Multifunction Meter			
Manufacturer designation / Model No.			
Applicable Standard			
Type			
Functions available			
Communication with SCADA / RTU			

Deviations from technical requirements and reasons for such deviations:

Signed: .....

As Representative for: .....

Address: .....

Date: .....

1.8 Technical particular for 132 kV Transformer Control & Relay Panels with SAS

DESCRIPTION	UNIT	REQD. Transformer Panel	Offered Transformer Panel
Manufacturer's name			
Country of Origin			
Applicable Standard			
Years of Manufacturing Experience	Years	Minimum 7	
ISO Certificate Submitted			
Manufacturer's sales record submitted	Yes/No	Yes	
1. Type (simplex/duplex)			
2. Applicable standard		IEC	
3. Control panels furnished as per specification?	Yes/No	Yes	
4. Enclosure protection class	IP	IP 43	
5. Thickness of sheet metal used			
a)Front and rear portion	mm	>=3	
b) Side, top & bottom covers	mm	>=2	
c) Doors	mm	>=3	
6. All instruments, meters, relays and control switches flush or semi-flush type?		flush type	
7. Ground bus			
a)Material		copper	
b) Size	mm x mm	25 x 6	
8. Overall dimension of control boards (LxWxH)	mm		
9. Shipping data			
a)Size of the large package (LxWxH)	mm		
b) Weight of the heaviest package	Kg		
10. Delivery of equipment in months following award of contract. (Allowing time for approval of drawing)	month		
11.Indicating Instruments			
a) Ammeter			
Manufacturer's designation / Model No.			
Type			

DESCRIPTION	UNIT	REQD. Transformer Panel	Offered Transformer Panel
Accuracy class		0.5	
Scale			
- Type of scale	linear / non-linear		
- Range of indication (...../1 A CT operated)	A		
b) Voltmeter			
Manufacturer's designation / Model No.			
Type			
Accuracy class			
Scale			
- Range of indication	kV		
- Linear / non-linear			
c) Active power meter			
Manufacturer's designation / Model No.			
Type			
Manufacturer's type designation			
Applicable standard		IEC	
Rated voltage	kV	*132/√3:* *0.11/√3*	
Rated current	A		
Current range (Transducer operation)	mA		
Accuracy class			
Scale			
- Type		*Digital*	
- Range of indication	MW	*0-30* *0-60*	
- Linear / non-linear			
d) Frequency meter		-	
Manufacturer's designation / Model No.		-	

DESCRIPTION	UNIT	REQD. Transformer Panel	Offered Transformer Panel
Range of indication	Hz	-	
e) Energy Meter			
Manufacturer / Model No.			
Type		electronic 3- ph, 4 wire	
Applicable standard		IEC	
Class of accuracy		*0.2*	
Import and export meter provided	Yes/No	*Yes*	
Rated voltage	kV	*132/√3:* *0.11/√3*	
Rated current	A		
VA burden	VA		
f) ANNUNCIATORS			
Manufacturer's designation / Model No.			
Type		numeric	
Number of inputs (annunciator /event)			
Number of active points	No.	24	
Number of rows	No.	3	
Number of columns	No.	8	
Type of mounting		flush	
Replacement of individual inscription plates and lamps from front panel possible?	Yes/No	Yes	
Sequence of operation as per specifications	Yes/No	Yes	
g) PHASE OVERCURRENT RELAYS: (Directional & Non-directional)			
Manufacturer's designation / Model No.			
Type		*numeric*	
Applicable standards		*IEC*	
Triple pole or single pole		*Triple pole*	
Continuous overload capacity	x In		

DESCRIPTION	UNIT	REQD. Transformer Panel	Offered Transformer Panel
Current setting range	% of rated current	*20 - 200%*	
Operating time at 10 times current setting	sec	3	
Reset time	ms		
Characteristics - IDMT(standard inverse) - IDMT(very inverse) - IDMT(extremely inverse) - Definite time			
Instantaneous unit provided	Yes/No	Yes	
- Current setting range	% of rated current		
Operating time	ms		
h) GROUND OVER CURRENT RELAYS (Directional & Non-directional)			
Manufacturer's designation / Model No.			
Type		numeric	
Applicable standards		IEC	
Single pole/Triple pole		three pole	
Continuous overload capacity	x In		
Current setting range	% of rated current	10 - 80%	
Operating time at 10 times current setting	sec	3	
Reset time	ms		
Characteristics - IDMT(standard inverse) - IDMT(very inverse) - IDMT(extremely inverse) Definite time		IDMT (standard inverse)	
Instantaneous unit provided	Yes/No	Yes	

DESCRIPTION	UNIT	REQD. Transformer Panel	Offered Transformer Panel
- Current setting range	% of rated current		
Operating time	ms		
i) BUS / TRANSFORMER DIFFERENTIAL RELAY			
Manufacturer's designation / Model No.			
Applied standards		IEC	
Type		numeric	
Current magnitude difference setting range	% of rated secondary current		
j) SYNCHRO-CHECK RELAY			
Manufacturer's designation / Model No.			
Applied standards			
Type			
Rated input measuring voltage	V		
Voltage magnitude difference setting range	% of Vn		
Phase angle difference setting range	Degrees		
Frequency difference setting range	Hz		
Operating time	ms		
Reset time	ms		
Specify whether each relay incorporate with the following options of reclosing on:			
- Dead bus-live line	Yes/No		
- Dead line - live bus	Yes/No		
If the options of reclosing on dead bus- live line and dead line- live bus are separately furnished and mounted, specify:			
- type.			

DESCRIPTION	UNIT	REQD. Transformer Panel	Offered Transformer Panel
-Voltage rating	V		
k) AUXILIARY TRIPPING & LOCKOUT RELAYS			
Manufacturer's designation / Model No.			
Applicable standards		IEC	
Type		numeric	
Operating time	ms		
l) BREAKER FAILURE RELAY			
Manufacturer's designation / Model No.			
Applicable standards		IEC	
Type		numeric	
Setting range	A		
- number of trip steps	No.		
- adjustable time of 1st step	ms		
- adjustable time of 2nd step	ms		
- both in steps	ms		
Operating times			
- maximum operating time	ms		
- reset time	ms		
m) DISTANCE RELAY			
Manufacturer's designation / Model No.			
Applicable standards			
Type			
No of zones		-	
- forward direction			
- reverse direction			
- Zone reach setting ranges including steps		-	
- Zone 1	Ω/phase	-	
- Zone 2	Ω/phase	-	

DESCRIPTION	UNIT	REQD. Transformer Panel	Offered Transformer Panel
- Zone3	Ω/phase	-	
- Reverse Zone	Ω/phase	-	
Zone timer setting ranges including steps		-	
- Zone 2	sec	-	
- Zone 3	sec	-	
- Reverse Zone	sec	-	
Directional sensitivity		-	
- Single phase and phase to phase faults		-	
- Three phase faults		-	
Are the following features incorporated in each distance relay?		-	
Instantaneous tripping when closing on three phase zero volt bolted fault	Yes/No	-	
Carrier auxiliary relays for additional following carrier transfer trip schemes		-	
- Zone acceleration	Yes/No	-	
- Permissive under reaching	Yes/No	-	
- Permissive overreaching	Yes/No	-	
Auxiliary tripping relays	Yes/No	-	
Single pole tripping and reclosing scheme	Yes/No	-	
Operation indicators for each function	Yes/No	-	
Alarm for auxiliary DC voltage failure	Yes/No	-	
Built-in test facilities	Yes/No	-	
Power swing blocking facility	Yes/No	-	
VT supply supervision facility	Yes/No	-	
Specify whether the distance relay is insensitive to:		-	
-Frequency changes	Yes/No	-	
-Power swing (Hunting)	Yes/No	-	
-Capacitive loading	Yes/No	-	
FAULT LOCATOR		-	
(inbuilt / seperate)			

DESCRIPTION	UNIT	REQD. Transformer Panel	Offered Transformer Panel
Accuracy	%	-	
Calculating time	ms	-	
Does the fault locator incorporate following features:		-	
- Independent of the fault type	Yes/No	-	
- phase selection indication	Yes/No	-	
Mis-operation protection for loss-of-potential due to short circuit in the secondary of CVT	Yes/No	-	
m) Multifunction Meter			
Manufacturer designation / Model No.			
Applicable Standard			
Type			
Functions available			
Communication with SCADA / RTU			

Deviations from technical requirements and reasons for such deviations:

Signed: .....

As Representative for: .....

Address: .....

Date: .....

1.9 Guaranteed technical particular for station grounding system

1.9.1 Technical Particular for Station Grounding System

DESCRIPTION	Size	Material	OFFERED DATA
Main ground grid conductor material		Mild Steel	
Main Earthing Conductor to be buried in ground	40 mm dia	Mild Steel rod	
Conductor above ground& earthing leads (for equipment)	75x12mm G.S. flat	Galvanised Steel	
Conductor above ground& earthing leads(for columns & aux. structures)	75x12mm G.S. flat	Galvanised Steel	
Earthing of indoor LT panels, Control panels and out-door marshalling boxes, MOM boxes, Junction boxes& Lighting Panels etc.	50x6 mm G.S. flat	Galvanised Steel	
Rod Earth Electrode	40 mm dia, 3000mm long	Mild Steel	
. Pipe Earth Electrode (in treated earth pit) as per IS.	40 mm dia, 3000mm long	Galvanised steel	
Earthing for motors	25x3mm GS flat	Galvanised steel	
Earthing conductor along outdoor cable trenches	50x6mm MS flat	Mild steel	
Earthing of Lighting Poles	20 mm dia 3000 mm long	Mild steel rod	
Earthing system designed for	≤ 1 ohm		

1.9.2 Technical Particular for Low Voltage Power Cable

DESCRIPTION	UNIT	REQ.	DATA
Manufacturer and Country of Origin			
Type		Armoured	
Applicable standard		IEC	
Voltage rating			
a) Suitable for max. system voltage	V	600	
b) Voltage grade of the cable (Uo/U)	V	600/1100	
Conductor material		Copper	
Insulation			
- Material		XLPE	
Overall jacket			

DESCRIPTION	UNIT	REQ.	DATA
- Fire retardative		Yes	
- Moisture resistant		Yes	
- Rodent Protection		Yes	
- Anti-termite Protection		Yes	

1.9.3 Technical Particular for Control Cable

DESCRIPTION	UNIT	REQ.	DATA
Manufacturer and Country of Origin			
Type		Armoured	
Applicable standard		IEC	
Voltage rating			
a) Suitable for max. system voltage	V	600	
b) Voltage grade of the cable (Uo/U)	V	600/1100	
Conductor material		Copper	
Insulation			
- Material		Polyethylene	
Overall jacket			
- Fire retardative		Yes	
- Moisture resistant		Yes	
Rodent Protection		Yes	
Anti-termite Protection		Yes	

1.9.4 Technical Particular for 11kV Power Cable

DESCRIPTION	UNIT	REQ.	DATA
Manufacturer and Country of Origin			
Type		Armoured	
Applicable standard		IEC	
Voltage rating			
a) Suitable for max. system voltage	V	12,000	
b) Voltage grade of the cable (Uo/U)	kV	17/10	
Conductor		Copper	

DESCRIPTION	UNIT	REQ.	DATA
Conductor Screen		XLPE	
Insulation		Extruded Semi-conducting	
Insulation Screen		Extruded Semi-conducting + Copper tape	
Inner Sheath		PVC	
Armour		Hard Drawn Aluminium round wire	
Overall jacket		PVC, Black Colour	
- Fire retardative		Yes	
- Moisture resistant		Yes	
-Rodent Protection		Yes	

Deviations from technical requirements and reasons for such deviations:

Signed: .....

As Representative for: .....

Address: .....

Date: .....

1.9.5 Technical Particular for 33 kV Power Cable

DESCRIPTION	UNIT	REQ.	DATA
Manufacturer and Country of Origin			
Type		Armoured	
Applicable standard		IEC	
Voltage rating			
a) Suitable for max. system voltage	V	33000	
b) Voltage grade of the cable (Uo/U)	kV		
Conductor		Copper	
Conductor Screen		XLPE	
Insulation		Extruded Semi-conducting	
Insulation Screen		Extruded Semi-conducting + Copper tape	
Inner Sheath		PVC	
Armour		Hard Drawn Aluminium round wire	
Overall jacket		PVC, Black Colour	
- Fire retardative		Yes	
- Moisture resistant		Yes	
-Rodent Protection		Yes	

Deviations from technical requirements and reasons for such deviations:

Signed: .....

As Representative for: .....

Address: .....

Date: .....

Guaranteed technical particular for 33 kV & 11kV Switchgear

1.9.6 Technical Particular for 33 kV & 11kV Switchgear

S. No.	General Performance	Unit	11 kV	33 kV	Bidder Data
Bus Bar					
1	Rated Frequency	Hz	50	50	
2	Voltage rating: a) Nominal system voltage b) Rated maximum voltage Rated Voltage	 kV kV	 11 12	 33 36	
3	Insulation level a) Impulse withstand voltage b) Power-frequency withstand voltage (1 min.)	 kV peak kV rms	 95 28	 170 70	
4	Rated Continuous Current	A	2000/1250	2500/1250	
5	Rated Short Time Current	kA	25	25	
6	Rated Duration of Short Circuit time	Sec	1	1	
7	Auxiliary supply a) Control circuit b) Space heater and auxiliary equipment.	 V DC V AC	 220 230/400V, 50 Hz	 220 230/400, 50 Hz	
8	Attitude at site	m	Please follow PSR		
Circuit Breaker					
1	Rated Frequency	Hz	50	50	
2	Voltage rating: a) Nominal system voltage b) Rated maximum voltage Rated Voltage	 kV kV	 11 12	 33 36	
3	Insulation level a) Impulse withstand voltage b) Power-frequency withstand voltage (1 min.)	 kV peak kV rms	 95 28	 170 70	
4	Rated Continuous Current	A			
5	Rated Short Time Current	kA	25	25	
6	Rated Duration of Short Circuit time	Sec	1	1	
7	Internal Arc Fault Performance Time Standard	kA Sec	25 0.1 IEC 62271:200	25 0.1 IEC 62271:200	
8	Operating Cycle		0-0.3s -CO-3 Min-CO	0-0.3s - CO-3 Min	

S. No.	General Performance	Unit	11 kV	33 kV	Bidder Data
9	Number of possible operations without maintenance: For breaker contact with: - Rated short circuit breaking current (25 kA) - Rated normal current - For mechanism				
10	Total maximum break time	ms	60	60	
11	Maximum make time	ms	120	120	
12	Additional Auxiliary Contacts		8 NO, 8 NC	8 NO, 8NC	
13	Spring charging motor	V DC	220	220	

Deviations from technical requirements and reasons for such deviations:

Signed: .....

As Representative for: .....

Address: .....

Date: .....

1.10 Technical particular for 220 kV BUS, Fittings and Insulators

DESCRIPTION	UNIT	REQ.	OFFERED DATA 220 KV	OFFERED DATA 33 KV
1. ACSR CONDUCTOR				
Manufacturer and Country of Origin				
Type		*MOOSE*		
Applicable standard				
No. of wires				
a) Aluminum	No.	*54*		
b) Steel	No.	*7*		
Cross section				
a) Aluminum	sq mm	*528.5*		
b) Steel	sq mm	*68.5*		
c) Complete conductor	sq mm	*597.00*		
Overall diameter				
a) Steel core	mm	*7/3.53*		
b) Complete conductor	mm	*31.77*		
Ultimate tensile strength	kg	*161.2*		
Weight	kg/km	*2004*		
2. SHIELD WIRE (If Applicable)				
Manufacturer and Country of Origin				
Type				
Applicable standard		*IEC*		
No. of wires	No.	*7*		
Nominal cross sectional area	sq mm	*61.7*		
Overall diameter	mm	*10.05*		
Ultimate tensile strength	kg	*7,400*		
Zinc coating	g/sq.m			
Equivalent modulus of elasticity	kg/mm^2	*19,000*		
Weight	kg/km			
3. ALUMINUM TUBULAR BUS				
Manufacturer and Country of Origin				
Applicable standard				
Cross-section	mm^2			

DESCRIPTION	UNIT	REQ.	OFFERED DATA 220 KV	OFFERED DATA 33 KV
Diameter inner / outer	mm			
Material				
4. FITTINGS				
Manufacturer and Country of Origin				
Applicable standards				
Material				
5. SUSPENSION/ TENSION INSULATOR STRING				
Manufacturer and Country of Origin				
Applicable standards				
Size of disc				
- Diameter	mm			
- Height	mm			
Number of units per string	No	*15/10*		
Combined mechanical and electrical failing load	kN			
Creepage distance per unit	mm	*6125/3625*		
Impulse withstand voltage	kV, crest	*1050/650*		
Dry power frequency withstand voltage	kV			
Wet power frequency withstand voltage	kV			
Puncture voltage	kV			
6. POST INSULATOR				
Manufacturer				
Applicable standards		IEC		
Rated system voltage	kV			
Max. rated voltage	kV			
Unit size (Diameter)	mm			
Unit size (length)	mm			
Creepage distance	mm			
Insulation level				
a) Impulse withstand voltage	kV, crest			

DESCRIPTION	UNIT	REQ.	OFFERED DATA 220 KV	OFFERED DATA 33 KV
b) Power frequency withstand voltage (1 min rms)	kV			
Failing load (bending)	kg			
Failing load (torsion)	kg-m			

Deviations from technical requirements and reasons for such deviations:

Signed: .....

As Representative for: .....

Address: .....

Date: .....

1.11 Technical particular for SUBSTATION AUTOMATION SYSTEM

TECHNICAL DATA SHEET **(To Be Completed By the Tenderer)**		
Sr. No.	Parameters	To be filled by
A	**BCU**	
1	Make and Type	
2	Numerical Technology	
3	Modular design	
4	Nos of Analogue Input	
5	Nos of Digital Input	
6	Nos of Output	
7	Data Storage	
8	Self- monitoring	
9	Power supply	
10	IEC 61850 Protocol Compatibility	
11	Binary Input processing & Nos	
12	Analogue Input processing & Nos	
13	Measured value acquisition	
14	Derived values	
15	Digital Outputs	
16	Sub-station/bay inter-locking	
17	Trip Circuit Supervision	
18	Event Logging Nos	
19	Disturbance files & record of wave forms , storage capacity	
20	Gateway support	
21	Local control, Operation and Display	
	Contact bouncing in digital inputs shall not be assumed as change of state	
23	I/O processing capacities	
24	Internal Ethernet switches	
	Nos of port –	
26	Environmental conditions	
27	Mounting & design	
28	Warranty	

29	Bay control functions	
30	Control mode selection	
31	Command supervision	
	Commands for	
32	Local communication facility through HMI	
	Local communication facility provided on front side for	
34	Compatibility with owner's SCADA for remote control	
35	Extension possibilities with additional I/O's inside the unit or via fiber-optic communication and process bus.	
B	Gateway	
1	Power supply	
2	Processor Type	
3	Chipset	
4	Memory Type	
5	Standard memory	
6	Memory slots	
	Internal hard disk drive	
	Hard disk drive speed	
	Optical drives	
	Video adapter, bus	
	Expansion slots	
	Network Interface	
	External I/O ports	
	Operating system installed.	
	Make	
	Antivirus s/w	
D	**HMI SERVER**	
1	Power supply	
2	Processor Type	
3	Chipset	
4	Memory Type	
5	Standard memory	
6	Memory slots	
7	Memory upgrade	
8	Internal hard disk drive	

9	Hard disk drive speed	
10	Optical drives	
11	Flexible disk drives	
12	Chassis type	
13	Video adapter, bus	
14	Expansion slots	
15	Audio	
16	Modem	
17	Network Interface	
18	External I/O ports	
19	Monitor	
20	Keyboard	
21	Pointing Device	
22	Operating system installed.	
23	Other	
24	Warranty	
25	UPS	
26	Make	
27	Antivirus s/w	
E	**DR WORK STATION**	
1	Power supply	
2	Processor Type	
3	Chipset	
4	Memory Type	
5	Standard memory	
6	Memory slots	
7	Memory upgrade	
8	Internal hard disk drive	
9	Hard disk drive speed	
10	Optical drives	
11	Flexible disk drives	
12	Chassis type	
13	Video adapter, bus	

14	Expansion slots	
15	Audio	
16	Modem	
17	Network Interface	
18	External I/O ports	
19	Monitor	
20	Keyboard	
21	Pointing Device	
22	Operating system installed.	
23	Other	
24	Warranty	
25	UPS	
26	Make	
27	Antivirus s/w	
F	**LINE INTERFACE UNIT**	
1	Area Network Type	
2	Power Supply	
3	Protocol/ Network	
4	Module	
5	No. of Ports	
6	Ports/Interfaces	
7	Features	
8	Make	
9	Manufacturer Warranty	
10	Suitability for Nos of F.O. Inlet/Outlet	
11	IEC 61850 Compatibility	
G	**COLOUR LASER JET PRINTER**	
1	Model	
2	Power Supply	
3	Black Print Speed	
4	Black Print Resolution	
5	Print Memory	
5	Processor	

6	Supported paper sizes	
7	Print technology	
8	Pages quantity	
9	Paper handling	
10	Connectivity	
11	Manufacturer Warranty	
12	Networking:	
13	Supporting OS	
14	Make	
15	Suitability to print all types of drafts and graphics	
H	**LASER JET PRINTER**	
1	Model	
2	Power Supply	
3	Black Print Speed	
4	Black Print Resolution	
5	Print Memory	
6	Processor	
7	Supported paper sizes	
8	Print technology	
9	Pages quantity	
10	Paper handling	
11	Connectivity	
12	Manufacturer Warranty	
13	Networking:	
14	Supporting OS	
15	Make	
16	Suitability to print all types of drafts and graphics	

Deviations from technical requirements and reasons for such deviations:

Signed: .....

As Representative for: .....

Address: .....

Date: .....