NEPAL ELECTRICITY AUTHORITY

(An Undertaking of Government of Nepal)
Project Management Directorate

ARUNKHOLA (DUMKIBAS) 132/33 kV SUBSTATION PROJECT

(A Component of Electricity Grid Modernization Project-Additional Financing)

BIDDING DOCUMENT
FOR

Procurement of Plant for
Design, Supply, Installation, Testing and Commissioning of 132/33/11 kV Air Insulated Substation at Dumkibas, Binayi Triveni Rural Municipality, Nawalparasi (Bardaghat-Susta East) District
(Package A-4)

Single-Stage, Two-Envelope
Bidding Procedure

Issued on:	**6 February, 2022**
Invitation for Bids No.:	**PMD/EGMPAF/ADSP–078/79 – 01**
OCB No.:	**PMD/EGMPAF/ADSP–078/79 – 01**
Employer:	**Nepal Electricity Authority**
Country:	**Nepal**

VOLUME – II(A) OF III

February 2022

Arunkhola (Dumkibas) 132/33 kV Substation Project
Project Management Directorate
NEA Project Management Directorate
Matatirtha, Kathmandu, Nepal
Telephone: +977-9851155752

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 June 2018. 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.

Abbreviations

BD........................	Bidding Document
BDF……………..	Bidding Forms
BDS......................	Bid Data Sheet
BOQ ……………..	Bill of Quantities
COF ……………..	Contract Forms
DP ……………….	Development Partners
DoLIDAR…………	Department of Local Infrastructure Development and Agricultural Roads
EMP.....................	Environmental Management Plan
ELI………………..	Eligibility
EQC.....................	Evaluation and Qualification Criteria
EXP………………	Experience
FIN……………….	Financial
GCC.....................	General Conditions of Contract
GoN.....................	Government of Nepal
ICB......................	International Competitive Bidding
ICC.......................	International Chamber of Commerce
ITB.......................	Instructions to Bidders
JV ………………..	Joint Venture
LIT………………..	Litigation
ICB ……………..	International Competitive Bidding
NEA……………....	Nepal Electricity Authority
PAN……………....	Permanent Account Number
PPA ……………..	Public Procurement Act
PPMO ……………	Public Procurement Monitoring Office
PPR ……………....	Public Procurement Regulations
PL.........................	Profit and Loss
SBD......................	Standard Bidding Document
SCC ……………..	Special Conditions of Contract
TS.........................	Technical Specifications
VAT……………….	Value Added Tax
WRQ………………	Works Requirements

Table of Contents - Summary Description

Volume II –Employer's Requirements

Section VI. Employer's Requirements

Arrangement of Chapters

CHAPTER- 1

PROJECT SPECIFIC REQUIREMENT (PSR)

For

132/33/11 kV AIS DUMKIBAS SUBSTATION

ANNEXURES

CHAPTER – 1

PROJECT SPECIFIC REQUIREMENT

1. GENERAL

Government of Nepal and Nepal Electricity Authority intend to construct a new 132/33/11 kV AIS Substation at Dumkibas, Binayee Tribeni Rural Municipality Ward No. 2, Gandaki Province under Arunkhola-Dumkibas 132/33 kV Substation project. It will be connected to Bardaghat-Sardi double circuit 132kV Transmission Line under LILO at Tamang Gaun, Dumkibas.

Nepal Electricity Authority (NEA) also intends to construct 3.2 km single circuit overhead 11kV Distribution feeders from the proposed Dumkibas Substation.

The above project is being funded by ADB and Nepal Electricity Authority is a Implementation Agency.

This specification describes the requirements for construction of the 132/33/11 kV AIS substations and 11kV distribution feeders overhead Line on a turnkey basis.

Sites are Greenfield and the Contractor shall be responsible for access and all necessary utilities.

2. INTENT OF SPECIFICATION:

The specification includes design, engineering, manufacture, fabrication, testing at manufacturers' works, delivery, unloading at site, storage, erection, testing and commissioning at site of

Dumkibas Substation:

Complete 132kV and 33 kV switchyards including outdoor AIS switchgears, 132kV, 33kV and 11kV Indoor/outdoor equipment, two numbers of 132/33 kV, 30 MVA and two numbers of 33/11 kV, 16.66 MVA, 3 phase Power Transformer, associated civil works, Fire Fighting System, internal and approach roads, drains, necessary Switchyard and control room buildings etc., 132kV system for making connections with outdoor 3 phase Power Transformers and 132kV overhead lines and associated works, Control & protection, Digital protection Coupler, FO based communication system and, other electrical and mechanical auxiliary systems and construction of township (residential) buildings, security room, store and pump house building, car shed and compound wall on turnkey basis.

Dead End Tower:

One number of Dead-End Tower shall be constructed at Dumkibas within the substation compound area between existing Towers AP12 and AP11 of Bardaghat- Sardi double circuit 132kV Transmission Line (under construction) for LILO.

11kV Distribution Line:

Construction of overhead **11kV** Distribution Line originates from 132/33/11kV Dumkibas Substation to surrounding areas through single circuit of AAAC Covered conductor on Steel Tubular Pole structure. The route length of line is around 3.2 km.

The new substation at Dumkibas is to be constructed along the Bardaghat-Sardi 132kV D/C transmission Line (under construction) which passes through the proposed substation location. The Contractor shall require to design and construct the substation and distribution line as per the site condition based on the indicative layout drawings provided in **Annexure - I**.

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.

Civil Works	External electrical Works	Transformers	Switchgear	Design and Integration
Substation access Approach Road Transformer bays.	All equipment necessary to connect the new substation to the 132kV, 33 kV & 11 kV supply	2x30MVA, 132/33kV; 2x16.66 MVA, 33/11 kV Rating applicable to both secondary voltages.	132kV AIS switchboard as described in the specification	The substation shall be designed by the contractor and shall follow NEA requirements.
132kV & 33kV AIS Switchgear	as described in the technical specification		as described in the technical specification	All equipment and protection shall be integrated by the contractor and commissioned in conjunction with NEA.
11kV Switchgear room	as described in the technical specification	Local transformer 33/0.4Kv	12 kV switchboard as described in the specification	The substations shall be constructed as fully integrated turnkey packages.
Associated control rooms, firefighting pump house building,	as described in the technical specification			The substations shall be designed by the contractor and shall follow NEA requirements.
Other facilities required by NEA and described in the specification	as described in the technical specification			Other facilities shall be designed by the contractor and shall follow NEA requirements.

3. SCOPE OF WORKS:

The scope of works under this contract includes design, manufacture, shop test, transportation & delivery to site, assembly, erection, installation, field testing, commissioning and remedying of defects within warranty period of all equipment necessary for complete operation of 132/33/11 kV substation on turnkey basis.

a) **Construction of a new 132/33/11 kV substation at Dumkibas with the provision of following bays as per Single Line Diagram & as indicated in BPS:**

i. 4 Nos. of 132 kV bays for LILO of 132 kV Bardaghat-Sardi Existing D/C Line.
2 Nos. of 132 kV bays for 2 Nos. of 132/33 KV, 24/27/30 MVA 3 Phase Power Transformer.

ii. 1 No. of 132 kV bay for Bus Coupler.

iii. 4 Nos. of 33 kV bays for 2 nos. for 10/13.33/16.66 MVA, 33/11 KV, 3 Phase Power Transformer and 2 nos. of 33 kV Lines

iv. 4 Nos. of 33 kV bays for 33 kV Outgoing Lines.

v. 12 kV Indoor Switchgear Panels for 6 Nos. of Outgoings feeders, 2 Nos. for transformer incomer i.e., from 2*16.66 MVA, 33/11 kV Power Transformers and 1 No. for 11kV Bus Coupler.

vi. Other associated equipment.

b) **Transformer:**

i. 132/33kV, 24/27/30 MVA, 3 phase Power Transformer - 2 Nos.

Ii. 33/11 kV, 10/13.33/16.66 MVA, 3 phase Power Transformers - 2 Nos.

iii. 33/0.4kV, 200 kVA Station service Transformers - 2 Nos.

c) **Substation Automation System (SAS) & Communication system:**

Sub-station Automation System (SAS), Tele-protection & Communication Equipment all complete work including all required hardware and software for remote control station along with associated equipment for 132kV, 33kV & 11 kV bays as per Single line diagram & as indicated in BPS and as per technical specification.

The Contractor shall be fully responsible for supply, installation, testing and commissioning of Substation Automation system, necessary for complete operation with the NEA SCADA system. Fiber Optic based communication system to be supplied under this Contract shall be compatible with the existing ones and the Contractor shall be fully responsible for complete interfacing between the existing and the new system. The interfacing works include the integration of the relevant data (associated with the scope of this work) into the SINAUT Spectrum of the Load Dispatch Center, Kathmandu by necessary addition/modification and parameterization.

d) **Fire Protection System:**

Fire Protection System for control room Building and transformers as per technical specification.

HVW spray system is envisaged for 132/33 kV and 33/11 kV Transformers. HVW system, HVW spray system & hydrant system complete work with all required Pumping arrangement, U/G & O/G piping and accessories for Power Transformers and equipment as per technical specification

e) **Monitoring and Analyzing Equipment:**

Online monitoring Equipment of fault gases, air components and moisture in transformer insulating fluids (Dissolved gas Analyzer) of 132/33 kV Power Transformer with Inside View (Analysis Software) as per specification

f) **Visual Monitoring System**

Visual Monitoring System for watch & ward as per technical specification

g) **Dead-End Tower (DET):**

Supply, Installation, erection, testing & commissioning of 1 no. of Dead-End Tower (DET) at Dumkibas within the substation compound area in between existing Tower no. AP11 & AP12 of newly constructed Bardaghat-Sardi double circuit 132 kV Transmission Line, along same alignment for LILO.

h) **11kV Distribution Line:**

Construction of overhead 11kV Distribution Line that originates from Dumkibas 132/33/11 kV Substation to surrounding areas through single circuit of AAAC Covered conductor and shall be erected using the steel tubular Pole structures. The route length of line is 3.2 km approximate.

4. DETAILED SCOPE OF WORK:

Detailed scope of work for each substation is brought out in subsequent clauses of this section:

4.1 132/33/11kV Dumkibas (New) AIS Substation:

The Scope includes Design & engineering, manufacture, testing, supply to site, including transportation & insurance, unloading, storage, erection, installation, testing and commissioning of the following equipment and items complete in all respect.

4.1.1 132/33/11 kV AIS SYSTEM:

Dumkibas 132/33/11 kV Substation shall have 132 kV double bus bar arrangement. The Substation 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.

Quantity of equipment shall be as per BPS/ technical specifications.

4.1.2 Control and Relay Panel with Substation Automation System comprising of:

a) Transformer control and relay panel complete with all accessories as per technical specifications for both HV and LV sides,
b) Bus coupler cum Bus bar protection control and relay panel complete with all accessories as per technical specifications,
c) Line control and relay panel complete with all accessories as per technical specifications.

Quantity of equipment shall be as per BPS/ technical specifications.

4.1.3 Power Cables:

a) 12 kV, 400 Sq.mm., single core XLPE, copper conductor, armored power cable including termination joints for both ends with all accessories complete from LV side of 33/11 kV power transformer to indoor 12 kV switchgear room as per drawing and technical specifications through cable trench.
b) 12 kV, 240 Sq.mm. three core XLPE, copper conductor, armored power cable armored including termination joints for both ends with other required accessories complete for 6 Nos. of outgoing feeders as per drawing and technical specifications through cable trench.

4.1.4 Transformer:

a) 3-Phase Power Transformer including all materials/fittings/accessories/Digital RTCC panel/Common MB/Individual MB, Cables including special cable (if any), tertiary delta formation & loading arrangement, both Neutral (HV & LV) formations etc.

b) 3-Phase Power Transformer including all materials /fittings /accessories/MB/Cables including special cable (if any) etc.

c) 3-phase Station service Transformers

4.1.5 Substation Automation System (SAS) & Communication system:

Supply, Installation, testing & commissioning of communication equipment's (Fibre Optic based) for Dumkibas Substation, under Arunkhola Dumkibas 132/33 kV Substation Project, as per technical specification for Fiber Optic Based Communication Equipment included in the present scope of work.

Complete Sub-station automation system (SAS) including complete hardware and software for remote control station along with associated equipment for following 132kV, 33kV & 11 kV 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.	07
2.	**33 kV bays**	Nos.	08
3.	**11 kV bays**	Nos.	09

4.1.6 Complete relay and protection system as per section:

Control and Relay (C & R) panels including Bus Bar Protection for 132 kV Double Bus Bar Switching Scheme and 33kV single Bus Bar Switching Scheme. Low Impedance numerical impedance relay with centralized type scheme is acceptable for 132 kV system.

4.1.7 33kV Outdoor Switchgear for 2 nos. of Transformer Incomer Bay 132/33kV, 4 nos. Feeders bays. The indoor Switchgear shall be kept in the control room Building.

4.1.8 Fire Protection System for control Building and transformers as per technical specification.

4.1.9 Lattice or pipe structures or Fasteners (galvanized): 132 kV Transmission Towers and switchyard gantry structures, Beams and equipment support structure, support structure for 33kV & 11 kV XLPE power cable termination shall be provided as per design and drawings to be developed by the contractor. However, the supply of support structure for circuit breaker is under scope of CB manufacturer.

4.1.10 Bus post Insulators, insulator strings and hardware, clamps & connectors, Equipment terminal connectors including for 11 kV XLPE Power Cable, spacers, Aluminumtube, 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.

4.1.11 Air Conditioning System should be installed for control room cum administrative building, switchgear room, Office room, communication room, battery room and township (Staff Quarters) buildings.

4.1.12 Ventilation system must be installed for control room cum administrative building.

4.1.13 LT switchgear (AC/DC Distribution boards) considering present bays and future bays including insulating Mats.

4.1.14 50 KVA, 400/230 V, 50 Hz Silent type DG Set with acoustic enclosure, control Panel & AMF panel as per technical specification.

4.1.15 110 V, 600 AH & 48 V, 300 AH maintenance free lead acid sealed type Batteries and Dual Mode Float Cum Boost Battery chargers separately for 110 V & 48 V batteries complete with all accessories to complete the specified scope of work (One for 132kV & one for 33kV).

4.1.16 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.

4.1.17 Complete indoor & outdoor lighting and illumination of the Switchyard, Substation area, Entrance & Internal Roads, Control Room, Township (Staff Quarters), Security room, store and firefighting pump house buildings, Boundary wall periphery & along main approach roads (with support where ever necessary), occupancy sensor and Street lights etc. and Emergency DC lighting system complete for switchyard, entrance and staff quarter area to complete the specified scope of works as per technical specification.

4.1.18 Earthing of substation with conductors, electrode, grounding materials complete. Earth mat, inside the AIS Control building and outdoor switch yards, earthing of all outdoor equipment including Transformers with all required accessories to complete the specified scope of works. Measurement of earth resistivity is in the scope of Contractor.

4.1.19 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.

4.1.20 Digital Protection Coupler (suitable for interfacing with E1 port of SDH (Synchronous Digital Hierarchy) equipment) and associated Power Cables, Communication & control cables between Digital Protection Coupler (DPC) and Relay Panel for both ends of the following lines:

1. Bardaghat-Sardi 132 kV D/C T/L

The specification of Digital Protection coupler is attached in **Annexure-VI**

4.1.21 FOTS (Fiber Optic Transmission System) based Telecommunication system

4.1.22 Visual Monitoring System for watch and ward of present scope as per Section-18, Visual Monitoring System. The design of the system shall be such that the common system shall be able to accommodate for all feeders/equipment including future bays at Dumkibas substation for all voltage level systems.

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

4.1.24 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.

4.2 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

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

4.2.2 Foundation for 2 Nos. of 24/27/30 MVA, 132/33 kV, 3-Phase and 2 Nos. of 10/13.33/16.66 MVA, 33/11 kV, 3-Phase Power Transformers along with jacking pads, rail track, Oil soak pit, sump pit, pylon support and fire-resistant wall (s) as required.

4.2.3 Foundation for Auxiliary LT transformers, 2 Nos. of 200 kVA, 33/0.4 kV, 3-phase Station service Transformers

4.2.4 Construction of One (1) Control room cum administrative Building, 1 No. of Three (3) storied and 1 No. of Two (2) storied Township (Staff Quarters) buildings having two (2) flats on each floor (i.e. Total ten (10) flats) and 1 No. of one storied Store building as per specification and drawings. Building design shall be in the scope of Contractor. Employer will provide such drawings for reference purpose only. The design of the Township (Staff Quarters) buildings shall be of Nepalese architecture. Contractor shall engage reputed consultant for architectural and structural design works, having at least five-year experience of designing of buildings and manage signatory engineer registered with Nepal Engineering council (NEC) (if required). 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.

4.2.5 Construction of one no. of one storied Security room (Guard House) building including septic tank and soak pit at Main Gate of substation boundary wall.

4.2.6 Construction of 1 No. of Firefighting pump house shed, Underground water tank, Firefighting Water tank and Vehicle Parking shed as per specification and drawings.

4.2.7 Construction of 132kV switch yard and 33kV switch yard.

4.2.8 Construction of septic tank & soak pit with external sewerage system for control Room building and Township (Staff Quarters) buildings at 3 different locations.

4.2.9 Foundation for structures of LM, 132kV Towers, 33kV Tower, equipment supports structures, 11 kV double pole structure and other equipment as per specification, drawings and NEA norms.

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

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

4.2.12 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.

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

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

4.2.15 Construction of rail- cum- road having four rails as per drawing and specifications.

4.2.16 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.

4.2.17 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.

4.2.18 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.

4.2.19 Switch yard Chain link fencing and gates.

4.2.20 Boundary wall along substation property line and main gates

4.2.21 Construction of retaining wall with random Rubble masonry in cement sand mortar

4.2.22 All civil works including foundations associated with erection of SF6 gas insulated metal enclosed switchgear along with its SF6 ducts inside the switch yard.

4.2.23 Foundation for SF6 duct supporting structures (outside building), SF6/Air bushings.

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

4.2.25 Surveying, Soil investigation, 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.

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

4.2.27 The technical specification for internal and external finishing of control room building and roofing has been included in Annexure…. Based on the specification included in Chapter 14 and Annexure… , external finishing shall be decided during detail engineering design.

4.2.28 External water supply arrangement from borewell/single point of water supply within substation boundary to Fire Fighting water Tank, Underground tank, Control Room cum administrative Building, Township (staff quarters), security room (guard house) and other buildings. Underground water tanks of sufficient capacity as per requirement shall be constructed. Water supply arrangement and sewerage system design, layout and drawings shall be developed by contractor.

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

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

4.3 Dead End Tower (DET):

Supply, Installation, erection, testing & commissioning of 1 no. of Dead-End Tower (DET) at Dumkibas within the substation compound area in between existing Tower no. AP11 & AP12 of Bardaghat-Sardi double circuit 132kV Transmission Line, along same alignment for LILO.

There shall be special arrangement for erection of Dead-End Tower between tower no. 11 & 12 of existing double circuit 132 kV transmission line (ACSR BEAR conductor, 230 sq. mm area). The arrangement must be prepared so that the new tower is erected, transmission line stringing and taping/connection/jumper work shall be completed in a single working day within specified time by the help of maximum no. of manpower, multiple cranes and best working technique of contractor.

4.4 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.

4.5 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.

4.6 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 methodologyfor transportation of transformers for approval of Employer within three months from the date of award.

4.7 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.

4.8 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.

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

4.10 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.

4.11 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.

5. SPECIFIC EXCLUSIONS

i) Employer's site office.

6. PHYSICAL AND OTHER PARAMETERS:

6.1 Location of the Substation:

The site of 132/33/11 kV AIS Dumkibas substation is located at Dumkibas, ward no. 2 of Binayee Triveni Rural Municipality, Nawalparasi (Bardaghat-Susta east) district, Gandaki Province. It lies approximately 2.75 km north from the Dumkibas chowk along the East- West Highway. Google Map coordinates of proposed substation location is 27°35'54" North Latitude and 83°51'24" East Longitude. The proposed substation site lies between Tower no. AP11 & AP12 and under the existing Bardaghat-Sardi 132 kV Double circuit transmission line. The proposed substation is located 11.5 Km from Existing NEA Bardaghat 132/11 kV Substation.

6.2 Dumkibas Substation area:

Total area	:	27,000 Square meter,
Length	:	195 m,
Breadth	:	145 m average,
Land type	:	Flat land

6.3 Meteorological data:

a)	Altitude above sea level	:	207 m from MSL
b)	Ambient Air Temperature	:	45ºC (max)/10ºC(min)
c)	Annual average temperature	:	32 degree C
d)	Average Humidity (in %)	:	100(max), 40(min)
e)	Substation location lying in the wind speed zone	:	4 i.e., 47m/s.
f)	Ice or snow expected thickness	:	0
g)	Atmospheric pollution	:	Light
h)	Isokeraunic level (thunderstorm days)	:	50
i)	Monsoon season	:	June-September
j)	Seismic Requirement for Substations	:	0.5g

(Horizontal peak acceleration value) Seismic Requirement for Substations structure: Minimum value of 0.36g (Horizontal peak acceleration value). The contractor shall provide the justification for use of above value during DDE.

However, for design purposes, ambient temperature should be considered as 50 degree centigrade and Relative humidity 100% for the substation.

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

S. No.	Voltage Level	Fault Level
1	132 Kv	31.5 kA for 1 Sec
2	33 Kv	25 kA for 3 Sec
3	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. 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. 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.

8.3 The auxiliary transformers of rating 200 KVA shall be used to feed the substation auxiliaries. The 200 KVA, 33/0.400kV auxiliary transformers shall be located outdoor in a suitable location. These auxiliary transformers should not be used for construction power supply purpose. The detailed scheme is shown in the single line diagram.

9. 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	Circuit Breaker Outdoor	Rev. 00(NEA)
Section – 5	Disconnector 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	11 kV Switchgear	Rev. 00(NEA)
Section - 10	LT Switchgear	Rev. 00(NEA)
Section - 11	Station Auxiliary supply	Rev. 00(NEA)
Section - 12	Battery & Battery Charger	Rev. 00(NEA)
Section - 13	Grounding and Lightning System	Rev. 00(NEA)
Section - 14	Illumination System	Rev. 00(NEA)
Section - 15	Cabling System	Rev. 00(NEA)
Section - 16	Power and Control Cable	Rev. 00(NEA)
Section - 17	Fire Protection System	Rev. 00(NEA)
Section - 18	Monitoring and Analyzing Equipment	Rev. 00(NEA)
Section - 19	Air Conditioning System	Rev. 00(NEA)
Section - 20	DG Set	Rev. 00(NEA)
Section - 21	GTR Transformer and Reactor	Rev. 00(NEA)
Section - 22	Switchyard Erection, Hardware and Miscellaneous Materials	Rev. 00(NEA)
Section - 23	Indoor Switchyard Equipment	Rev. 00(NEA)
Section - 24	Transmission Line Tower and Tower foundation	Rev. 00(NEA)
Section - 25	Substation Automation System	Rev. 00(NEA)
Section - 26	Fiber Optics Based Communication Equipment	Rev. 00(NEA)
Section - 27	Visual Monitoring System	Rev. 00(NEA)
Section - 28	11 kV Distribution line	Rev. 00(NEA)
Section - 29	Steel Tubular Pole	Rev. 00(NEA)
Section - 30	12 kV Covered Conductor	Rev. 00(NEA)
Section - 31	11 kV Line Materials and Hardware	Rev. 00(NEA)
Section - 32	Structures	Rev. 00(NEA)
Section - 33	Civil Works	Rev. 00(NEA)
Section - 34	Inspection Testing and Commissioning	Rev. 00(NEA)
Section - 35	Technical Schedule format	Rev. 00(NEA)
Section - 36	Forms and Procedures	Rev. 00(NEA)
Section - 37	Payment of Works.	Rev. 00(NEA)
Section - 38	Tender Drawings	Rev. 00(NEA)
Section - 39	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. 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. 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. FACILITIES TO BE PROVIDED BY THE OWNER

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.

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

13. SPECIFIC REQUIREMENT:

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

b. 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.

c. Augmentation and integration work related to SCADA System

The 132, 33, 11 kV bays under present scope at the substation shall be integrated by the contractor into existing SCADA system of Siemens 'SINAUT Spectrum' (version 4.3.2) installed at Master Station i.e. Nepal Electricity Authority Load Dispatch Centre (located 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

d. Augmentation and integration work related to Communication System

The scope of work for supply, installation of approach optical fiber (as per requirement from JB to ODF box), Optical Line Termination Equipment, Digital Multiplexer, hardware accessories etc. at Dumkibas substation, LDC Kathmandu and its integration work (at LDC Kathmandu) for onward transmission of Data and Voice communication up to LDC Kathmandu is included in the contract. The technical specification is enclosed at **Annexure- IV.**

The existing FO communication link including RTU exists between existing Bardaghat-Sardi Substations. Data and voice communications from various substations and power houses flow to LDC in the direction of between Bardaghat Substations – Siuchatar. The scope of work for supply, installation of approach optical fiber (as per requirement from JB to ODF box), Optical Line Termination Equipment, Digital Multiplexer, hardware accessories etc. at Dumkibas Substation and its integration work (at existing Bardaghat & LDC Kathmandu) for onward transmission of Data and Voice communication up to LDC Kathmandu is included in the contract.

e. In Chapter 2 GTR and other Technical specifications, the term "Purchaser" and/or "Employer" may be read as "Owner".

f. 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.

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

- **Training at Manufacturer's works:**

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

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

S. No.	Description of training	No. of days	No. of Trainees
1.	Substation Control & Protection and Substation Automation System	5 Days	3
2.	Transformer and Substation/Switchyard Equipment (Circuit Breaker, Isolator, CT, CVT & LA)	5 Days.	3
3.	Tele-protection & Communication Equipment (SDH, MUX & NMS (Craft Terminal)) and Visual Monitoring System	5 Days	3

➢ **On Job Training in Nepal:**

h. The traveling and living expenses of Employer's personnel for the training program conducted in Nepal shall be borne by the Employer.

The training shall be provided to Employer's personnel in the field of erection, testing & commissioning, operation & maintenance at substation site as per following:

S. No	Description of training	No. of days	No. of Trainees
1.	Substation Control & Protection	5 Days	5
2.	Substation Automation System including integration aspect of existing SCADA (of Siemens supplied SINAUT Spectrum Software) at Load Dispatch Center	5 days	4
3.	Tele protection & Communication Equipment (SDH, MUX & NMS (Craft Terminal))	5 Days	4
4.	Transformer and Substation/Switchyard Equipment (Circuit Breaker, Isolator, CT, CVT & LA)	5 Days	5
5.	Fire Protection System and Visual Monitoring System	3 Days	4
6.	Power Substation Design Course (Parameter and physical layout for 132, 220, 400KV etc.)	10 Days	5

i. 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.

j. For illumination in switchyard panel room average Lux level at ground level shall be 300 lux**.** The lighting fixtures for switchyard lighting shall be mounted on LMs wherever LMs are provided. Where LMs are not available, the fixtures may be mounted on Gantry structures or on lighting poles to be provided by the contractor. <u>All the lighting fixtures, Air condition, ceiling Fans etc. to be installed at substation shall be energy efficient (low power consumption).</u>

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

l. 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.

m. 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).

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

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

p. 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 – V.**

q. 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.

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

s. The distance protection relays to be supplied for 132 kV lines should have feature of load encroachment blinder to safeguard the protection trip during heavy load condition.

t. 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.

u. 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.

v. 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.

w. The layout drawing for connection arrangement of 132/33 kV Transformer at Dumkibas substation shall be made 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 bus and LV bus, buses & neutral of spare unit are to be extended up to the other units which could be connected through flexible conductor / rigid bus and connectors when spare unit is required to be connected. However, the detail configuration and actual sizes of various items shall be finalized during detail engineering and shall be subject to Employer's approval. The formation of HV, LV and Neutral buses are included under present scope of work.

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

y. For Design of MSB/ACDB/DCDB/MLDB/ELDB, future 132 kV lines/ transformer has to be considered.

z. 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.

aa. The 132kV Switching scheme shall be Double Main with bypass isolator for Dumkibas Substations.

Suitable arrangement for converting one of the Main Buses as Transfer Bus as per requirement is included in the scope.

bb. LIST OF PREFERED SHORTLISTED MAKE/MANUFACTURER:

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

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

14. 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. SOCIAL SAFEGUARD AND ENVIRONMENT MANAGEMENT PLAN

The Contractor shall prepare Social Safeguard and 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 whenever new workers are recruited. Feedback and training during the works and after the monitoring and control exercise, additional training and awareness activities may be necessary if it happens that the previous sessions had failed to achieve the desired effects.

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.

Erection of Poles: Vegetation should be removed only in so far as strictly necessary for opening foundations for poles and for such other operations as may be performed at each spot.

When erecting the poles, necessary precaution should be taken to minimize the impact on adjacent areas.

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, behaviour and preventive measures: Before switching on the infrastructure installed as part of the project, the neighbouring 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 behaviour 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.

Additional EMP that will be considered necessary by ADB to be implemented during the project preconstruction and construction stages are attached in **ANNEXURE VII**

16. 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.

17. 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. 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 Supplier 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.

Annexture–I

List of Drawings

ANNEXURE- II

Description of Items of 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- III

LIST OF PREFERED (SHORTLISTED) MAKE

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

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

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

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

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

(vi) ***AVR*****:** The AVR to be equipped on the RTCC shall be from MR Germany or ABB Sweden or equivalent.

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

(viii) **Communication System:** NOKIA, NOKIA SIEMENS, SIEMENS, ABB or equivalent

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

ANNEXURE-IV

EXISTING RTU BASED SCADA & ITS DATA ACQUISITION

1.0 GENARAL INFORMATION

1.1 Remote Terminal Units (RTU)

The Load Dispatch Centre (LDC) at Kathmandu controls and monitors the network of Integrated Nepal Power System (INPS) via RTUs and SAS located at its various substations. 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 & SAS for interfacing of the following supervisory controls and data acquisitions:

Remote Control

Remote control of all 132/33kV circuit breakers.

Status indications

Status indications of all 132kV circuit breakers, bus bar and line isolators.

Status indications of all 33kV& 11kV line feeders.

1.3 Integration of SCADA of existing Substation

The existing communication protocol used for SCADA at LDC Kathmandu is IEC 101. For the present scope of work no RTU is envisaged and the Data for SCADA purpose shall be obtained from the Substation Automation System (based on IEC 61850) using Gateway port with communication protocol IEC 101/104 as per requirement being provided at Arunkhola Dumkibas Substation under present contract. The details of substation automation systems are included in the separate chapter Substation Automation.

Table: 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 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

- Bus bar voltages (separate for each bus bar and section) of all 132/33/11 kV Bus bars.
- Active and reactive power for
  - All 132kV Line feeders and 132kV and 33kV Transformer feeders.
- Three phase current measurement for all 132kV, 33kV and 11kV feeders.
- Power factor measurement for all 11kV feeders
- Energy meter for all 132kV, 33kV, 11kV feeders and also for 0.4 kV out point.
- Single phase current measurements for all 33kV lines participating in load shedding Scheme.

ANNEXURE - V

SPECIFICATION FOR REVENUE METER & METERING (INSTRUMENT) TRANSFORMER

1. General

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

2. 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) Poly phase Quantities kWh, kVA Rh, 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, kVA Rh Import, kVA Rh 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 – VI

TECHNICAL SPECIFICATION OF DIGITAL PROTECTION COUPLER

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

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

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

Contractor has to utilize the same fibre for communication and digital protection purpose; no separate fibre shall be provided to the contractor for digital protection. Therefore bidders are instructed to include all the cost providing necessary equipments/ cards and their installation in Dumkibas as well as far end substations (Bardaghat).

1.2 Principle of operation

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

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

1.3 Loop testing

An automatic loop testing routine shall check the teleprotection channel. It shall also be possible to initiate a loop test manually at any station by pressing a button on the front of the equipment. Internal test routine shall continuously monitor the availability of the protection signalling equipment. Proper tripping signal shall always take the priority over the test procedure.

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

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

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

High security and dependability shall be ensured by the manufacturer. Probability of false tripping and failure to trip shall be minimum. Statistical curves/figures indicating above mentioned measures shall be submitted along with the bid. The DPC can be either housed in offered Control & Protection Panel/PLCC Panel or in separate panel.

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

i) General equipment interface tests:

a) Insulated voltage withstand tests

b) Damped oscillatory waves disturbance test

c) Fast transient bursts disturbance test

d) Electrostatic discharge disturbance test

e) Radiated electromagnetic field test

f) RF disturbance emission test

ii) Specific power supply tests:

a) Power supply variations

b) Interruptions

c) LF disturbance emission

d) Reverse polarity

iii) Tele-protection system performance tests:

a) Security

b) Dependability

c) Jitter

d) Recovery time

e) Transmission time

f) Alarm functions

g) Temperature and Humidity tests (As per IEC 68-2)

- Dry heat test (50°C for 8 hours)

- Low temperature test (-5°C for 8 hours)

- Damp heat test (40°C/95%RH for 8 hours)

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

iv) Relays

a) Impulse voltage withstand test as per IEC 60255.

b) High frequency disturbance test as per IEC 60255.

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

The input/output interface to the protection equipment shall be achieved by means of relays and the input/output rack wiring shall be carefully segregated from other shelf/cubicle wiring. The isolation requirements of the protection interface shall be for 2kV rms.

1.4 Major Technical Particulars

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

i)	Power supply	48V DC +10%, -10%
ii)	Number of commands	4 (four)
iii)	Operating time	<7 ms
iv)	Back to back operating time without	
	propagation delay	≤8 ms
v)	Interface to Protection relays	
	Rated Voltage	250 Volts DC
	Maximum Current Rating	5 Amps
	Output	Contact Rating
	Rated Voltage:	250 Volts DC
	Rated Current:	0.1 A DC
	Other Parameters:	As per IEC 255-0-20
vi)	Alarm Contact	
	Rated Voltage	250 Volts DC
	Rated Current	0.1 A DC
	Other Parameters	As per IEC 255-0-20
vii)	Digital Communication Interface	G 703(E1)

ANNEXURE VII

ENVIRONMENTAL MANAGEMENT PLAN

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
Project-wide EMP							
Detailed design and pre-construction preparations							
General							
Compliance with national regulations and international good practice guidelines.	Environment, health, and safety impacts and risks of the project in general	NEA and Contractor to ensure compliance with national and international regulatory framework as set out in Section II of the IEE, including ADB Safeguard Policy Statement (2009), IFC EHS General Guidelines (April 2007), and IFC EHS Guidelines for Electric Power Transmission and Distribution (April 2007) plus other applicable environment, health and safety laws and regulations in force during project implementation, in addition to any further mitigation measures set out in this EMP.	No breaches of national regulations and/or international good practice guidelines.	PMD to comply with requirements throughout project implementation. PMD supervise and monitor contractor to ensure their compliance with delegated requirements.	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor.	Contractor to comply with requirements throughout contract implementation.	NEA counterpart funds Part of PSC budget Part of contract cost, include costs of implementing EMP as BOQ line
Grievance Redress	Environment, health, and safety impacts and risks of the	NEA with support of Contractor to establish multi-level GRM as per Section VII of IEE, including identification of GRM Officers at	GRM operationalized upon loan	PMD to comply with requirements	PSC to supervise, monitor,	Contractor to comply with requirements	NEA counterpart funds

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
Mechanism (GRM).	project on affected persons; including construction workers and affected local communities	all GRM levels and Grievance Redress Committee members. NEA and Contractor to carry out community awareness raising during community meetings and one-to-one discussions about the GRM with directly affected persons before the commencement of works including details of how to submit a grievance to either NEA and/or the Contractor, consultations are to be documented. NEA and Contractor to disseminate GRM contact details verbally and by SMS as well as through distribution of leaflets, and prominently posting GRM arrangements on noticeboards located at the project sites and at local NEA offices, project substations, community centers etc. Contractor to carry out awareness raising amongst workers about the GRM at the start of their employment on-site, including details of how to submit a grievance to either NEA and/or the Contractor. Disseminate GRM contact details verbally and by SMS as well as through noticeboards located at temporary	effectiveness, affected persons are aware of its existence and are actively using GRM to raise their grievances. 100% of grievances received are resolved in a timely manner by NEA and Contractor. Details of GRM operationalization including photos of awareness raising activities to be submitted in first monitoring	throughout project implementation. PMD to supervise and monitor contractor to ensure their compliance with delegated requirements.	and assist PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor.	throughout contract implementation.	Part of PSC budget Part of contract cost, include costs of implementing GRM as BOQ line

Barijan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		construction workers camps and construction site offices. Contractor to ensure that throughout construction, signage is prominently visible detailing site and office contacts in case of grievance. NEA and Contractor to encourage affected persons to make use of the GRM yet clarify that this does not prevent them from pursuing any legal action, if they feel that it is needed. NEA and Contractor to inform communities about the ADB Accountability Mechanism and their possibility to resort to it if any of their grievance is not resolved by the project's GRM. NEA and Contractor to keep record of grievances received and their resolution as report on these, as per Section VII of the IEE.	report, records and grievances and their resolution specified in subsequent monitoring reports.				

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
Environment safeguards staffing – see also site-specific measures for additional staffing requirements	Environment, health, and safety impacts and risks of the project in general	PMD: NEA to operationalize the formal, fully functional environment and social safeguard safeguards unit within PMD and provide requisite facilities and equipment to enable its operation. NEA to assign / start appointing suitably qualified and experienced environmental safeguards team, under the direction of the safeguards unit, to support EMP implementation and be responsible for undertaking regular on-site supervision and monitoring of the project. The environmental safeguards team for the project will comprise: (i) a full-time Senior Environment Officer, (ii) a full-time Senior Health and Safety Officer, (iii) a full-time Senior Biodiversity Officer, (iii) 2 full-time Junior EHS Field Officers, who are to be based on-site during the construction period, and (v) a full-time Community Engagement/GRM Officer. PMD and environment safeguards team to oversee EMP implementation, providing guidance on corrective action as required, and recording construction activities and	PMD environment and social safeguard safeguards unit has been operationalized. 100% of required staffing has been recruited to oversee EMP implementation during detailed design, pre-construction, construction, and operation & maintenance. PMD environment safeguards team and PSC shall be ready	PMD to comply with requirements by establishing environment and social safeguard safeguards unit within PMD and appointing required staff for the duration of the project. PMD to supervise and monitor contractor to ensure their compliance with these requirements.	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor.	Contractor to comply with requirements and appoint required staff for the duration of their contract.	NEA counterpart funds Part of PSC budget Part of contract cost, include costs of safeguards staffing as BOQ line

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		environment, health, and safety conditions on-site through photos and notes. PMD senior officers to undertake at least monthly supervision visits as well as periodic “spot check” site visits to all contract packages whilst directing supervision efforts towards the most environmentally sensitive components of the project. PSC: NEA to recruit PSC, including international environment safeguard specialist, international health and safety specialist, international biodiversity specialist, international heritage specialist as well as national equivalents in accordance with TOR agreed with ADB. PSC to assist PMD to oversee EMP implementation, providing NEA and Contractor with guidance on corrective action as required, and recording construction activities and environment, health, and safety conditions on-site through photos and notes.	and on-board upon loan effectiveness. Contractor environment safeguards team appointed upon commencement of contract, CVs for approval of environment safeguard team submitted as part of bid or subsequently for approval of NEA before field mobilization. List of staff and copies of CVs to be submitted in first monitoring report, any				

Naripan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		PSC to visit all contract packages at least semiannually during ongoing construction works whilst directing their supervision efforts towards the most environmentally sensitive components. Contractor: Contractor to employ as part of the team delivering each package at least one suitably qualified and experienced, dedicated, environment officer and at least one suitably qualified and experienced, dedicated, health and safety officer responsible to be based on-site and monitor and supervise safeguards implementation on a day-to-day basis for the duration of the works. Contractor to nominate a community engagement/GRM officer as part of the team delivering each package/lot to be based on-site and keep affected persons informed of the status of works and be available to receive and deal with any grievances at the project site level, for all new transmission lines this will be a dedicated officer.	updates/changes in staffing specified in subsequent monitoring reports.				

Kanijan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontracto r	
		Contractor's environment safeguard team to oversee EMP implementation, providing guidance on corrective action as required, and recording construction activities and environment, health, and safety conditions on-site through photos and notes. Contractor's environment safeguard team will be based on-site. Contractor to ensure each active construction site or team has a project manager based on-site full-time who is nominated to the role of EHS Supervisor with responsibility for ensuring EMP implementation by their site/team, acting on the advice of, and reporting to the environment safeguards team on compliance. Project manager will be supported by full time OHS steward(s) for each construction site/team who will supervise all works. NEA and Contractor should not discriminate and should proactively encourage the employment of suitably skilled women on the project.					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
Biodiversity management – see also site-specific EMP	Impacts on biodiversity including biodiversity of Chure Conservation Area	NEA will ensure that except for Dumkibas Substation and Chobar-Lagankhel Underground Transmission Line all other project components will be situated outside the boundaries and buffer zones of current or proposed protected areas and/or key biodiversity areas. NEA will ensure that none of the project components including temporary construction facilities is situated within forest area. Contractor will employ field ecologists during detailed route and topographic surveys of the transmission lines. They will perform habitat survey to confirm modified habitat is situated beneath the towers and right of ways in the final alignment; the field ecologists will also record any fauna observed in the project area. Contractor to site tower footprints to avoid the felling trees, cutting trees in ROW outside tower footprints will be kept to an absolute minimum and only be permitted when it is required for laying and stringing of conductors, to meet safety clearance requirements under the Electricity Rules.	Project meets the SPS requirements for legally protected areas before issue of related bidding documents. Final IEE/EMP documents consultations and reflects the mitigation measures required by and support for promotion/enhancement measures agreed with the protected area management Detailed designs minimize	PMD to comply with requirements prior to issue of bidding documents, approval of detailed design and before the commencement of works. PMD to supervise and monitor contractor to ensure their compliance with delegated requirements.	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor. PSC to help develop capacity of NEA and be responsible for reviews of Contractor's documentation.	Contractor to comply with requirements prior to approval of detailed design and before the commencement of works.	NEA counterpart funds Part of PSC budget Part of contract cost, include costs of implementing EMP as BOQ line

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		In preference to being cut, trees in ROW that can survive it will be pruned in preference to being cut, such that they might reestablish quicker following works. Contractor to ensure detailed design of transmission line incorporates lightening protection to minimize fire risks. Detailed design will need to include firefighting provision at substations with development of emergency response plan with basic fire training and training drills undertaken for substation staff in event of forest fire. Detailed design will have minimum height from ground level 6.1 m sufficient for safe passage fauna (i.e., the lowest point of a conductor between two adjacent towers to be above 6.1m from the ground) Contractor's detailed designs will be reviewed by the PSC International Biodiversity Specialist to confirm biodiversity impacts have been minimized before approval of detailed designs.	biodiversity impacts, reflect international good practice for "bird sensitive" design and respond to any concerns raised by Bird Conservation Nepal.				

Narijan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
Protected area management consultation and physical cultural resources management – see also site-specific EMP for Chobar-Lagankhel UG Line in Kathmandu Valley	Impacts on physical cultural resources of Kathmandu Valley Cultural, Religious and Archeological Sites from construction of Chobar-Lagankhel UG transmission line	NEA will ensure that all project components are sited and designed to avoid significant damage to physical cultural resources. NEA will ensure that none of the project components are situated within the boundaries or buffer zones of current or proposed World Heritage Sites or any other area of national archeological or cultural significance. Contractor will confirm during detailed route surveys that other than the pati and old well near Lagankhel Substation no other physical cultural resources of local importance fall within the right of way of transmission lines.	Detailed designs minimize impacts on identified physical cultural resources and respond to concerns raised by their users.	PMD to comply with requirements prior to issue of bidding documents, approval of detailed design and before the commencement of works. PMD to supervise and monitor contractor to ensure their compliance with delegated requirements.	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor. International Heritage Expert of PSC to help develop capacity of NEA and be responsible for reviews of Contractor's	Contractor to comply with requirements prior to approval of detailed design and before the commencement of works.	NEA counterpart funds Part of PSC budget Part of contract cost, include costs of implementing EMP as BOQ line

Barijan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
					documentation.		
Meaningful consultations with affected people and other concerned stakeholders.	Environment, health, and safety impacts and risks of the project in general, community could be disrupted and disturbed by works hence they need to be consulted and kept well informed about the project and its progress	NEA with the support of the PSC to prepare detailed communication/consultation plan upon loan effectiveness. NEA will not award any contract for project components until meaningful consultation requirements are confirmed as met by ADB. NEA to undertake additional meaningful consultations covering all project components with affected people and other concerned stakeholders such as Rural Municipalities as detailed in Section VI prior to the issue of bidding documents utilizing the agreed questionnaires. In particular, ensure all local affected communities within 500m of substations and transmission lines have been informed of the project through NEA local offices and contact with village heads, have had the opportunity to be actively involved in the design process and that any concerns raised have been duly addressed. For Kathmandu Valley component (Chobar-Lagankhel UG transmission line) assistance through the	Detailed communication/ consultation plan reflecting final EMP requirements developed upon loan effectiveness. Meaningful consultations for all project components undertaken, documented, and reported on in final IEE. Local communities and other	PMD to comply with requirements prior to issue of bidding documents and before the commencement of works. PMD to supervise and monitor contractor to ensure their compliance with delegated requirements.	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor. International Environment Expert to help develop capacity of NEA and prepare	Contractor to comply with requirements prior to the commencement of works, and then continue to remain actively involved with the local communities through ongoing consultations throughout contract duration. .	NEA counterpart funds Part of PSC budget Part of contract cost, include costs of implementing EMP as BOQ line

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Kathmandu Valley Development Authority may be sought. For all new substations requiring permanent water supply etc. NEA to consult with and seek the agreement of local communities to use any community resources (e.g., water supplies, village ponds) to identify any potential conflict. If additional demand may place stress on community resources plan for alternative sourcing for these resources for project needs. NEA to ensure the final IEE/EMP documents the consultations undertaken and demonstrates how concerns raised have been responded to. During detailed route surveys, Contractor to consult one-on-one with all affected persons within ROW of transmission lines as well as all persons occupying properties in close proximity to the substations up to 500m and within the ROW up to 50m of the transmission line alignment, to seek their views and respond to individual environment, health, and safety concerns about alignment. Obtain no objection from private landowners.	concerned stakeholders kept informed throughout project implementation. Details of ongoing consultations, including photos and records of participants (including gender) documented and included in monitoring reports.		detailed communication/consultation plan.		

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Contractor to consult with and seek the agreement of local communities on their proposed locations for any temporary construction workers camps, site offices, storage areas, and areas for waste management, etc. Contractor to consult with and seek the agreement of local communities to temporarily use any community resources (e.g., water supplies, village ponds) during construction to identify any potential conflict, if additional demand may place stress on community resources plan for alternative sourcing for these resources for project needs. Contractor to communicate at least four weeks (one month) prior to the commencement of works, advance notice to local communities within 500m of substations and transmission lines verbally through NEA local offices and contact with village heads and through notices, pamphlets or similar in Nepali about the agreed schedule of and details of planned construction works in their area to help					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontracto r	
		manage any disruption and disturbance and potential conflicts with local communities. Contractor to continue to undertake one-on-one consultation with affected persons, especially those within ROW of transmission lines and within at least 20m of new substations who will be most impacted to keep them fully informed of the nature of works and latest schedule, notifying them at least four weeks (one month) prior to the commencement of works of intended start date and schedule. NEA and Contractor to ensure, in the context of the COVID-19 pandemic, that all consultations are carried out following latest national COVID-19 requirements and WHO social distancing and hygiene guidelines as detailed in Appendix 8 of the IEE. Consultations undertaken during project implementation will be documented as reported in either final/updated IEE or attached to periodic monitoring reports.					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
Obtain national EIA/IEE approvals, and other EHS permits and licenses	Environment, health, and safety impacts and risks of the project in general	NEA to ensure all national EIA/IEE required are approved by the responsible authority prior to the start of any bidding process. Contractor to comply with the conditions of the national EIA/IEE, if there is any conflict between the measures set out in this EMP and the national EIA/IEE conditions most stringent provision will take precedence. Contractor to acquire all other national EHS permits and licenses required by national laws and regulations, ensuring that these are all obtained before start of related works, including enabling works.	National EIA/IEE clearances obtained prior to the issue of bidding documents. 100% of applicable clearances, permits and licenses obtained prior to the start of works. Copies of clearances, permits and licenses to be submitted with monitoring reports.	PMD to comply with requirements prior to issue of bidding documents and start of any works. PMD to supervise and monitor contractor to ensure their compliance with delegated requirements.	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor.	Contractor to comply with requirements prior to the commencement of works, and to comply with any conditions imposed throughout contract duration. .	NEA counterpart funds Part of PSC budget Part of contract cost, include costs of implementing EMP as BOQ line

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
Update and disclose IEE prior to contract award, update as required to reflect detailed designs.	Environment, health, and safety impacts and risks of the project in general	NEA to update the IEE to reflect additional meaningful consultation and national environmental clearance conditions for ADB clearance and disclosure prior to contract award. NEA to review the final IEE following the completion of the detailed designs and update it, as required, to reflect the detailed design for all project components, and obtain ADB's clearance before the commencement of any works, including enabling works. If a change in project scope or design occurs during project implementation or if unanticipated impacts are identified at any point during project implementation NEA to inform ADB and, if deemed appropriate, NEA will update the IEE for clearance and disclosure by ADB. Project components having associated facility unable to avoid significant irreversible impacts post-mitigation on protected areas, natural and critical habitat do not qualify for financing under this project. NEA will ensure all associated facility of the project comply with national laws and regulations, and are	Updated IEE cleared and disclosed by ADB prior to contract award. IEE updated, as required, to reflect the detailed design for all project components prior to the start of any works. Final IEE, any subsequent updates to it, and other environmental safeguards documentation are locally disclosed.	PMD to comply with requirements prior to issue of bidding documents and before the commencement of works. PMD to supervise and monitor contractor to ensure their compliance with delegated requirements.	PSC to supervise, monitor, and assist PMD in ensuring their own compliance. PSC to support PMD in finalizing and updating IEE/EMP documentation.	Contractor to immediately inform NEA if any unanticipated impacts are identified at any point and make a copy of the latest IEE available at the project sites.	NEA counterpart funds, including costs of printing Part of PSC budget Part of contract cost, include costs of implementing EMP as BOQ line

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		consistent with SPS requirements by requiring them to comply with this EMP. NEA to locally disclose in a timely manner the final IEE, any subsequent updates to it, and other environmental safeguards documentation by posting them on the NEA website and ensuring full copies of the latest IEE and its executive summary translated into Nepali are available at all local NEA offices and project substations. Notices will also be placed on noticeboards at the project sites and local NEA offices and pamphlets should be distributed in the project areas in Nepali, informing of the main findings of the IEE and the availability of the IEE and reports with notice given that help with their translation into Nepali and affected persons' dialects will be extended free of charge on request.					
Bidding and contract documentation, contractor, and subcontractor	Environment, health, and safety impacts and risks of the project in general	NEA to ensure the final EMP cleared by ADB is included prior to the issue of bidding documents and contract award. NEA will ensure the requirement to comply with the final EMP forms an integral and binding part of the contract, including appropriate incentives and/or penalties for (non-)compliance related to their	Final EMP cleared by ADB and related provisions included in all bidding and signed contract documentation.	PMD to comply with requirements prior to issue of bidding documents and during	PSC to supervise, monitor, and assist PMD in ensuring their own compliance, reviewing	Contractor to comply with requirements throughout contract implementation, ensuring adequate budget for	NEA counterpart funds Part of PSC budget

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
management.		environment, health, and safety management. Contractor will preferably have in place corporate environment, health and safety policies and corporate environment, health, and safety management system certifications, such as, ISO 14001 for environment, ISO 45001 for health and safety, or equivalents. Contractor will comply with all relevant provisions of the final EMP and any updates to it following detailed designs or in response to any unanticipated impacts, they will be responsible for implementing and budgeting for all the measures required. Contractor will comply with any corrective action plan required and cover the costs where corrective action is required due to non-compliance on behalf of the contractor, its subcontractors or third parties. Contractor will ensure all its subcontractors and third parties, irrespective of being formally or informally employed, also comply with the final EMP and any updates to it, as well as their own CEMP and H&S Plan, and	No breaches of final EMP by contractor, subcontractor or third parties with prompt corrective action taken if it is required.	procurement process.	bidding and contract documents to ensure they reflect requirements.	implementing final EMP is included in their contract cost.	Part of contract cost, include costs of implementing EMP as BOQ line

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		that this responsibility is cascaded down any chain involved. Contractor will not engage in any activities described on the ADB Prohibited Investment Activities List in Appendix 5 of ADB's SPS (2009) Contractor to ensure no persons under 18 are employed on the project. Contractor will put in place appropriate incentives and/or penalties for (non-)compliance by workers related to PPE, prohibition on firewood and NTFPs collection and fishing, hunting, or poaching by workers.					
Trainings and awareness raising activities.	Environment, health, and safety impacts and risks of the project in general.	NEA with the support of the PSC to prepare detailed training plan upon loan effectiveness elaborating how training and awareness raising activities required by the final EMP will be conducted. EHS management: NEA with support of the PSC to conduct training sessions on EMP implementation for	Detailed training plan reflecting final EMP requirements developed upon loan effectiveness. Trainings and awareness	PMD to comply with requirements throughout project implementation, including conducting training sessions and ensuring	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision	Contractor to comply with requirements throughout contract implementation, including conducting training sessions and ensuring	NEA counterpart funds Part of PSC budget

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		all those with management responsibilities under it to clarify national and ADB SPS (2009) requirements, requirements at each stage of the project, roles and responsibilities, and, record keeping and reporting requirements. NEA with support PSC to conduct training sessions on GRM operationalization for all those with responsibilities under it, including the nominated PMD Community Engagement/GRM Officer, and all members of the grievance redress committee. Contractor to ensure all members of its project management team, environment safeguards team, design team, construction management team, and community engagement/GRM officers attend NEA trainings. Training of all PMD 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 of old equipment with SF6	raising delivered in accordance with the plan. Contractor and construction workers fully aware of their responsibilities under EMP through training. Details of training and awareness raising sessions, including photos and records of participants (including gender) documented and included in monitoring reports.	relevant staff attendance. PMD supervise and monitor contractor to ensure their compliance with delegated requirements.	and monitoring of the contractor. PSC to develop training materials for NEA, act as resource person to deliver them, and ensure relevant specialists' attendance.	relevant staff attendance.	Part of contract cost, include costs of implementing EMP as BOQ line Indicative costs for trainings and awareness raising are included in the EMP budget table

Parijat

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Construction workers: Contractor to conduct training for construction management and provide all workers and visitors on-site, irrespective of them being formally or informally employed by contractor, subcontractor or third-party with an environmental, health and safety induction before being allowed on-site including do's and don'ts in relation to construction site, temporary workers camps, local communities, protected areas, etc. Contractor to ensure topics covered by training and induction will include but not be limited to: good housekeeping at all times; environmentally sound waste management practices; hygiene and communicable disease prevention including COVID-19 and HIV/AIDS; snake and rodent bites and precautionary measures for avoidance i.e. avoid work after rain, flood, and in the crop ripening seasons, caution while putting hands in holes; sexual exploitation, abuse and harassment prevention; culturally acceptable practices; biodiversity conservation awareness; fire safety prevention; prohibition on firewood and NTFPs collection by workers; prohibition on fishing, hunting, or poaching by workers;					

Banjara

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		heritage conservation awareness; chance find procedures; OHS, including use of PPE; etc. Contractor to conduct training for construction management and regular drills involving workers irrespective of them being formally or informally employed by contractor, subcontractor or third-party on emergency preparedness and response procedures in case of an environmental or health and safety incident including spillage, fire, natural disaster, disease outbreak etc. 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 the scenario of potential or confirmed COVID-19 infection on-site. Contractor to continue to deliver short environmental, health and safety refresher sessions to construction management and all workers on a monthly basis throughout construction period, and cover pertinent environmental, health and safety topics on daily basis in toolbox talks. Contractor to ensure workers with a specific role have attended specialized health and					

Banjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		safety trainings related that role e.g. first aiders, fire safety officers, as well as ensuring workers have task-specific trainings for working at height, working with electricity, etc. Community awareness: Contractor to undertake construction safety community awareness raising activities in local affected communities within 500m of substations and transmission lines prior to construction. NEA to undertake electrical safety community awareness raising activities in local affected communities within 500m of substations and transmission lines prior to construction, awareness raising activities to be repeated on completion of construction; to include electrocution risks, EMF, corona noise, etc.					
Detailed design.	Environment, health, and safety impacts and risks of the project in general	NEA and Contractor to address all site-specific measures detailed in this EMP with regards biodiversity and physical cultural resources as well as other sensitive	NEA approved detailed designs minimize impacts and	PMD to comply with requirements prior approval	PSC to supervise, monitor, and assist	Contractor to comply with requirements prior to	NEA counterpart funds

Banjara

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		receptors during the detailed design, as well as ensuring the detailed designs reflect international engineering best practice/ good EHS practices. Contractor's detailed designs will be reviewed by the PSC to confirm that all measures required by the final EMP have been adequately incorporated and that they reflect international engineering best practice/good EHS practice before they are approved by NEA. Disaster risk management: During detailed route survey identify presence of any floodplain, waterlogged or unstable land, avoid locating any project components in such locations, including areas of the Terai that get waterlogged when temporary inundation occurs during the monsoon. Select an appropriate foundation design for substations and towers considering climatic factors such as wind, geological factors such as seismic risk, and hydrological factors	risks on environment, health and safety during construction and operation & maintenance stages.	of detailed design. PMD to supervise and monitor contractor to ensure their compliance with delegated requirements.	PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor. PSC to review detailed design and confirm in accordance with final EMP and reflective of international engineering best practice/good EHS practice.	approval of detailed design.	Part of PSC budget Part of contract cost, include costs of implementing EMP as BOQ line

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		such as high groundwater table or karst in the project component locations. Given high seismic risk across the project area, design of all substation and tower foundations and any structural components (e.g., buildings) to consider seismic zone, main frontal thrust, main boundary thrust etc. and be checked for seismic safety by the design team as well as by an independent expert, separate to the design team, to confirm that international good practice seismic design standards are met. Buildings, transmission towers, and conductors to incorporate climate adaptation measures as per the CVRA, including to withstand extreme temperatures and gale force wind speeds, at minimum equal to upper end of gale conditions on Beaufort scale (40 knots) given 30 knots experienced during the 31 March 2019 tornado event in Nepal. Consider placement of equipment within substations to avoid water logging in operation & maintenance, ensure placement above the maximum flood level (allowing for climate change) and incorporate adequate					

Barijan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		drainage design to avoid waterlogging during the wet season. Drainage will be designed so that discharge from substation site is no more than greenfield runoff rates; so as not to exacerbate flooding on land which is outside of the substation/downstream. Set all transmission towers back by at least 100m from the edge of river banks and irrigation canals. Detailed design to avoid locating any towers in river beds and irrigation canals, tower design at crossing locations (single wire spans) to keep tower footing away from the river and irrigation canals by 100m. In the event towers sited in locations that get waterlogged when temporary inundation occurs during the monsoon cannot be avoided, they will be of suitable construction and raised above the high-water level. Pollution risk management:					

Hanjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Use of PCBs will be prohibited in all new transformers and any other project facilities or equipment provided by the project. Equipment purchased by NEA or Contractor for use on the project is to be accompanied by letter from the manufacturer stating that it is guaranteed PCB free and to be labelled as PCB free before its installation. Contractor to provide NEA with material data sheets for insulating oil meeting technical specifications for use in new transformers. During detailed route survey identify presence of any surface water bodies including rivers/ponds and groundwater sources including springs/wells/pumps/water spouts and confirm if any are used by local communities for drinking water. Contractor to coordinate with Department of Water Resources and Irrigation and relevant irrigation authority where ROW crosses rivers and water channels to obtain their no objection. Detailed design of substations to locate new transformers; storage areas; and septic tanks/soak away ideally 500 m from any					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		surface waterbodies and groundwater sources but at least 100m to reduce pollution risk. If closer placement is required due to substation's proximity to surface waterbodies and groundwater sources, further assessment to be carried out by Contractor to demonstrate using source-pathway-receptor model that there will be no adverse impact on aquatic ecology or human health. Detailed design of transformers and fuel, oil chemical, and waste storage areas to incorporate impermeable concrete surface bunded to 110% volume which is not connected to the drainage system to collect spills and leaks; ideally storage areas to be 500m to water sources (surface water and groundwater wells, springs, water spouts etc.) but if this is not possible minimum distance is to be 100m. Detailed design of fuel, oil chemical, and waste storage areas to provide for a covered storage area of sufficient size to accommodate all anticipated storage requirements, ensure storage areas have the ability to be locked, are well-ventilated and will not reach extreme temperatures.					

Nepal Electricity Authority

Ranjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Substation detailed design to incorporate adequate drainage; no drainage water will be permitted to discharge direct to surface water, oil interceptors are to be fitted on all drainage to catch oil spill. Detailed design of substations to minimize cut and fill in order to reduce the extent of earthworks and thus dust generation during construction. Detailed design of substations to ensure operation noise will be limited to the following as 1 hour LAeq: (i) 70 dB(A) at the site boundary; (ii) at residential properties, 55 (day) and 45 (night) dB(A) in urban areas and 45 (day) and 40 (night) dB(A) in rural areas as defined by Nepal regulations; and (iii) at "peace areas" such as schools as defined by Nepal regulations, 50 (day) and 40 (night) dB(A) – if these levels are already exceeded by the background, the Contractor will ensure that the noise standards are met by the project design alone and/that substation operation will not result in an increase of 3dB(A) above background levels.					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Detailed design of transformers and other noise sources to locate them as far as practical from the substation site boundary since noise diminishes with distance, at minimum given transformer noise is generally in the range 60-80 dBA they are to be located at least 10m from substation site boundary – if this is not possible Contractor must carry out noise calculations (modelling) to demonstrate that site boundary levels can be met. If any properties are within 100m of the substation site boundary then baseline measurements must be carried out during detailed design and noise calculations (modelling) considering low frequencies associated with transformer hum undertaken by the Contractor to demonstrate that these noise levels will be met. If noise levels cannot be met through siting alone detailed design to incorporate acoustic barrier designed to international good practice around either the noise source and/or substation site boundary to attenuate					

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		noise to level such that noise levels will be met. Health and safety: Use of any asbestos containing materials is prohibited. Include in the design of all substations and transformers within the substation a secure wall or fence with lockable entry featuring written and visual warning signs to include the ISO 7010 "Hazard Type: Electrical Symbol" warning of the risk of electrocution. Include in the design of all towers anti-climb features together with posting of written and visual warning signs to include the ISO 7010 "Hazard Type: Electrical Symbol" warning of the risk of electrocution. Contractor to ensure detailed design of transmission lines incorporates lightening protection to minimize fire risks. Detailed design of substations to include fire safety measures including detector, alarm, and firefighting equipment in accordance					

Karijan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		national regulations and IFC EHS Guidelines on OHS. Indoor work areas at substations to be well ventilated and well-lit in accordance national regulations and IFC EHS Guidelines on OHS. Detailed design of substations to ensure EMF levels within the substation boundary are within international good practice levels as per International Commission on Non-Ionizing Radiation Protection (ICNIRP https://www.icnirp.org/cms/upload/publications/ICNIRPemfgdl.pdf) (reference and peak values) for the occupational exposure; in areas where EMF levels could be exceeded posting of written and visual warning signs. Detailed design of substations and transmission lines to ensure EMF levels at all regularly occupied properties is within international good practice levels as per International Commission on Non-Ionizing Radiation Protection (ICNIRP) (reference and peak values) applicable to the public exposure. Use of shielding equipment/materials to decrease electromagnetic field exposure.					

Nanjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Establish applicable right of way and safety clearance corridor in accordance with the Electricity Rule. During detailed route survey identify the presence and use of any structures found in the (i) right of way and (ii) safety clearance corridor. Consider re-siting of angle point towers such that any structures are outside the ROW or if not possible outside the safety clearance corridor. If it is not possible to avoid regularly occupied structures in the safety clearance corridor these are to be relocated with adequate compensation in accordance with the Resettlement Plan. Such properties must be relocated, and applicable compensation provided by NEA prior to the start of any works. Consider grounding roofs and other metallic surfaces on any properties remaining within ROW to avoid induced current and electricity related accidents. During detailed route survey identify presence of any existing utilities such as power lines, communications, streetlights, groundwater pumps, water spouts as well as through consultation with service providers (electric, water, gas, telecoms etc.)					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		In cases where excavation works may be needed, including drilling or open trenching for underground cables, underground utility scans using a Cable Avoidance Tool (CAT) or equivalent must be undertaken by the Contractor to identify any services. Contractor to coordinate with operators where ROW crosses existing utilities to obtain no objection. Detailed design to consider the risk of damage to utilities and allow for sufficient vertical and horizontal safety clearances to minimize health and safety risks as per the Electricity Rules, and crossings for communications as per Electricity Regulation 1993. Pit latrines and disposal of untreated sanitary wastewater to surface or groundwater is prohibited. Detailed design of substations to include adequate sanitation and welfare facilities for all NEA workers to be posted at or visiting the substations including indoor kitchen, eating and sleeping facilities (if applicable) and adequate number of indoor toilets/washrooms with a hot and cold running water supply which are					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		connected to either existing sewerage system or to septic tank with soak away. Disposal of worker generated waste (e.g. plastic bottles) on-site is prohibited and adequate waste storage areas to be incorporated into the detailed design. Composting of food waste may be permitted on-site if detailed design incorporates enclosed composting facilities (enclosed to avoid attraction of vermin etc.) located away from accommodation and any properties outside the site boundary. Incineration may be permitted on-site if detailed design incorporates an enclosed, small volume solid waste incinerator with stack and pollution control that is designed for residence time and temperatures that minimize incomplete combustion for waste disposal at substation, to reduce the volume of solid waste to be removed off-site given lack of suitably engineered and licensed sanitary waste facilities in rural municipalities. Source of drinking water that meets drinking water standards to be provided to substations. If substation is in district which suffers from arsenic contamination of drinking water, groundwater must not be					

Kanjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		used, and alternative source must be identified. If any surface or groundwater sources are proposed for use in substations, Contractor is to undertake a baseline water quality sampling per EMoP (Table 10.B) to confirm its suitability for use. If drinking water standards are not met, detailed design to consider alternative source or include water treatment facilities at the substation to facilitate safe drinking water supply. Provide a dedicated shelter to security guards, shielding them from rain, wind, and extreme (hot and cold) temperatures. Greenhouse gas emissions: Use of chlorofluorocarbons (CFCs) including halon is prohibited. Detailed design of GIS substations will comply with international norms and standards for handling, storage, and management of SF6. SF6 insulated equipment will be tested and guaranteed by the supplier at less than 0.1% leakage rate.					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontracto r	
		SF6 emergency response plan to be prepared by contractor for construction, NEA in relation to operation to deal with event of an accidental leak.					
Planning for on-site environment , health, and safety managemen t.	Environment, health, and safety impacts and risks of the project during construction in general.	NEA and Contractor to address all site-specific measures detailed in this EMP with regards biodiversity and physical cultural resources as well as other sensitive receptors before commencing construction works, including any enabling works, ensuring that all pre-construction preparations reflect international engineering best practice/good EHS practices. Contractor's pre-construction documentation will be reviewed by the PSC to confirm that all measures required by the final EMP have been adequately incorporated and that they reflect international engineering best practice/good EHS practice before they are approved by NEA. Contractor to prepare and submit a Construction Environmental Management Plan (CEMP) to NEA for approval, for each	CEMP and topic- and site-specific sub-plans including CPPP, CWMP, CTMP, BMP, HMP, CFP, CHSMP, CEPRP all prepared and approved prior to any construction works, including enabling works.	PMD to comply with requirements including approval of Contractor's pre-construction documentation, seeking review and comment of other concerned stakeholders as appropriate e.g. for protected areas etc. PMD to supervise and monitor	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor. PSC to review Contractor's pre-construction documentation and confirm in	Contractor to comply with requirements prior to any construction works, including enabling works.	NEA counterpart funds Part of PSC budget Part of contract cost, include costs of implementing EMP as BOQ line

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		works package. CEMP to include details on how the Contractor plans to implement the construction mitigation measures specified in the final EMP, and the relevant parts of the IFC EHS General Guidelines including the Construction and Demolition section, and IFC EHS Electric Power Transmission and Distribution Guidelines. The CEMP will also identify the temporary construction facilities needed and their location e.g., laydown and storage areas, workers facilities, etc. Contractor to keep CEMP as a living document, to be updated as required and re-approved by NEA if any changes in construction methods, site conditions etc. Land take: Ensure relocation and compensation of any affected persons within the ROW has been paid and ensure effective relocation of any households living within the safety clearance corridor (Electricity Rules) has taken place prior to any construction work.		contractor to ensure their compliance with delegated requirements. PMD to ensure checklist of all pre-construction measures is cleared before giving go ahead for works to Contractor.	accordance with final EMP and reflective of international engineering best practice/good EHS practice. PSC to verify checklist of all pre-construction measures is cleared before NEA gives go ahead for works to Contractor.		

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Biodiversity management: Contractor to strictly locate all temporary construction facilities outside of forest areas, all temporary workers camps unless within substation boundaries are to be located at least 500 m for forest areas. Location of related project facilities is to be identified by contractor, PSC international biodiversity expert to review if locations are suitable prior to NEA approval. Include in CEMP or site-specific BMP emergency fauna rescue and handling procedure, including contacts of protected area management, nearest veterinary etc. Physical cultural resources management (chance finds): Contractor to strictly locate all temporary construction facilities at least 100m from any identified physical cultural resource e.g., temple. NEA to develop a Chance Find Procedure (CFP) to be followed by contractor as part of their CEMP prior to commencement of any works, including enabling works, to address					

Nanjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		the event any physical cultural resources (including fossils) are found during works. CFP is to include the following procedures: If suspected physical cultural resources are encountered, halt all works at the find site immediately. The find should be assessed by a competent DOA Official, and procedures to avoid, minimize or mitigate impacts to such physical cultural resources to be agreed in writing with them. Work will not resume until the procedures to avoid, minimize, or mitigate impacts to the physical cultural resources have been agreed with DOA and confirmed by them in writing to have been implemented in full. If avoidance is not feasible, and no alternatives to removal of the physical cultural resources exist, thorough cost-benefit assessment need to be carried out to assess whether the project works should continue or stop at site. If the project benefits outweigh the anticipated cultural heritage loss from removal from site, following clearance of ADB the physical cultural resources are to be removed and preserved					

Nepal Electricity Authority

Kanjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		using the best available technique in accordance with relevant national heritage protection laws and regulations as well as international best archeological practice. Records to be maintained of all finds, including chain of custody instructions for movable finds. Construction workers must be made aware of the chance-find procedure and the types of finds (including fossils) to be reported through training and induction before the commencement of any works. Pollution risk management: The Contractor will prepare for NEA approval a construction pollution prevention plan (CPPP) as part of the CEMP 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 in accordance with national laws and					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		regulations and the EHS General Guidelines prior to commencement of any works. The Contractor will prepare for NEA approval a Construction Waste Management Plan (CWMP) as part of the CEMP for dealing with all solid and hazardous waste generated in an environmentally sound and safe manner in accordance with national laws and regulations and the EHS General Guidelines section on Waste Management prior to the start of any works. Contractor to undertake air quality monitoring per the EMoP (Appendix 10, Table 10.B) to confirm current background levels in the project area at least one week prior to the commencement of any actively on-site. Plan construction works in the vicinity of waterbodies, considering erosion issues and surface water pollution risk. If any surface waterbodies or groundwater sources within 100m, Contractor is to undertake a baseline water quality sampling per EMoP (Table 10.B) to confirm their current water quality status at least one					

Kanjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		week prior to the commencement of any actively on-site. Contractor to schedule, as far as practical, earthworks at substation sites and installation of towers during the dry season to minimize exposed areas subject to erosion by surface water runoff. To inform development of the CPPP in relation to noise management, the Contractor will be required to measure and confirm the distance from their construction works to sensitive receptors during the detailed design, to confirm if the noise standards can be met based on their construction methods or temporary acoustic barriers are required. Contractor to undertake noise monitoring per EMoP (Table 10.B) to confirm current background noise levels in the project area at least one week prior to the commencement of any actively on-site. Construction methods to ensure construction noise will be limited to the following as 1 hour LAeq: (i) 70 dB(A) at the site boundary; (ii) at residential properties, 55 (day) and 45 (night) dB(A) in urban areas					

Nanjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		and 45 (day) and 40 (night) dB(A) in rural areas as defined by Nepal regulations; and (iii) at "peace areas" such as schools as defined by Nepal regulations, 50 (day) and 40 (night) dB(A). If noise levels may be exceeded, Contractor to erect temporary acoustic barrier around either the noise source and/or site boundary to attenuate noise to level such that noise levels will be met. For any sites where piling or blasting may be necessary for substation or tower foundations, Contractor to identify properties at risk of vibration damage, undertake a through structural survey, supported by photographic evidence of any properties at risk, and determine whether such buildings may require the installation of vibration monitors during construction to monitor movement. Health and safety: For each contract package, the Contractor is to undertake a H&S risk assessment through a facilitated workshop to be attended by PMD, PSC and the Contractor during the					

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		detailed route survey so that it can inform both the detailed design and pre-construction preparations. H&S risk assessment to consider both occupational and community H&S risks resulting from the construction and operation & maintenance stages of the project. Informed by the H&S risk assessment, Contractor to prepare a Construction Health and Safety Management Plan (CHSMP) for each package/lot including site-specific measures as needed for each construction site. CHSMP will address both occupational and community H&S risks and adherence to national health, safety labor laws and regulations. Measures reflected in the CHSMP will be in accordance with the EHS General Guidelines sections on Occupational and Community Health and Safety and the Electric Power Transmission and Distribution Guidelines. Contractor to keep CHSMP as a living document, to be updated as required and re-approved by NEA if any changes in construction methods, site conditions, in response to accident, near miss etc.					

Banjara

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		In the absence of NEA records to confirm transformers are PCB free (ones installed post-1990 should have records, NEA to facilitate access to data archive) all existing transformers already in-situ must be assumed by the Contractor for health and safety purposes to contain PCBs and if needing to be disturbed by them the oil must be sampled and analyzed following UNEP Guidelines for the Identification of PCB and Materials Containing PCB and a health and safety risk assessment and plan prepared referring to the measures in UNEP (2002) PCB Transformers and Capacitors: From Management to Reclassification and Disposal. Provide workers with training on PCBs and their safe handling and disposal. Label any equipment or container containing PCBs found in existing transformers and other project equipment and unless being retained in-situ replace it with new PCB free equipment under the project. NEA must ensure appropriate transport, storage, decontamination, and disposal of redundant contaminated units; disposal should involve facilities capable of safely transporting and disposing of hazardous waste containing PCBs. A hazardous waste					

Ranjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		management plan to be prepared for handling PCBs. Assess surrounding soil exposed to PCB leakage from equipment removed or retained in-situ and implement appropriate removal and / or remediation. CHSMP to include a Construction Emergency Preparedness and Response Plan (CEPRP) including communication systems and protocols to report an emergency situation (health emergency, work-related accident, traffic accident, accident involving the community, natural disaster, fire especially forest fire, virus outbreak etc.). Contractor to 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 PMD within 24 hours of occurrence with a response plan detailing the incident and how its reoccurrence will be avoided. NEA to then report any lost time or fatal incidents to ADB within 48 hours. Record of all incidents and response taken should include date, time,					

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		details of incident, treatment given and outcome, and lessons learnt for the future. CHSMP and its CEPRP are to be submitted for approval of NEA prior to commencement of any works, including enabling works In undertaking H&S risk assessment and preparing CHSMP and CEPRP adequate attention will be given to the risks associated with COVID-19 pandemic and other communicable viral diseases. National restrictions for containing the spread of COVID-19 must be complied with and Government of Nepal (https://covid19.mohp.gov.np/) and ADB guidance (https://www.adb.org/publications/safety-well-being-workers-communities-covid-19) is to followed, as well as further guidance detailed in Appendix 8. Contractor will provide adequate sanitation and welfare facilities including hand washing and clean PPE in sufficient quantity are provided on-site and at accommodation; Contractor will also consider the ability of communities to comply with protective measures such as regular hand washing and the local health care facilities' capacity to deal with any infections agreeing with the with nearest					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Health Center and/or Hospital for emergency cares of workers. Particular attention must be paid to accommodation of workforce given the transient nature of work on transmission lines, to avoid spreading any virus between communities. CEPRP must include response flow chart and contact details to deal with any construction worker or community member being diagnosed with COVID-19 during the course of the works. To limit contacts and hence contamination risk, the same workers should be grouped in accommodation, transport, and work teams. Medical insurance will be provided by Contractor for all workers with sick leave allowance to ensure symptomatic workers do not attend site; Contractor will avoid no-work-no-pay policies, whereby by fear of not getting paid workers would be tempted to report to work and hide any symptoms, creating more risk for the wider workforce and community. Given the unprecedented nature of responding to COVID-19, public health officials/experts must be consulted in undertaking the risk assessment and management planning for COVID-19.					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Traffic management: NEA and the Contractor to consult with and seek the agreement of the irrigation authority to use the existing irrigation access roads for the purposes of construction. For all works on or adjacent to public roads, the Contractor will prepare for NEA approval a Construction Traffic Management Plan (CTMP) appropriate to the pedestrian and vehicular traffic flows on the road as part of the CEMP in consultation with relevant local authorities/traffic police to ensure proper execution of traffic controls including where temporary blockage of the road during installation is required for health and safety purposes and ensure that highly visible guides, advance warning signs or flag persons are in place to direct pedestrian and vehicular traffic. Damage to crops, structures, and utilities: Contractor to schedule works affecting agricultural land outside the cropping season.					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Contractor to maximize use of existing substation compounds for temporary construction facilities (e.g., laydown and storage areas, workers facilities etc.) Contractor to locate temporary construction facilities as much as possible on uncultivated land (not natural habitat) to minimize disturbance to cultivated lands. Contractor to locate temporary construction facilities (e.g., laydown and storage areas, workers facilities etc.) at least 500m away from residential areas/villages within rural areas, at least 500m from surface waterbodies, groundwater wells/springs/water spouts, and 100m from other sensitive receptors (e.g., individual houses, schools, clinics, temples, touristic areas etc.) avoiding land which is steeply sloping or in floodplain/waterlogged. Construction methods to be selected to minimize risk of damage to roads, utilities, structures, drains etc. Contractor to plan for using appropriate scaffolding or overhead bamboo frames during stringing works crossing roads, irrigation canals, utilities, structures, or					

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		drains to minimize traffic disruption, accident risk, and property damage. For existing roads, irrigation canals, utilities, structures, drains etc. photographic and/or structural pre-condition surveys are to be completed by the Contractor and agreed with NEA and property owners prior to any works, including enabling works. These must be documented in a pre-project condition report submitted to NEA, which will serve as baseline in case any damage to property occurs Contractor will be required to restore any property damage that is caused by their works including damage caused by heavy construction traffic using access roads to at least pre-project condition at their own cost. Contractor to avoid piling or blasting and other vibration inducing activities as much as possible; 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. Risk may be high if structures previously damaged during earthquake and not repaired. If risk of structural damage to properties identified					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		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 condition at their own cost.					
Employment of staff for construction	Temporary employment opportunities, both skilled and non-skilled laborers will be required.	Contractor to abide by the Nepal Labor Code and labor regulations Contractor must prohibit child labor (under 18 years old). Contractor should not discriminate in employment Contractor should proactively encourage employment from local communities where appropriately skilled. Contractor should proactively encourage employment of women on the project where appropriately skilled. GRM will be available to workers for receiving and handling complaints about unfair treatment or unsafe living or working	No child labor has been recruited, as per detailed record of employment, and gender/age/origin analysis, provided in monitoring reports.	PMD to comply with requirements throughout project implementation. PMD supervise and monitor contractor to ensure their compliance with delegated requirements.	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor.	Contractor to comply with requirements throughout contract implementation.	NEA counterpart funds Part of PSC budget Part of contract cost, include costs of implementing EMP as BOQ line

Banjara

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		conditions, ensuring no coercion nor reprisal. Provide health/accident insurance for all workers (formal and informal) for the duration of their contracts. Contractor to allow a minimum number of sick leave as per Nepal law or 10 days per year, whichever is the higher.					
On-site enabling works, construction works, testing and commissioning of project components							
Biological Environment							
On-site pre-construction and construction activities	Impacts on biodiversity including Chure Conservation Area	Comply with CEMP during construction works Ensure clear demarcation of the working area and avoid encroachment outside the agreed corridor of impact. Trees are to be cleared during non-bird breeding season, if this not possible due to weather restrictions on access, trees cleared during breeding season to be checked by field ecologist for nests prior to clearance, if	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA and Contractor as determined	PMD to comply with requirements during construction. PMD to supervise and monitor contractor to ensure their	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision and	Contractor to comply with requirements throughout construction	NEA counterpart funds Part of PSC budget Part of contract cost, include costs of

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		present harvesting to be postponed until the young have fledged. Unnecessary use of machinery to be avoided to minimize disturbance to fauna. Revegetate any disturbed areas beyond footprint of substation and tower foundations to at least original condition through revegetation using native species etc. Construction of new access track is not allowed. Use will be made of existing access roads and tracks for transporting tower materials and machinery, in locations where access is restricted use of manual labor to transport, install and string the towers and lines traversing uncultivated land (not natural habitat) as much as possible to avoid damage to crops Prior to excavation for tower and substation foundation, area will be checked by ecologist for any signs of burrows etc. If determined to be occupied, only manual digging under the supervision of ecologist will be permitted. Excavated pits will be robustly fenced or covered so as to prevent fauna accidentally falling in, further an escape ramp will be	through regular site checks, photographic record etc. No outstanding biodiversity-related grievances from local communities.	compliance with delegated requirements.	monitoring of the contractor.		implementing EMP as BOQ line Indicative costs for purchase of bird diverters (excluding their installation) and support for the promotion and enhancement or protected areas are included in EMP budget table

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		provided to allow their escape – particularly in Chure Conservation Area. Keep written record, supported by photographs, of any animal casualties, including a cause of death if known. In wet conditions, minimize use of heavy machinery and consider temporary installation of removable steel plates to protect soil and its vegetation cover. Strict prohibition on construction workers to enter forest areas whilst working for the project. Strict prohibition on purchase, sale, and use of firewood, timber and NTFPs, hunting and poaching of fauna by workers. Contractor to undertake regular, compulsory awareness raising activities for all workers related to prohibitions including tool box talks, and posting of information and warning signs at site offices, worker camps, patrols by security guards employed by the Contractor, regular inspections of the worker camps, and, disciplinary procedures for any contravention by the workers.					

Banjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontracto r	
		Contractor to provide good standard of worker accommodation with heating and all meals to help discourage breaches of prohibition by the workers. Strict prohibition of fuelwood or timber being cut by the construction workers. Contractor and construction workers will be prevented from the use of firewood for cooking their food and heating etc. Contractor to provide alternative fuel source (e.g. kerosene/LPG, which will be stored in safe conditions) to communal kitchen and for heating of worker accommodation. Fuel will be stored outside of and refueling will take place close to forest or plantation areas to minimize the risk of fire. Contractor to provide fire-fighting equipment at work site with compulsory basic fire training for all workers and training drills undertaken in preparation for forest fire. In case of forest fire, Contractor to act swiftly so as to minimize impacts on the environment and human life.					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Remove and dispose of any identified invasive plant species in an ecologically sound manner.					
Physical Environment							
On-site pre-construction and construction activities	Changes in topography/ terrain as a result of earthworks, primarily at substations	Comply with CEMP during construction works Contractor to examine stability of tower locations before excavation. Balance cut and fill in the areas where leveling of sites is required. Carry out landscaping at each tower location, including bioengineering and slope protection work. On completion of works re-vegetate disturbed areas to avoid soil erosion. Restore temporarily used sites to at least their pre-project condition following works.	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA and Contractor as determined through regular site checks, photographic record etc.	PMD to comply with requirements during construction. PMD to supervise and monitor contractor to ensure their compliance with delegated requirements.	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor.	Contractor to comply with requirements throughout construction.	NEA counterpart funds Part of PSC budget Part of contract cost, include costs of implementing EMP as BOQ line

Banjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
			No outstanding topography/ terrain related grievances from local communities.				
On-site pre-construction and construction activities	Changes in ambient air quality - dust and suspended particulate matter from earthworks, and other pollutants from vehicular emissions, may affect ambient air quality with impacts on the health of workers and community.	Comply with CEMP, CPPP, and the IFC EHS General Guidelines in relation to air quality and avoid the occurrence of pollution incidents as far as practicable Require construction equipment and vehicles to meet national emissions standards, see Appendix 2 of IEE. Perform regular checks, upkeep, and maintenance of construction equipment and vehicles to keep them in good working order as per the manufacturer's specifications to meet emission standards. Keep log of maintenance undertaken. Sprinkle water during earthworks to avoid dust being dispersed by wind, cover with materials like gravel to minimize re-suspension of dust.	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA and Contractor as determined through regular site checks, photographic record etc.	PMD to comply with requirements during construction. PMD to supervise and monitor contractor to ensure their compliance with delegated requirements.	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor.	Contractor to comply with requirements throughout construction, keep required maintenance records and undertake ambient air quality monitoring in accordance with the EMoP	NEA counterpart funds Part of PSC budget Part of contract cost, include costs of implementing EMP as BOQ line

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Stockpiles of spoil and other dust generating materials to be kept to a minimum necessary to undertake works for the day Cover stockpiles with tarpaulin. Locate stockpiles at least 500m from residential property to avoid inconvenience to avoid inconvenience from fugitive dust and ensure they are enclosed by a fence or similar to minimize windblown dust. Minimize double handling and drop loads. Trucks importing loose raw materials or removing spoil to local approved disposal sites must be covered with tarpaulin to reduce dust generation, all trucks used are to be serviced and meet Nepal emission standards and belching of black smoke prohibited. Position any stationary emission sources (e.g., water pumps, diesel generators, compressors, etc.) as far as practical from sensitive receptors (houses, schools, clinics, temples, touristic areas etc.) Impose speed limits on construction vehicles to minimize exhaust and dust emissions along areas where sensitive receptors are	Monitoring confirms ambient air quality within national standards or no worsening of the baseline situation if already exceeded. No outstanding air quality-related grievances from local communities or workers.				

Banjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontracto r	
		located (houses, schools, clinics, temples, touristic areas etc.). Trucks transporting loose material will be covered. Limit engine idling to maximum 5 minutes. Sprinkle excavations, earthen access road, and material stockpiles with water during the construction period to 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. Clean dust from the access road after construction work is completed. Strictly prohibit the burning of wastes generated by project-related activities. Ensure workers working in close proximity to 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.					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
On-site pre-construction and construction activities	Changes in ambient noise and vibration levels - mobilization of heavy equipment and machinery, use of construction vehicles, and construction activities may increase ambient noise level. Exposure to high levels of ambient noise may affect hearing of workers or cause anxiety and disturbance to community.	Comply with CEMP, CPPP, and the IFC EHS General Guidelines in relation to noise and avoid the occurrence of pollution incidents as far as practicable Schedule construction activities so as to minimize nuisance to sensitive receptors (houses, schools, clinics, temples, touristic areas etc.) i.e., avoid works at night, on weekend, during holidays, school exam periods, etc. Select construction techniques and low noise generating machinery and equipment e.g. less than 55dBA sound pressure level at 1m, and stage noisy works to limit their duration to minimize noise and vibration Construction noise must be noise limited to the following as 1 hour LAeq: (i) 70 dB(A) at the site boundary; (ii) at residential properties, 55 (day) and 45 (night) dB(A) in urban areas and 45 (day) and 40 (night) dB(A) in rural areas as defined by Nepal regulations; and (iii) at "peace areas" such as schools as defined by Nepal regulations, 50 (day) and 40 (night) dB(A) – if these levels are exceeded the Contractor will be required to implement additional noise mitigation such as placing temporary	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA and Contractor as determined through regular site checks, etc. Monitoring confirms ambient noise within national standards or no worsening of the baseline situation if already exceeded.	PMD to comply with requirements during construction. PMD to supervise and monitor contractor to ensure their compliance with delegated requirements.	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor.	Contractor to comply with requirements throughout construction, keep required maintenance records and undertake noise monitoring in accordance with the EMoP	NEA counterpart funds Part of PSC budget Part of contract cost, include costs of implementing EMP as BOQ line

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		acoustic barriers around the works site to ensure that the noise standards are met and/or the construction works do not result in an increase of 3dB(A) above background levels. Use of piling or blasting and other vibration inducing activities are to be avoided. Structural or cosmetic damage caused by vibration to be repaired by Contractor to at least pre-project condition at their own cost. Require construction equipment and vehicles to meet national standards, see Appendix 2 of IEE– all trucks should carry fitness certificates issued by the Nepal Road Traffic Authority and renewed annually under the applicable regulations of Nepal. Fit all vehicles, machinery and equipment used in construction with exhaust silencers where the manufacturer's design allows this Perform regular checks and maintenance of construction equipment and vehicles to keep them in good working order as per the manufacturer's specifications to meet emission standards. Keep log of maintenance undertaken.	No outstanding noise or vibration-related grievances from local communities or workers.				

Nanjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Position any stationary emission sources (e.g., water pumps, diesel generators, compressors, etc.) as far as practical from sensitive receptors (houses, schools, clinics, temples, touristic areas etc.) Prohibit use of horn by construction vehicles Limit vehicle movement and offloading of construction materials to daytime in areas where sensitive receptors are located (houses, schools, clinics, temples, touristic areas etc.) transport of materials and spoil by truck will be limited to the daytime without hooting. Outside of Kathmandu Valley noisy construction activity (especially piling works) will take place between 6 am to 6 pm. Residents will be informed will in advance of the construction schedule for noisy activities. Impose speed limits on construction vehicles to minimize noise emissions along areas where sensitive receptors are located (houses, schools, clinics, temples, touristic areas etc.). Limit engine idling to maximum 5 minutes.					

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		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 80dBA for more than 8hours per day and ensure they wear it e.g. if using breakers. 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.					
On-site pre-construction and construction activities	Changes in quality of surface and groundwater – due to sediment laden runoff or spills/leaks of fuel, oil and chemicals used in construction works.	Comply with CEMP, CPPP, and the IFC EHS General Guidelines in relation to water quality and avoid the occurrence of pollution incidents as far as practicable. Follow General EHS Guidelines in relation to water quality for the use and storage of fuel, oil, and chemical including prevention and control of hazards associated with spill prevention, emergency response, spill clean-up and remediation. Establish dedicated fuel, oil, and chemicals stores on impermeable bunded area of 110% volume to avoid spills and leaks	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA and Contractor as determined through regular site checks,	PMD to comply with requirements during construction. PMD to supervise and monitor contractor to ensure their compliance	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision and monitoring	Contractor to comply with requirements throughout construction.	NEA counterpart funds Part of PSC budget Part of contract cost, include costs of implementing

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		contaminating soil and affecting water quality Avoid storage of fuel, oil, and chemicals in areas within 500m to water sources (surface water and groundwater wells, springs, water spouts etc.) to avoid direct contamination or contamination through run off, if this is not possible minimum distance is to be 100m. Place all equipment that may leak fuel or oil on drip trays it not sited on impermeable surface with 110% bunded capacity. Undertake refueling only on areas of hard protected soil, preferably bunded, at least 500m from surface water, but if this is not possible minimum distance to be 100m, with all drainage directed through oil interceptors. Provide spill response kit with sufficient absorbent materials (e.g. sorbents, dry sand, sandbags) on-site for soaking up any fuel, oil, or chemical leaks/spills. For transformers, follow the Spill Prevention Control and Countermeasures (SPCC) plan as recommended by United States Institute of Electrical and Electronics Engineer Inc. (IEEE) standard 908.	photographic record etc. No outstanding water quality-related grievances from local communities or workers.	with delegated requirements.	of the contractor.		EMP as BOQ line

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Undertake construction during the dry season as much as possible to minimize exposed areas subject to erosion by surface water runoff. Undertake all construction 100m either side of river crossings and in floodplain during the dry season to avoid flood risk, leading to accidents and/or water contamination. 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 sediment laden runoff shall not discharge directly to surface water but shall be discharged through sedimentation basin and oil interceptor. If water from excavations is pumped it must either be disposed of to an adjacent defined area of ground for percolation, or to waiting					

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		tanker trucks for proper disposal, it must not be disposed of 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. Cement will be stored in rented private storage facilities; enclosed and not exposed to the elements. Do not undertake any concrete mixing within 500m of surface water, if this is not possible minimum distance to be 100m. Provide portable sanitary facilities for construction workers, so as to avoid surface and ground water pollution. Locate these at least 500m away from surface water bodies including rivers/ponds and groundwater sources including springs/wells/pumps/water spouts, away from floodplain, any waterlogged land and shallow groundwater. Strict prohibition on open defecation and urination by construction workers; no use of pit latrines for worker camps.					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Toilets and washing facilities to be connected to existing sewerage system, septic tank (with soak pit) or as portable self-contained units for disposal of wastewater off site to sewage treatment works. No untreated wastewater is to be discharged direct to surface water or the ground. Construct adequate drainage with oil interceptors for all new substation sites according to detailed design; install adequate bunding to transformers and storage areas.					
On-site pre-construction and construction activities	Use of raw materials and generation construction waste	Comply with CWMP and with IFC EHS General Guidelines in relation to waste management. Import all materials from existing licensed sources and keep records of all materials used, and sources. Storage yards will be fenced. Prior to the start of works the contractor will ensure the waste management system is established at the construction sites and workers camps.	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA and Contractor as determined through regular site checks,	PMD to comply with requirements during construction. PMD to supervise and monitor contractor to ensure their compliance with delegated requirements.	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor.	Contractor to comply with requirements throughout construction, keep records in accordance with the EMoP	NEA counterpart funds Part of PSC budget Part of contract cost, include costs of implementing EMP as BOQ line

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Separate waste containers (drums, bins, skips or bags) will be provided for different types of waste. 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 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. Encourage recovery of recyclable wastes that could be reused or sold to recyclers, rather than disposing of it.	photographic record etc. No outstanding material use or waste-related grievances from local communities or workers. 100% wastes removed off site have been disposed of by licensed waste contractors who reused/recycled or disposed of it to suitably licensed waste management facility, as confirmed by documented full-				

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		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 drains, rivers, 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. Contractor may compost biodegradable kitchen scraps on site if of small volume in enclosed composting facilities (enclosed to avoid attraction of vermin etc.) located ideally 500m but at least 100m from water sources (surface water and groundwater wells, springs, water spouts etc.).	cycle transfer notes.				

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontracto r	
		Document all wastes removed off site 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 – for solid waste disposal this will need to be to Kathmandu, and for hazardous waste this will need to be to a neighboring country since no such facilities currently exist in Nepal. 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– in Kathmandu as no such facilities are existing in rural municipalities. Ensure any hazardous waste such as oily rags or old drums disposed of in suitably licensed hazardous waste facilities– out of country since no such facilities in Nepal.					
Socio-economic Impacts							

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
On-site pre-construction and construction activities	Changes to land use as substation compound and tower footing land is permanently lost and temporary crop loss during installation within the ROW	Compensate private land required for the project through acquisition or rental in agreement with the land and/or property owners. Permanent land acquisition and crops or private trees lost due to construction will be compensated according to the project Resettlement and Indigenous People Plan. Phase activities according to the agricultural cycle to allow farmers to harvest standing crops. Except for substations as mentioned in the IEE, no construction of access track is allowed, use will be made of existing access roads and tracks for transporting tower materials and machinery, in locations where access is restricted use of manual labor to transport, install and string the towers and lines traversing uncultivated land (not natural habitat) as much as possible to avoid damage to crops On completion of works restore all temporarily used sites to at least their pre-project condition following works; this will involve cleaning site of any debris or wastes, left over material and soil/rocks/sand, contaminated soil although this should have	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA and Contractor as determined through regular site checks, photographic record etc. No outstanding resettlement / economic-displacement / land-related grievances from local communities.	PMD to comply with requirements during construction. PMD to supervise and monitor contractor to ensure their compliance with delegated requirements.	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor.	Contractor to comply with requirements throughout construction.	NEA counterpart funds Part of PSC budget Part of contract cost, include costs of implementing EMP as BOQ line Budget for compensation included in Resettlement Plan and Indigenous People

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		been avoided through EMP measures; revegetation if required; drainage if required; local topographical adjustments; addition of good quality soil if the latter was eroded/removed by construction works; etc. Follow detailed design drawings and implement careful construction practices to avoid damage to existing structures (e.g. buildings) and roads, utilities, drains etc. Contractor to repair and/or compensate for any unforeseen damage to at least pre-project condition in conjunction with relevant local authorities and/or property owner at cost to the contractor Safe access to property will be maintained and alternative signed routes and access will be provided where there are temporary diversions or blockages. Locate stockpiles away from properties and only in designated areas where no access will be blocked.	100% of land used for temporary facilities returned to initial condition upon finalization of construction works.				
On-site pre-construction and	Occupational health and safety of workers at risk due to	Comply with CHSMP and with IFC EHS General Guidelines in relation to occupational H&S.	Compliance with national laws and regulations.	PMD to comply with requirements	PSC to supervise, monitor,	Contractor to comply with requirements	NEA counterpart funds

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
construction activities	the hazards created during the construction period, e.g. movement of heavy equipment, vehicles, and machineries, working conditions, etc. Workers may be exposed to occupational health risks and safety hazards, regarding site clearance for pre-construction and during construction relating to working with electricity and working at height, as well as from handling PCBs or asbestos in upgrade works at existing substations.	Ensure health and safety supervisor is on site at all times (implies an alternate off on leave or on sick). Require subcontractors and workers to confirm they have seen and understood the requirements of the CHSMP before proceeding with their work. Provide worker training on H&S and daily/weekly briefings led by site-appointed Health and Safety Officer. PPE to be provided for all workers (regardless formal and informal, directly contracted or subcontracted) in accordance with Table 2.7.1. Summary of Recommended Personal Protective Equipment According to Hazard in IFC EHS Guidelines on OHS. Enforce disciplinary system (e.g. immediate removal from site) for non-compliance with PPE requirements and other H&S measures (e.g. social distancing for COVID-19). Check health condition of workers on daily basis, for example, use of self-certification forms and temperature checks before being allowed on the construction site with more	Mitigation measures successfully implemented by NEA and Contractor as determined through regular site checks, photographic record etc. No outstanding OHS related grievances No fatalities or lost time incidents, if they do occur to be reported to NEA board and management	during construction. PMD to supervise and monitor contractor to ensure their compliance with delegated requirements.	and assist PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor. PSC international health and safety expert to work closely with PMD health and safety staff to ensure knowledge transfer and development of knowledge	throughout construction, maintain records of health and safety incidents per the EMoP and maintain copies of training records.	Part of PSC budget Part of contract cost, include costs of implementing EMP as BOQ line Budget for compensation included in Resettlement Plan and Indigenous People

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		thorough monthly health checks by qualified medical professional. Check the load of the vehicles before use, all drivers, and passengers to fasten seatbelt and comply with all transportation-related H&S laws and regulations Examination of all equipment and tools' quality and the presence of operational safety features before use Implementation of safety measures while excavating to avoid collapse e.g. shoring if soil unstable Untrained workers will not be permitted to work with live electricity or at height. Observe IFC EHS Guideline on Electric Power Transmission and Distribution requirements for working with live power lines; only allow suitably trained workers that meet the requirements set out in above-referred IFC guideline to work on live power lines with strict adherence to safety standards including those listed in said guidelines; these workers must have training record of attending suitable training course	within 24h and to ADB within 48h. 100% of H&S incidents including near miss recorded, immediately investigated, and corrective action taken to prevent repeat		able health and safety team at NEA.		

Narijan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		on electrical safety and be provided with and wear the appropriate PPE for their role. Ensure proper grounding and deactivation of any live power lines during construction work or before any work in close proximity to the lines and that this has been checked and certified by the on-site Health and Safety Officer in advance. 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. Require workers to observe the minimum approach distances for excavations, tools, vehicles, pruning, and other activities when working around power lines. Observe IFC EHS Guideline on Electric Power Transmission and Distribution requirements for working at height; only allow suitably trained and qualified workers to work at height, these workers must have training record of attending suitable training course and be provided with and wear the appropriate PPE for their role. Require					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		workers to test the structural integrity of towers prior to proceeding with the work. Use fall protection measures when working on towers, i.e. mobile elevated working platform, and all workers at height are required to wear body harness. Ensure sufficient harnesses and gear are available on site for all workers, that workers are trained to use such harness and are obligated to use the latter at all times when working at height. Unless transformers have been certified PCB free workers must wear suitable chemical and/or oil resistant gloves, goggles, and protective clothing whilst working with transformers. Eye wash station and water supply to shower to be provided during works due to risk of PCB coming into contact with skin. Ensure good housekeeping in the premises at all times, including on construction site, workers camps, storage areas, etc. Perimeter is to be kept neat and tidy, with no trip hazards on the ground e.g. open channels, materials, equipment, trash laying around. Do not leave hazardous conditions (e.g. unlit open excavations without means					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		of escape) overnight unless no access by public can be ensured. During construction works, ensure qualified first aider and trained fire marshal is available on-site at all times with an appropriately equipped first aid kit and appropriate fire extinguisher and other firefighting equipment immediately available for use. Provide an ambulance for more serious cases to transport the patient to the hospital for treatment Prepare signboards reminding of health and safety measures and procedures to follow in case of accident, including key contact details (ambulance, doctor, hospital, etc.) Keep a log of all incidents, near-misses and accidents and include these in monthly monitoring reports submitted to NEA and periodic monitoring reports to ADB Temporary construction camps will include proper sanitation, alternative fuel to firewood, clean eating area, water supply, and secure storage of domestic solid wastes					

Nanjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		for disposal off site to suitably licensed waste management facilities. Pit latrines prohibited, and adequate number (about 1 toilet per 10 workers, can refer to EBRD guidance note on workers' accommodation) of toilets and washing facility with hot and cold running water. Toilets to be connected to existing sewerage system, septic tank, or as portable self-contained units for disposal of wastewater off site to sewage treatment works to be provided. Toilets to be equipped with soap and hand sanitizer. There should be an indication of whether toilet and washing facility is "in use" or "vacant" if not gender segregated. Toilets should be cleaned at least twice daily to ensure they are kept in a hygienic condition. Prevent standing water as it may become a breeding habitat for mosquitoes etc. Provide workers with access to a shaded rest area on-site.					

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontracto r	
		Provide workers with a clean eating area for breaks and lunchtime. Provide all construction workers will an adequate supply of potable drinking water meeting national standards. Groundwater used must be appropriately treated and only be used where it will not put stress on local water resources. Where a risk of arsenic contamination is identified, prohibit the use of groundwater as a source of the drinking water. If ground or surface water is used for drinking water, it must first be tested to confirm it meets drinking water standards and continue to be regularly tested every week. If drinking water standards are not met, potable water shall be imported to site. If workers are not local to the area use may be made of existing accommodation facilities but if a construction camp is provided it must be adequately equipped with sufficient toilets, hand washing facilities,					

Nanjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		showers or baths, food preparation and clean eating area, etc.					
On-site pre-construction and construction activities	Community health and safety - at increased H&S risk from communicable diseases as workers coming from elsewhere, including COVID-19, social disturbances related to workers camps, traffic, electricity infrastructure etc.	Comply with CHSMP and with IFC EHS General Guidelines in relation to community H&S. Installation of barriers (a temporary fence ideally solid fence) at construction areas with hazard warning signs to deter people from accessing the construction site Do not leave hazardous conditions (e.g. unfenced and unlit open excavations without means of escape) overnight unless no access by public can be ensured Define construction schedule for sections along or crossing roads in coordination with local authorities/traffic police particularly where road closures required. Implement CTMP during construction works with advance warning signs or flag persons to ensure traffic safety of construction workers and road users, in coordination with traffic police.	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA and Contractor as determined through regular site checks, photographic record etc. No outstanding CHS related grievances	PMD to comply with requirements during construction. PMD to supervise and monitor contractor to ensure their compliance with delegated requirements.	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor. PSC international health and safety expert to work closely with PMD health and safety	Contractor to comply with requirements throughout construction, maintain records of health and safety incidents per the EMoP.	NEA counterpart funds Part of PSC budget Part of contract cost, include costs of implementing EMP as BOQ line Budget for compensation included in Resettlement Plan and

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Road safety and warning signs must be posted at 500m, 100m, and immediately in advance of the works at least two weeks prior to the works commencing to inform the public of the temporary blockage. Access to the construction site will be under traffic controls when trucks enter and exit. Require all project drivers to abide by Nepal road safety regulations at all times. Use of scaffold and bamboo frames to support stringing to protect structures, roads, irrigation canals, utilities etc. as well as pedestrians, vehicles, and the conductor itself. Restore the utilities immediately after all necessary works carried out to minimize public inconvenience Construction workers including subcontractors will be given awareness raising in HIV/AIDS, other communicable diseases including COVID-19, and sexual, exploitation, abuse and harassment with strict penalties (e.g. immediate removal from	No project-related accident reported within community - if they do occur to be reported to NEA board and management within 24h and to ADB within 48h. 100% of H&S incidents including near miss recorded, immediately investigated, and corrective action taken to prevent repeat		staff to ensure knowledge transfer and development of knowledgeable health and safety team at NEA.		Indigenous People

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		site) for any non-compliance of workers to an agreed code of practice Avoid ponding of water during construction to avoid habitat creation of vector borne diseases e.g. malaria. Keep a log of all incidents, near-misses and accidents and include these in monthly monitoring reports submitted to NEA and periodic monitoring reports to ADB					
On-site pre-construction and construction activities	Loss of physical cultural resources (PCR) - chance find procedures will be implemented in case of chance find (including fossils).	Comply with CEMP and chance find procedure; implement as soon as any monuments or artefacts encountered during construction activities. Strictly ensure no chance finds are tampered with. Brief workers on chance find protocol and on apply penalties applying for tempering with them. Contractor to declare a chance find to DOA and NEA within 24h of find. PMD to report on any chance find having occurred within 48h to ADB.	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA and Contractor as determined through regular site checks, photographic record etc.	PMD to comply with requirements during construction. PMD to supervise and monitor contractor to ensure their compliance with delegated requirements.	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor.	Contractor to comply with requirements throughout construction.	NEA counterpart funds Part of PSC budget Part of contract cost, include costs of implementing EMP as BOQ line

Barijan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
			No outstanding PCR related grievances 100% of chance finds were reported to DOA and dealt with in accordance with chance find procedure				Budget for compensation included in Resettlement Plan
Operation & Maintenance							

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
General maintenance	Environment, health, and safety impacts and risks of the project in general	During maintenance activities, mitigation measures applicable to the construction stage are also applicable to NEA maintenance activities and workers. Regular visual and technical inspection of condition and maintenance as required to be carried out by NEA daily at substations to check any leaking oil from transformers or any SF6 leak both of which are to be immediately addressed. Regular visual and technical inspection of condition and maintenance as required to be carried out by NEA quarterly for transmission lines to check: minimum vertical clearance (6.1m) is maintained; integrity of the towers and wires is in good condition, including bird diverters, insulation, anti-climbing devices; electrical safety warning signs and lighting arrestors; missing or corroded parts are immediately identified and replaced; and, any vegetation growth that may damage or threaten the integrity of the lines etc. Keep photographic records and log of all inspections and actions taken in response.	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA as determined through regular site checks, photographic record etc. No outstanding operation & maintenance related grievances Project infrastructure maintained in working order	PMD to implement EMP in collaboration with NEA operation & maintenance teams on site.	n/a	n/a	NEA's operational budget.

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
			and good condition at all times.				
Biological Environment							
General maintenance of ROW	Impacts on biodiversity including biodiversity supported by Chure Conservation Area	Protected Areas: NEA will continue to implement the promotion/enhancement measures agreed with Chure Conservation Area Maintenance and vegetation control: Regularly visually inspect the lines to spot any low hanging lines to ensure 6.1 m clearance is kept at all times above ground for safe passage of terrestrial fauna and that “bird sensitive” design features including bird divertors have not be lost or damaged,	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA as determined through regular site checks,	PMD to implement EMP in collaboration with NEA operation & maintenance teams on site.	n/a	n/a	Indicative costs for reforestation included in EMP budget table.

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		immediately undertake maintenance work if required. During inspections of transmission lines count fauna carcasses encountered, if any, record species and assess cause of death (e.g., electrocution/collision). Prohibit the use of herbicides, pesticides or burning to control any vegetation growth or to manage vegetation waste, in substations and along ROW. Regularly trim trees located within the RoW that are above 5 m high, at least once every two years, following maximum clearance as per Electricity Regulation, 1993 During maintenance activities, all EMP requirements for construction phase, in particular strict prohibitions on workers are applicable.	photographic record etc. Reforestation resulted in no-net loss of biodiversity as a result of the project. No outstanding biodiversity-related grievances from local communities.				
Physical Environment							

Banjara

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
GIS substations	Climate change from fugitive emission of SF6	Keep record of all gas insulated switchgear and gas insulated transformers, including presence, if any, and quantity of SF6 in these. Provide SF6 leakage detection kit at each substation. NEA to monitor SF6 emissions through inventory control and accounting per the requirements set out in the EMoP. Proper handling and storage procedures to be implemented in accordance with equipment suppliers' specifications and best practices. Check for SF6 gas leakage in every shift of the operation. Maintain SF6 leakage records in every substation and report in periodic monitoring reports to ADB. Define a safe SF6 retrieval arrangement, with appropriate handling, storage, disposal process for end of life equipment in accordance international good practice.	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA as determined through regular site checks, photographic record etc. SF6 leakage below 0.1% per annum	PMD to implement EMP in collaboration with NEA operation & maintenance teams on site.	n/a	n/a	NEA's operational budget.

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
Substation operation	Noise in the form of buzzing or humming can often be heard around transformers or power lines producing corona. Transformer oil spill and leakage.	Maintain transformers and other noise generating equipment to ensure noise to be limited to the following as 1 hour LAeq: (i) 70 dB(A) at the site boundary; (ii) at residential properties, 55 (day) and 45 (night) dB(A) in urban areas and 45 (day) and 40 (night) dB(A) in rural areas as defined by Nepal regulations; and (iii) at "peace areas" such as schools as defined by Nepal regulations, 50 (day) and 40 (night) dB(A). Transformers to be routinely inspected and maintained to avoid spills and leakage. Collect and segregate 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 or bags) for each distinct type of waste. Store solid waste in enclosed bins to contain leachate and avoid vermin.	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA as determined through regular site checks, etc. Monitoring confirms ambient noise within national standards or no worsening of the baseline situation if already exceeded.	PMD to implement EMP in collaboration with NEA operation & maintenance teams on site.	n/a	n/a	NEA's operational budget.

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Encourage recovery of recyclable wastes that could be reused or sold to recyclers, rather than disposing of it. Prohibit open/uncontrolled burning of wastes. Prohibit dumping of O&M wastes on-site, into drains, rivers, in agricultural fields etc. NEA may compost biodegradable kitchen scraps on site if of small volume in enclosed composting facilities (enclosed to avoid attraction of vermin etc.) located ideally 500m but at least 100m from water sources (surface water and groundwater wells, springs, water spouts etc.). Incineration may be permitted on-site if enclosed, small volume solid waste incinerator with stack and pollution control that is designed for residence time and temperatures that minimize incomplete combustion for waste disposal at substation is available. Document all wastes removed off site 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	No outstanding O&M-related grievances from local communities				

Nanjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		according to type – for solid waste disposal this will need to be to Kathmandu, and for hazardous waste this will need to be to a neighboring country since no such facilities currently exist in Nepal. Collect solid waste and dispose of it along with municipal waste to suitably engineered and licensed sanitary waste facilities– in Kathmandu as no such facilities are existing in rural municipalities. Ensure any hazardous waste such as oily rags or old drums disposed of in suitably licensed hazardous waste facilities– out of country since no such facilities in Nepal. Label all containers with its content and potential risk signs (e.g. flammable, corrosive, toxic, etc.) Display material data sheets for fuels, oil, or chemicals. If chemicals are handled on site, provide an emergency eye wash or shower. Store end-of-life or unused equipment in designated areas on site, ensure these are not left lying around.					

Banjara

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Store equipment in the dedicated, covered, labelled storage area (tools, machinery, material, equipment, and spare parts) Ensure liquids (fuel, oil, and chemicals, empty drums, old transformers, etc.) are stored in area with impermeable floor with spill containment bund of 110% capacity. Ensure liquids storage areas are locked at all times. Keep track of any maintenance activities carried out with regards to transformers (in particular each time transformer oil is changed) on a maintenance logbook kept on the premises. Ensure transformers have a label indicating it contains PCB (polychlorinated biphenyl) or is PCB free. Obtain and keep evidence to confirm transformers are PCB free, for future reference. Perform visual checks of any evidence of oil leaking or having previously leaked from transformers, and if identified, address immediately - maintenance of and handling of transformer oil is to be carried out only by trained workers using appropriate PPE.					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Keep spill prevention equipment available on site at all times.					
Socio-economic environment							
Presence of electrical infrastructure and need for maintenance	Occupational safety risks (project maintenance workers) and community safety risks	Ensure adequate sag and tension always maintained. Maintain warning / advisory signs in good and visible condition on all dangerous equipment. Maintain the good condition of non-climb features on transmission towers. Maintain the good condition of boundary fences, regularly check the security fence for any gaps and repair. Keep boundary gates locked at all times (except when workers are in-coming or exiting) but at times when the gate is unlocked, ensure one staff is always present to control any unauthorized entry.	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA as determined through regular site checks, photographic record etc.	PMD to implement EMP in collaboration with NEA operation & maintenance teams on site.	n/a	n/a	NEA's operational budget.

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Consider employing security personnel to guard the premises where the risk of entry for theft might be high. Carry out periodic safety related awareness raising in neighboring communities regarding living in proximity to power lines and substations, including but not limited to, electrocution risks and effects of EMF; include information to the community regarding potential corona noise heard during operation. NEA to ensure all substation staff and maintenance workers have received appropriate OHS trainings for their role EMF: Monitor electromagnetic field strength workers are exposed to and ensure occupational exposures are within the limits of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) reference level. If EMF limits are often reached, provide workers with personal radiation monitors that shall set off an alarm when exposure limits are reached.	No outstanding H&S related grievances All fatalities reported to government within 24h and to ADB within 48h. No project-related accident reported.				

Manjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Monitor electromagnetic field strength where regularly occupied properties are in the ROW and ensure public exposures are within the reference levels of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines. Housekeeping: Keep the substation neat and tidy at all times. Remove any trip hazards on the ground, e.g. open channels, materials, equipment, trash laying around. Carry out regular pest control where pests are a risk; favor natural pest control measures when possible. Display clear emergency exits signs (in working order, if light signs, ensure works) and keep exits clear of any blockage. Visually inspect for any standing water on site, and when identified, remove or provide appropriate drainage to remove in timely manner; ensure drainage system is not blocked and fully operational.					

Banjara

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		Maintain all lights in working order. Ensure all vents are free of blockages and regularly maintained. Emergency situations: Ensure a recent, full, first aid kit and adequate firefighting equipment is available on site at all times, stored in clearly labelled and easily accessible area. Replace the first aid equipment timely as required to keep all equipment within its expiry date. Service the firefighting equipment timely as required to keep all equipment in date Provide first aid and firefighting training to select, volunteer staff; at least one staff having recently carried out first aid and firefighting training must be present on site at all times. Refreshers are to be provided once a year. Hang posters showing first aid procedures especially for electrocution, and fire procedures, as well as listing all emergency contacts. Display the emergency phone					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontracto r	
		number and location of doctor and hospital in a clear and easily accessible location. Keep an accident log and make accident logbook available on site upon request. Monitor closely in case of extreme weather events and be ready to act immediately. Ensure any buildings on site are structurally sound if any earthquake occurs, check building soundness prior to allowing workers back on site.					
Site-specific EMP							

Karijan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
Contract Package 4 - Dumkibas Substation	Substation located with Chure Conservation Area	NEA to continue to consult with and secure written confirmation from the Chure Conservation Area with specific reference to the substation proposals as to (i) actions required to ensure works are in accordance with their management plans and (ii) measures NEA can support to promote and enhance their conservation aims. NEA will implement the promotion/enhancement measures agreed with the protected area management in parallel with construction works. NEA will not award any contract for Dumkibas substation until ADB SPS (2009) protected area management requirements have been confirmed as met by ADB. NEA and the Contractor will continuously liaise with the protected area management of Chure Conservation Area to keep them informed of progress on construction. NEA to deliver awareness raising on bird electrocution and collision with power lines and adopting international good practice for “bird sensitive” design to contractor’s staff with design responsibilities.	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA and Contractor as determined through regular site checks, photographic record etc. No outstanding site specific-related grievances from local communities.	PMD to comply with requirements during detailed design, preconstruction, construction, and operation & maintenance. PMD to supervise and monitor contractor to ensure their compliance with delegated requirements.	PSC to supervise, monitor, and assist PMD in ensuring their own compliance and assist with supervision and monitoring of the contractor.	Contractor to comply with requirements throughout detailed design, preconstruction, construction.	NEA counterpart funds Part of PSC budget Part of contract cost, include costs of implementing EMP as BOQ line

Navijan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		To minimize electrocution risk, "bird sensitive" design measures will include insulators/isolators between live and earthed components of infrastructure, bird guards to prevent perching and nesting by birds, and considering insulating any lower voltage wires and/or jumpers at substation connections. Contractor's detailed designs will be reviewed by the PSC International Biodiversity Specialist to confirm that all the measures required by the international good practice (APLIC, 2006 and 2012) have been adequately incorporated before approval of detailed designs and that the detailed designs have responded to any concerns raised by Bird Conservation Nepal. For Dumkibas Substation, NEA to fit any future lower voltage wires and/or jumpers at incoming and outgoing distribution line connections with "bird sensitive" design measures. Construction works including temporary construction facilities are to be confined to agricultural land and within the boundaries of					

Ranjan

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		the proposed substation, no encroachment on forest area. Contractor will not allow any works to be undertaken from 1 hour before sunset to 1 hour after sunrise to avoid disturbance to the fauna. No lighting is to be used by the Contractor in Chure Conservation Area. Contractor to develop as part of CEMP a site-specific biodiversity management plan (BMP) detailing mitigation and monitoring measures as required for approval by NEA prior to the commencement of any works, including enabling works. BMP will set out how impacts on the protected area will be minimized through the detailed design, construction methods, siting of temporary construction facilities, restrictions on construction workers etc. The Contractor will act in accordance with the agreed site-specific EMP and BMP as well as in manner consistent with the protected area management plan. NEA to suspend the Contractor's works if needed due to an unanticipated impact/risk					

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	Institutional responsibilities (including implementation, supervision, and monitoring)			Budget/source
				PMD	PSC	Contractor / Subcontractor	
		or non-compliance with requirements until corrective action is taken to address this. Contractor's environment safeguard team to oversee all activities in Chure Conservation Area with Contractor engaging security to ensure workers do not engage in prohibited activities. Contractor's environment officer for monitoring and supervision at Dumkibas substation is to have an ecological background given the location in Chure Conservation Area. For Dumkibas Substation the contractor's Environment Officer will help liaise with the protected area management, and support implementation of promotion/enhancement measures agreed with them. Prior to connecting the substation to the Bardhaghat-Sardi 132 kV DC transmission line, NEA will obtain written confirmation from MEWRI, Department of Forests, and the President Chure Terai Madhesh Conservation Development Board all requisite national environmental clearance requirements have been complied with.					

CHAPTER 2- GENERAL TECHNICAL REQUIREMENT

TABLE OF CONTENTS

1.0 FOREWORD

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

2.0 GENERAL REQUIREMENT

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

2.2 It is 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.

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

3.0 STANDARDS

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

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

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

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

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

3.6 Other internationally accepted standards which ensure equivalent or better performance than that specified in the standards specified under Annexure-A / individual chapters for various equipment 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 equipment 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 equipment 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:

To facilitate erection of equipment, all items to be assembled at site shall be "Match Marked". 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 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.	Rated Insulation levels	
i)	Full wave impulse withstand voltage (1.2/50 microsec.)	1050 kVp
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, 33 kV and 11kV System

SL No	Description of parameters	132 kV System	33 kV System	11 kV System
1.	System operating voltage	132kV	33kV	11kV
2.	Maximum operating voltage of the system (rms)	145kV	36kV	12kV
3.	Rated frequency	50Hz	50Hz	50Hz
4.	No. of phase	3	3	3
5.	Rated Insulation levels			
i)	Full wave impulse withstand voltage (1.2/50 microsec.)	650 kVp	170 kVp	75 kVp
ii)	One minute power frequency dry and wet withstand voltage (rms)	275kV	70kV	28kV
6.	Corona extinction voltage	105kV	-	-
7.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 92KV rms for 132KV system	500 micro-volt	-	-
8.	Minimum creepage distance (25mm/kV)	3625 mm	900 mm	300 mm
9.	Min. Clearances			
i.	Phase to phase	1300 mm	320 mm	120 mm
ii.	Phase to earth	1300 mm	320 mm	120 mm
iii)	Sectional clearances	4000 mm	3000 mm	3000 mm
10.	Rated short circuit current	31.5 kA for 1 Sec	25 kA for 3 Sec	25 kA for 3 Sec
11.	System neutral earthing	Effectively earthed	Effectively earthed	Effectively earthed

Note:

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

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)	245
(b)	Impulse withstand voltage (dry & wet) (kVp)	± 1050
(c)	Power frequency withstand voltage (dry and wet) (kV rms)	460
(d)	Total creepage distance (min) (mm)	6125

The requirement of alternate long & short sheds stated in model technical specification shall not be applicable in case of 11 kV.

132kV, 33kV & 11kV System

S.N.	Parameters	**132 kV**	**33 kV**	**11kV**
(a)	Max. System voltage Um(kV)	145	36	12
(b)	Impulse withstand voltage (dry & wet) (kVp)	± 650	± 170	± 74
(c)	Power frequency withstand voltage (dry and wet) (kV rms)	275	70	28
(d)	Total creepage distance (min) (mm)	3625	900	300

4.6.3 Major Technical Parameters

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

4.6.3.1 (A) For 36 kV & 145 kV Equipment

	For 36 kV	**For 145 kV**
Rated voltage kV (rms)	33	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	± 170 kVp	±650 kVp
- between terminals with circuit breaker open	± 170 kVp	±650 kVp
- between terminals with isolator open	± 200 kVp	±750 kVp

2) One minute power frequency dry and wet withstand voltage

- between line terminals and ground	70 kV (rms)	275 kV (rms)
- between terminals with circuit breaker open	70 kV (rms)	275 kV (rms)

- between terminals with Isolator open		315 kV (rms)
Max. radio interference voltage (microvolts) for frequency between 0.5 MHz and 2 MHz in all positions of the equipment.		500 (at 92 kV rms)
Minimum creepage distance: -		
Phase to ground (mm)	900	3645
Between CB Terminals (mm)	900	3645
System neutral earthing	Effectively earthed	Effectively earthed
Seismic acceleration	- 0.5g horizontal -	
Rating of Auxiliary	10 A at 220/110 V DC (as applicable) Contacts	
Breaking capacity of Auxiliary Contacts	2 A DC with circuit time constant of not less than 20ms.	
Phase to phase spacing (mm)	1500	3000 or 2700

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

(B) FOR 36 kV & 145 kV CT/CVT/SA

Rated voltage kV (rms)	36	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	± 170 kVp	±650 kVp
- for arrester housing	± 170 kV peak	±650 kVp
2) One minute power frequency dry and wet withstand voltage		
- between line terminals and ground for CT and CVT		275 kV rms
- for arrester housing		275kV rms
Max. radio interference voltage (microvolts) for frequency between 0.5 MHz and 2 MHz in all positions of the equipment		500 (at 92 kV rms)
Minimum creepage distance :-		
Phase to ground (mm)	900	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, 22kV & 11kV Vacuum Circuit Breaker and Isolator**:

Rated voltage kV (rms)	36	12	
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	±170 kVp	±150 kVp	±75 kVp
- between terminals with circuit breaker open	±170 kVp	±150 kVp	±75 kVp
- between terminals with isolator open	±170 kVp	±150 kVp	±75 kVp

2) One minute power frequency dry and wet withstand voltage

- between line terminals and ground	70kV(rms)	50kV(rms)	28kV(rms)
- between terminals with circuit breaker open	70kV(rms)	50kV(rms)	28kV(rms)
- between terminals with Isolator open	70kV(rms)	50kV(rms)	28kV(rms)

Minimum creepage distance:

Phase to ground (mm)	900	625	300
Between CB Terminals (mm)	900	625	300

System neutral earthing	Effectively earthed	
Seismic acceleration	0.5 g	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, 22kV & 11kV CT/VT/SA

Rated voltage kV (rms)	36	25	12
Rated frequency (Hz)	50	50	11
No. of poles	1	1	1
Design ambient temperature (°C)	50	50	50

Rated insulation levels :

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

- between line terminals and ground	±170 kVp	±150 kVp	±75 kVp
- for arrester housing	±170 kVp	±150 kVp	±75 kVp

2) One minute power frequency dry and wet withstand voltage

- between line terminals and ground	70kV rms	50kV rms	28kV rms

- for arrester housing	70kV rms	50kV rms	28kV rms
Minimum creepage distance :			
Phase to ground (mm)	900	625	300
Between Terminals (mm)	900	625	300
System neutral earthing	- Effectively earthed –		
Seismic acceleration	0.5 g	0.5 g	0.5 g
Cantilever strength of bushing	350 kg (minimum)		

(E) Technical Parameters of Bushings/Hollow Column Insulators/support insulators for 33kV, 22kV & 11kV:

(a)	Rated Voltage (kV)	36	25	12
(b)	Impulse withstand voltage (Dry & Wet) (kVp)	±170	±150 kVp	75
(c)	Power frequency withstand voltage (dry and wet) (kV rms)	75	50	28
(d)	Total creepage distance (mm)	900	625	300

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

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 finalized 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 along with 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)	2 weeks from the date of final approval
	(b) Routine Test Reports (one copy for each substation)	-do-
vi)	Furnishing of instruction/ (2 copies per substation and one softcopy (pdf format) for corporate centre& per substation)	As per agreed schedule operation manuals
(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 0MATERIAL/ 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 In case 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 Materials containing chemicals such as Asbestos and PCB materials should not be used in executing this project.

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 favorable 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, CB, CT, CVT, SA, Isolators, C & R panels and PLCC equipment 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 equipment to provide the best coordinated 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 finalized 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;

Kanjan

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

8.2 Quality Assurance Documents

The contractor would be required to submit all the Quality Assurance Documents as stipulated in the Quality Plan at the time of 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.

9.2 The reports for all type tests as per technical specification shall be furnished by the Contractor along with 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 at least 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 labour, 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 comply 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 equipment for these tests shall be provided by the Purchaser.

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 are assessed as listed below. The duration of such visits shall be as per inspection/testing requirements.

- Power Transformer	2 persons, 2 visit
- Circuit Breakers	2 persons, 1 visit
- Disconnecting Switch	1 person, 1 visit

- Instrument Transformers	1 person, 1 visit
- 11 kV Switchgear	1 person, 1 visit
- Tower & Steel Structure	2 person, 1 visit
- CRP & Substation Automation System	2 persons, 1 visit
- SCADA/Communication System	2 persons, 1 visit
- Steel Tubular Pole	1 person, 1 visit
- ACSR Conductor, AAAC and Accessories (PG Clamp& Compression Joints)	1 person, 1 visit
- Insulators and Insulator Fittings	1 person, 1 visit
- Stay Set and accessories	1 person, 1 visit

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 equipment 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 discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel globules, spiky deposits, blistered surface, flaking or peeling off, etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

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

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

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

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

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

12.3 PAINTING

12.3.1 All sheet steel work shall be degreased, pickled, phosphated in accordance with the 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 equipment.

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 along with 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 energisation at rated voltage.

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

13.3 The contractor shall have to ensure that the hard and flat indoor and outdoor storage areas are in place prior to commencement of delivery of material at site. Contractor shall also ensure availability of proper unloading and material handling equipment like cranes etc. and polyester/nylon ropes of suitable capacity to avoid damage during unloading and handling of material at site. All indoor equipments shall be stored indoors. Outdoor equipment may be stored outdoors but on a hard and flat raised area properly covered with waterproof and dustproof covers to protect them from water seepage and moisture ingress. However, all associated control panels, marshalling boxes operating boxes etc. of outdoor equipments are to be stored indoors only. Storage of equipment on top of another one is not permitted if the wooden packing is used. Material opened for joint inspection shall be repacked properly as per manufacturer's recommendations.

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

13.4 In case of any doubt/misunderstanding as to the correct interpretation of manufacturer's drawings or instructions, necessary clarifications shall be obtained from the 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 along with 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 meters.

17.0 CLAMPS AND CONNECTORS INCLUDING TERMINAL CONNECTORS

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

For connecting, ACSR conductors	Aluminum alloy casting conforming to BS: 1490/ Equivalent International Standard
For connecting equipment terminals made of copper with ACSR conductors	Bimetallic connectors made from aluminum alloy casting conforming to BS:1490/ Equivalent International Standard with 2mm thick bimetallic liner.

For connecting GI Galvanized mild shield wire

i) Bolts nuts and plain washers

ii) Spring washers for item 'a' to 'c' Electro galvanized for sizes Plain, washers below M12, for others hot dip galvanized. 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 is 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°Cover 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 at least 2.0 mm thick cold rolled or 2.5 mm hot rolled or alternately 1.6 mm thick stainless steel can also be used. The box shall be properly braced to prevent wobbling. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation. In case of aluminum enclosed box the thickness of aluminum shall be such that it provides adequate rigidity and long life as comparable with sheet steel of specified thickness.

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

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

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

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

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

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

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

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

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

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

18.12 a) The following routine tests along with 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 Not Available

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, signalling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with miniature circuit breaker **/** switchfuse units. Selection of the main and Sub-circuit fuse ratings shall be such as to ensure selective clearance of sub-circuit faults. Potential circuits for relaying and metering shall be protected by HRC fuses.

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

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 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 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 rise over the ambient temperature of 50 degree 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 along with 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 atleast 100 Kms of 1.1 KV or higher grade PVC insulated power cables as on the date of bid opening. Further the manufacturer should also have designed, manufactured, tested and supplied at least 1 km of 1C x 150 Sq. mm or higher size as on the originally Scheduled date of bid opening.

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

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 (ie Moulded 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.

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 Hexafloride
IEC-60437	-	Radio Interference Test on High Voltage Insulators.
IEC-60507	-	Artificial Pollution Tests on High Voltage Insulators to be used on AC Systems.
IEC-62271-1	-	Common Specification for High Voltage Switchgear & 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	-	Techniquest for Dielectric Tests
ANSI-C76.1/EEE21	-	Standard General Requirements and Test Procedure for Outdoor Apparatus Bushings.
ANSI-SI-4	-	Specification for Sound Level Metres
ANSI-Y32-2/C337.2	-	Drawing Symbols
ANSI-Z55.11	-	Gray Finishes for Industrial Apparatus and Equipment No. 61 Light Gray
NEMA-107T	-	Methods of Measurements of RIV of High Voltage Apparatus
NEMA-ICS-II	-	General Standards for Industrial Control and Systems Part ICSI-109
CISPR-1	-	Specification for CISPR Radio Interference Measuring Apparatus for the frequency range 0.15 MHz to 30 MHz
CSA-Z299.1-1978h	-	Quality Assurance Program Requirements
CSA-Z299.2-1979h	-	Quality Control Program Requirements
CSA-Z299.3-1979h	-	Quality Verification Program Requirements
CSA-Z299.4-1979h	-	Inspection Program Requirements

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 trans formers
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 up to and including 100 MVA with 55 deg C or 65 deg C Winding Rise
ANSI-CG,1EEE-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 controlgear - Part 102: Alternating current disconnectors and earthing switches
IEC-60265 (Part 1 & 2)	-	High Voltage switches
ANSI-C37.32	-	Schedule of preferred Ratings, Manufacturing Specifications and Application Guide for high voltage Air Switches, Bus supports and switch accessories
ANSI-C37.34	-	Test Code for high voltage air switches
NEMA-SG6	-	Power switching equipment

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

Protection and control equipment

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

MOTORS

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

Electronic equipment and components

MIL-21B, MIL-833 & MIL-2750		
IEC-60068 (P1 to P5)	-	Environmental testing
IEC-60326 (P1 to P2)	-	Printed boards
		Material and workmanship standards
ASTM	-	Specification and tests for materials

Clamps & connectors

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

Bus hardware and insulators

IEC-60120	-	Dimensions of Ball and Socket Couplings of string insulator units.
IEC-60137	-	Insulated bushings for alternating voltages above 1000 V.
IEC-60168	-	Tests on indoor and outdoor post insulators of ceramic material or glass for Systems with Nominal Voltages Greater than 1000 V.
IEC-62155	-	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V
IEC-60273	-	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 colours for insulation for low-frequency cables and wires.
IEC-60331	-	Fire resisting characteristics of Electric cables.
IEC-60332 (P1 to P3)	-	Tests on electric cables under fire conditions.
IEC-60502	-	Extruded solid dielectric insulated power cables for rated voltages from 1 kV upto to 30 kV
IEC-754 (P1 and P2)	-	Tests on gases evolved during combustion of electric cables.

Painting

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

HORIZONTAL CENTRIFUGAL PUMPS

API-610	-	Centrifugal pumps for general services
	-	Hydraulic Institutes Standards

Harijan

BS:599 - Methods of testing pumps

PTC-8.2 - Power Test Codes - Centrifugal pumps

DIESEL ENGINES

ASME Power Test Code - Internal combustion engine PTC-17

- Codes of Diesel Engine Manufacturer's Association, USA

PIPING VALVES & SPECIALITIES

BS:5150 - Specification for cast iron gate valves

PG Test Procedures

NFPA-13 - Standard for the installation of sprinkler system

NFPA-15 - Standard for water spray fixed system for the fire protection

NFPA-12A - Standard for Halong 1301 Fire Extinguishing System

NFPA-72E - Standard on Antomatic Fire Detectors

NFPA-12 - Standard on Carbon dioxide extinguisher systems

Electrical generating and distributing stations code of practice

Steel structures

ANSI-B18.2.1 - Inch series square and Hexagonal bolts and screws

ANSI-B18.2.2 - Square and hexagonal nuts

ANSI-G8.14 - Round head bolts

ASTM-A6 - Specification for General Requirements for rolled steel plates, shapes, sheet piling and bars of structural use

ASTM-A36 - Specifications of structural steel

ASTM-A47 - Specification for malleable iron castings

ASTM-A143 - Practice for safeguarding against embilement of Hot Galvanized structural steel products and procedure for detaching embrilement

ASTM-A242 - Specification for high strength low alloy structural steel

ASTM-A283 - Specification for low and intermediate tensile strength carbon steel plates of structural quality

ASTM-A394 - Specification for Galvanized steel transmission tower bolts and nuts

ASTM-441 - Specification for High strength low alloy structural manganese vanadium steel.

ASTM-A572	-	Specification for High strength low alloy colombium- Vanadium steel of structural quality
AWS D1-0	-	Code for welding in building construction welding inspection
AWS D1-1	-	Structural welding code
AISC	-	American institute of steel construction
NEMA-CG1	-	Manufactured graphite electrodes
Piping and pressure vessels		
ASME	-	Boiler and pressure vessel code
ASTM-A120	-	Specification for pipe steel, black and hot dipped, zinc- coated (Galvanized) welded and seamless steel pipe for ordinary use
ASTM-A53	-	Specification for pipe, steel, black, and hot-dipped, zinc coated welded and seamless
ASTM-A106	-	Seamless carbon steel pipe for high temperature service

ASTM-A284	-	Low and intermediate tensile strength carbon-silicon steel plates for machine parts and general construction.
ASTM-A234	-	Pipe fittings of wrought carbon steel and alloy steel for moderate and elevated temperatures
ASTM-S181	-	Specification for forgings, carbon steel for general purpose piping
ASTM-A105	-	Forgings, carbon steel for piping components
ASTM-A307	-	Carbon steel externally threated standard fasteners
ASTM-A193	-	Alloy steel and stainless steel bolting materials for high temperature service
ASTM-A345	-	Flat rolled electrical steel for magnetic applications
ASTM-A197	-	Cupola malleable iron
ANSI-B2.1	-	Pipe threads (Except dry seal)
ANSI-B16.1	-	Cast iron pipe flangesand glanged fitting. Class 25, 125, 250 and 800
ANSI-B16.1	-	Malleable iron threaded fittings, class 150 and 300
ANSI-B16.5	-	Pipe flanges and flanged fittings, steel nickel alloy and other special alloys
ANSI-B16.9	-	Factory-made wrought steel butt welding fittings
ANSI-B16.11	-	Forged steel fittings, socket-welding and threaded
ANSI-B16.14	-	Ferrous pipe plug, bushings and locknuts with 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	Design calculation for Sag – Tension stringing chart
9	GTP and drawings for Bus-Post Insulator
10	Tension/suspension string insulator and Hardware Assembly GTP and drawing
11	Soil Investigation Report (if applicable)
12	**Circuit Breakers (220kV,132kV, 33 kV- As applicable)** - GA drawing, GTP, Type test Reports
13	**CTs & CVTs (220kV,132 kV, 33kV- As applicable)** - GA drawing, GTP, Type test Reports
14	**Surge Arrestors (216kV,120kV, 30kV- As applicable)** - GA drawing, GTP, Type test Reports
15	**Isolators (220kV,132kV, 33 kV- As applicable)** - GA drawing, GTP, Type test Reports
16	**Control, Relay Panels and Substation Automation system** - GTP, technical literature, type test reports
17	**PLCC, LINE TRAP & Digital Protection Coupler** - GTP and technical literature
18	**Civil Works (as applicable)** **a)** Control Room Building Structure Design, Foundation Design & Drg., Plinth Beam Design & Drg. and column Design & Drg. upto G.F. Level **b)** Auto transformer foundation design/drawings **c)** Reactor foundation design/drawings **d)** 220/132/11kV Tower, structure & foundation design/drawings. **e)** 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.

CHAPTER 3– SWITCHGEAR

CIRCUIT BREAKERS

CONTENTS

CHAPTER - SWITCHGEAR

CIRCUIT BREAKERS

1.0 GENERAL

1.1 The circuit breakers and accessories shall conform to IEC: 62271-100, IEC: 62271-01 and other relevant IEC standards except to the extent explicitly modified in the specification and shall also be in accordance with requirements specified in Chapter 2-GTR.

1.2 245/145 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.

The 145kV circuit breaker shall be SF6 gas type whereas the 36 kV circuit breaker shall be Vacuum type.

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 245/145/33 kV effectively grounded system, and perform make and break operations as per the stipulated duty cycles satisfactorily.

2.3 The breaker shall be capable of interrupting the steady state and transient magnetising current corresponding of power transformers.

2.4 The circuit breaker shall also be capable of:

i) Interrupting line/cable charging current as per IEC without use of opening resistors.

ii) Clearing short line fault (Kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.

iii) Breaking 25% of the rated fault current at twice rated voltage under phase opposition condition.

2.5 The Breaker shall satisfactorily withstand the high stresses imposed on them during fault clearing, load rejection and re-energisation of lines with trapped charges. The breaker shall also withstand the voltages specified under Clause 15 of this Chapter.

3.0 TOTAL BREAK TIME:

3.1 The total break time as specified under this Chapter shall not be exceeded under any of the following duties:

i) Test duties T10, T30, T60, T100a, T100s (TRV as per IEC: 62271-100)

ii) Short line fault L75, L90 (- do -)

3.2 The Bidder may please note that total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage, (70-110%) and arc extinguishing medium pressure etc. While furnishing the proof of the total break time of complete circuit breaker, the Bidders may specifically bring out the effect of non-simultaneity between contacts between poles and show how it is covered in the guaranteed total break time.

3.3 The values guaranteed shall be supported with the type test reports.

4.0 CONSTRUCTIONAL FEATURES:

The features and constructional details of circuit breakers shall be in accordance with requirements stated hereunder:

4.1 **Contacts**

4.1.1 The gap between the open contacts shall be such that it can withstand 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).

Vacuum Interrupter for vacuum circuit breaker

Vacuum interrupter, which makes use of the excellent dielectric properties, should confirm to obtain a highly reliable extinguishing device such as to quench the arc as soon as possible without causing the visible formation of the arc. There should not be any deterioration of the quenching medium. The design and manufacturing technology of the interrupter should ensure the vacuum integrity. The recovery should be faster and hence the arc quenching should be accomplished within the adequate contact gap to support the required rating. The contact surface should be free of impurities and pollution layers. Materials of high conductivity should be used such that the contact resistance will be very low. During switching, the Breaker should be re-strikes free.

4.2 The SF6 Circuit Breaker shall meet the following additional requirements:

a) The circuit breaker shall be single pressure type. The design and construction of the circuit breaker shall be such that there is a minimum possibility of gas leakage and entry of moisture. There should not be any condensation of SF6 gas on the internal insulating surfaces of the circuit breaker.

b) All gasketted surfaces shall be smooth, straight and reinforced, if necessary, to minimise distortion and to make a tight seal, the operating rod connecting the operating mechanism to the arc chamber (SF6 media) shall have adequate seals. The SF6 gas leakage should not exceed 0.5% per year and the leakage rate shall be guaranteed for at least 10 years. In case the leakage under the specified conditions is found to be greater than 0.5% after one year of commissioning of circuit breaker, the manufacturer will have to supply free of cost, the total gas requirement for subsequent ten (10) years, based on actual leakage observed during first year of operation after commissioning.

c) In the interrupter assembly there shall be an absorbing product box to minimise the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be fully compatible with SF6 gas decomposition products.

d) Each pole shall form an enclosure filled with SF6 gas independent of two other poles (for 245 kV CBs) and the SF6 density of each pole shall be monitored. For CBs of voltage class of 145 kV or less, a common SF6 scheme/density monitor shall be acceptable.

e) The dial type SF6 density monitor shall be adequately temperature compensated to model the pressure changes due to variations in ambient temperature within the body of circuit breaker as a whole. The density monitor shall have graduated scale and shall meet the following requirements:

i) It shall be possible to dismantle the density monitor for checking/replacement without draining the SF6 gas by providing suitable interlocked non return valve coupling.

ii) Each Circuit Breaker shall be capable of withstanding a vacuum of minimum 8 millibars without distortion or failure of any part.

iii) Sufficient SF6 gas including that will be required for gas analysis during filling shall be provided to fill all the circuit breakers installed. In addition spare gas shall be supplied in separate unused cylinders as per requirement specified in **Chapter 1---PSR.**

4.3 Provisions shall be made for attaching an operational analyser to record contact travel, speed and making measurement of operating timings, pre-insertion timings of closing resisters if used, synchronisation of contacts in one pole.

5.0 SULPHUR HEXAFLUORIDE GAS (SF6 GAS):

a) The SF6 gas shall comply with IEC 60376, 60376A and 60376B and shall be suitable in all respects for use in the switchgear under the operating conditions.

b) The high pressure cylinders in which the SF6 gas is shipped and stored at site shall comply with requirements of the relevant standards and regulations.

c) Test: SF6 gas shall be tested for purity, dew point, air, hydrolysable fluorides and water content as per IEC 60376, 60376A and 60376B and test certificates shall be furnished to Employer indicating all the tests as per IEC 60376 for each lot of SF6 gas in stipulated copies as indicated in Chapter-GTR. Gas bottles should be tested for leakage during receipt at site.

6.0 INSULATORS:

a) The porcelain of the insulators shall conform to the requirements stipulated under **Chapter 2-GTR.**

b) The mechanical characteristics of insulators shall match with the requirements specified under this Chapter.

c) All hollow insulators shall conform to IEC-62155.

d) Hollow Porcelain for pressurised columns/chambers should be in one integral piece in green and fired stage.

7.0 SPARE PARTS AND MANDATORY MAINTENANCE EQUIPMENT:

The bidder shall include in his proposal spare parts and maintenance equipment in accordance with Chapter 1-PSR. Calibration certificates of each maintenance equipment shall be supplied 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 antipumping and trip free (as per IEC definition) under every method of closing.

8.1.4 The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause trip or closing operation of the power operating devices.

8.1.5 A mechanical indicator shall be provided to show open and close position of the breaker. It shall be located in a position where it will be visible to a man standing on the ground level with the mechanism housing closed. An operation counter shall also be provided in the central control cabinet.

8.1.6 Working parts of the mechanism shall be corrosion resisting material, bearings which require grease shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or changing adjustment with repeated operation of the breaker.

8.1.7 The bidder shall furnish detailed operation and maintenance manual of the mechanism 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 aluminium and shall be conforming to Australian standard AS-2935 for rated current. The terminal pad shall have protective covers which shall be removed before interconnections.

11.0 INTERPOLE CABLING:

11.1 All cables to be used by contractor shall be armoured and shall be as per IEC-502 (1100 Volts Grade). All cables within & between circuit breaker poles shall be supplied by the CB manufacturer.

11.2 Only stranded conductor shall be used. Minimum size of the conductor for interpole control wiring shall be 1.5 sq.mm. (Copper).

11.3 The cables shall be with oxygen index Min-29 and temp. index as 250^{o}C as per relevant standards.

12.0 FITTINGS AND ACCESSORIES

12.1 Following is a partial list of some of the major fittings and accessories to be furnished by Contractor in the Central Control cabinet. Number and exact location of these parts shall be indicated in the bid.

i) Cable glands (Double compression type), Lugs, Ferrules etc.

ii) Local/remote changeover switch.

iii) Operation Counter

iv) Control switches to cut off control power supply.

v) Fuses as required.

vi) The number of terminals provided shall be adequate enough to wire out all contacts and control circuits plus 24 terminals spare for future use.

vii) 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 analyser to determine the breaker contact movement during opening, closing, auto-reclosing and trip free operation under normal as well as limiting operating conditions (control voltage pressure etc.). The tests shall show the speed of contacts directly at various stages of operation, travel of contacts, opening time, closing time, shortest time between separation and meeting of contacts at break make operation etc. This test shall also be performed at site for which the necessary operation analyser along with necessary transducers, cables, console, etc. where included in scope of supply shall be furnished and utilised. In case of substations where operation analyser is existing the bidder shall utilise the same. However necessary adopter and transducers etc. if required shall have to be supplied by the bidder.

2) Measurement of Dynamic Contact resistance measurement for arcing & main contacts. Signature of Dynamic contact resistance measurements shall be taken as reference for comparing the same during operation and maintenance in order to ascertain the healthiness of contacts.

15.0 TECHNICAL PARAMETERS:

(In addition to those indicated in Chapter 2-GTR)

I. 245 kV CIRCUIT BREAKER:

A15.1	Rated continuous current (A) at design ambient temperature.	1600/2500 (as applicable)
A15.2	Rated short circuit current breaking capacity	40 kA / 50 kA (as applicable) with percentage DC component as per at rated voltage IEC: 62271-100 corresponding to minimum opening time under operating conditions specified.
A15.3	Symmetrical interrupting capability (kArms)	40 / 50 (as applicable)
A15.4	Rated short circuit making current (kAp)	100 / 125 (as applicable)
A15.5	Short time current carrying capability for one second (kArms)	40 / 50 (as applicable)
A15.6	Rated operating duty	O-0.3sec-CO-3min-CO cycle
A15.7	Reclosing	Single phase & three phase 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 Control cabinet	All Contacts & control circuits to be wired out upto common control cabinet plus 24 terminals exclusively for Purchaser's use.

II. 145 kV CIRCUIT BREAKER:

B15.1	Rated continuous current (A) at design ambient temperature.	1250
B15.2	Rated short circuit Current breaking Capacity at total voltage	31.5 kA with percentage dc component as per IEC 62271-100 corresponding to minimum opening time & operating condition 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-0.3 sec-CO-3min-CO cycle
B15.7	Reclosing	Single phase (for Line only) & three phase Autoreclosing

B15.8	First pole to clear factor		1.3
B15.9	Rated line/cable charging interrupting current at90 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 up to common control cabinet plus 24 terminals exclusively for Purchaser's use.

III 33kV VACUUM CIRCUIT BREAKER

a)Rated operating duty cycle	0-3min-CO-3 min-CO
b)First pole to clear factor	1.3

(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	Spring
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	220V DC with variation as specified
j)Noise level at base of CB and upto 50 mtr distance from base of CB.	140 db (max)
k) Rated terminal load	As per IEC
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 owners's use.
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.
s)Reclosing	Three phase auto reclosing

1.	Type	33 kV VCB, outdoor type
2.	Voltage rating:	
	a) Nominal system voltage	33 kV
	b) Rated maximum voltage	36 kV
3.	Insulation level	
	a) Impulse withstand voltage	170 kV (crest)
	b) Power-frequency withstand voltage (1 min)	70 kV (rms)
4.	Frequency	50 Hz
5.	Current rating	
	a) Rated continuous current at 40 degree C ambient	1600/1250/800 A
	b) Short circuit breaking current	25 kA
	c) Short circuit making current	62.5 kA
6.	Creepage distance	900 mm
7.	Auxiliary supply	
	a) Control circuit	220 V DC
	b) Space heater and auxiliary equipment.	AC, 230/400V, 50 Hz
8.8	Rated Capacitor Breaking current	≥400A
.	Operation	Three pole operation type
9.	Reclosing duty cycle	O-0.3 sec-CO-3 min-CO
10.	Total maximum break time	
11.	First pole to clear factor	1.3
12	Additional Auxiliary Contacts	8 NO, 8 NC
13.	Maximum make time	

14. Spring charging motor 220 V DC

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.

CHAPTER 3.2 – SWITCHGEAR

ISOLATORS CONTENTS

CHAPTER 3- SWITCHGEAR

ISOLATORS

1.0 GENERAL:

1.1 The Isolators and accessories shall conform in general to IEC: 62271-102 except to the extent explicitly modified in specification and shall be in accordance with requirement of Chapter 2-GTR.

1.2 Isolators shall be outdoor, off-load type. Earth switches shall be provided on isolators wherever called for, with possibility of being mounted on any side of the isolator. 220 kV & below rated isolators shall be double break type, unless specified otherwise.

1.3 Complete isolator with all the necessary items for successful operation shall be supplied including but not limited to the following:

1.3.1 Isolator assembled with complete Support Insulators, operating rod insulator, base frame, linkages, operating mechanism, control cabinet, interlocks etc.

1.3.2 All necessary parts to provide a complete and operable isolator installation, control parts and other devices whether specifically called for herein or not.

1.3.3 The isolator shall be designed for use in the geographic and meteorological conditions as given in Chapter 2-GTR.

2.0 DUTY REQUIREMENTS:

a) Isolators and earth switches shall be capable of withstanding the dynamic and thermal effects of the maximum possible short circuit current of the systems in their closed position. They shall be constructed such that they do not open under influence of short circuit current.

b) The earth switches, wherever provided, shall be constructionally interlocked so that the earth switches can be operated only when the isolator is open and vice versa. The constructional interlocks shall be built in construction of isolator and shall be in addition to the electrical interlocks. Suitable mechanical arrangement shall also be provided for delinking electrical drive for manual operation.

c) In addition to the constructional interlock, isolator and earth switches shall have provision to prevent their electrical and manual operation unless the associated and other interlocking conditions are met. All these interlocks shall be of fail-safe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from DC supply and within a variation range as stipulated in Chapter 2-GTR.

d) The earthing switches shall be capable of discharging trapped charges of the associated lines.

e) The isolator shall be capable of making/breaking normal currents when no significant change in voltage occurs across the terminals of each pole of isolator on account of make/break operation.

f) Isolator rated for above 72.5 kV shall be of extended mechanical endurance class - M2 as per IEC-62271-102. Isolator rated for 72.5 kV and below shall be of extended mechanical endurance class - M1 as per IEC-62271-102. All earth switches shall be of M0 duty.

3.0 CONSTRUCTIONAL FEATURES:

The features and constructional details of Double Break Isolators, earth switches and accessories shall be in accordance with requirements stated hereunder:

3.1 Contacts:

a) The contacts shall be self-aligning and self-cleaning and so designed that binding cannot occur after remaining closed for prolonged periods of time in a heavily polluted atmosphere.

b) No undue wear or scuffing shall be evident during the mechanical endurance tests. Contacts and spring shall be designed so that readjustments in contact pressure shall not be necessary throughout the life of the isolator or earthing switch. Each contact or pair of contacts shall be independently sprung so that full pressure is maintained on all contacts at all time.

c) Contact springs shall not carry any current and shall not lose 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 galvanised 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/aluminium. Bolts, screws and pins shall be provided with lock washers. Keys or equivalent locking facilities if provided on current carrying parts, shall be made of copper silicon alloy or stainless steel or equivalent. The bolts or pins used in current carrying parts shall be made of non-corroding material. Ferrous parts, other than stainless steel shall not be used in close proximity of main current path. All ferrous castings, if used elsewhere shall be made of malleable cast iron or cast-steel. No grey iron shall be used in the manufacture of any part of the isolator.

b) The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces, where this is impracticable adequate corona rings shall be provided. Corona shields are not acceptable. Corona rings shall be made up of aluminum/aluminum alloy.

c) Isolators and earthing switches including their operating parts shall be such that they cannot be dislodged from their open or closed positions by short circuit forces, gravity, wind pressure, vibrations, shocks, or accidental touching of the connecting rods of the operating mechanism.

d) The switch shall be designed such that no lubrication of any part is required except at very infrequent intervals. i.e. after every 1000 operations or after 5 years whichever is earlier.

3.4 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

3.5 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 structure.

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 at least 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	As per table III of IEC-62271-102 or

	terminal load	as per value calculated in Chapter 2-GTR whichever is higher.
A11.7	Operating mechanism of isolator/earth switch	A.C. Motor operated
A11.8	No. of auxiliary contacts on each isolator	Besides requirement of this spec., the bidder shall wire up 5 NO + 5 NC to TBs (Reversible) for Purchaser's future use.
A11.9	No. of auxiliary contacts on each earthing switch	Besides requirement of this spec., the bidder shall wire up 3 NO + 3 NC to TBs (Reversible) for Purchaser's future use.
A11.10	Operating time	15 sec. or less
A11.11	Number of terminal in control cabinet (Interpole cabling shall be supplied by Contractor)	All contacts & control circuits are to be wired upto control cabinet plus 24 spare terminals evenly distributed.

II. 145 kV ISOLATORS:

B11.1	Type	Outdoor
B11.2	Rated current at 50^{o}C ambient temperature	1250 A
B11.3	Rated short time withstand current of isolator and earth switch	31.5 kA for 1 Sec.
B11.4	Rated dynamic short circuit withstand current of isolator and earth switch	80 kAp
B11.5	Temperature rise over design ambient temperature	As per table V of IEC-694.
B11.6	Rated mechanical terminal load.	As per table III of IEC-62271-102 or as per value calculated in Chapter 2-GTR whichever is higher.
B11.7	Operating mechanism of isolator/earth switch	A.C. Motor operated
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 terminal in control cabinet (Interpole cabling shall be supplied by Contractor)	All contacts & control circuits are to be wired upto control cabinet plus 24 spare terminals evenly distributed.

III. 33kV ISOLATOR

C11.1	Type	Outdoor (Double Break)
C11.2	Temperature rise over design ambient temperature	As per table V of IEC 62271-1
C11.3	Rated mechanical terminal load	As per table-III of IEC 62271-102 IEC 129(1984) or as per value calculated in Chapter 2- GTR whichever is higher
C11.4	Number of terminals in Control cabinet (interpole cabling Shall be supplied by contractor)…………	All contacts and control circuits are to be wired up to control cabinet plus 24 spare terminals evenly distributed
C11.5	Rated current at design ambient temperature	1250/800 Amps (as applicable).
C11.6	Rated short time withstand current of isolator and earthswitch	25 kA for 3 Sec
C11.7	Rated dynamic short circuit withstand current of isolator and earth switch	As per IEC
C11.8	Operating mechanism for Isolator Earth switch	Manual and
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.

CHAPTER 3.3: SWITCHGEAR
INSTRUMENT TRANSFORMERS
CONTENTS

CHAPTER 3 - SWITCHGEAR

INSTRUMENT TRANSFORMERS

1.0 GENERAL:

1.1 The instrument transformers and accessories shall conform to the latest version of the standards specified below except to the extent explicitly modified in the specification and shall be in accordance with the requirements in Chapter 2-GTR.

Current Transformers IEC: 60044-1

Capacitive Voltage Transformers IEC:60044-5 / IEC-60358

Inductive Voltage Transformers IEC:60044-2

1.2 The instrument transformers shall be complete with its terminal box and a common marshalling box for a set of 3 instrument transformers.

1.3 The external surface of instrument transformer, if made of steel, shall be hot dip galvanized or painted as per **Chapter 2-GTR.**External surface of alumunium can have natur al finish.

1.4 The impregnation details alongwith tests/checks to ensure successful completion of impregnation cycle shall be furnished for approval.

1.5 The instrument transformers shall be designed for use in geographic and meteorological conditions as given in Chapter 2-GTR.

2.0 CONSTRUCTION FEATURES:

2.1 The features and constructional details of instrument transformers shall be in accordance with requirements stipulated hereunder:

a) Instrument transformers shall be of 245/145 /33kV class, oil filled/ SF6 gas filled, suitable for outdoor service and upright mounting on steel structures. 245/145/33kV 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 /33kV 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 transportationIt 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 245/145/33 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 up to 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..

b) Voltage transformers secondaries shall be protected by HRC cartridge type fuses or MCBs for all the windings. In addition fuses/MCBs 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/MCB.

c) CVTs shall be suitable for high frequency (HF) coupling required for power line carrier communication. Carrier signal must be prevented from flowing into potential transformer (EMU) circuit by means of a RF choke/reactor suitable for effectively blocking the carrier signals over the entire carrier frequency range i.e.40 to 500 KHz. Details of the arrangement shall be furnished along with the bid. H.F. terminal of the VT shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling filters of the carrier communication equipment, when utilised. Further, earthing link with fastener to be provided for HF terminal.

d) The electromagnetic unit comprising compensating reactor, intermediate transformer and protective and damping devices should have separate terminal box with all the secondary terminals brought out.

e) The damping device, which should be permanently connected to one of the secondary windings, should be capable of suppressing the ferro-resonance oscillations.

f) The accuracy of 0.2 on secondary III for all VTs should be maintained throughout the entire burden range upto 50 VA on all the windings without any adjustments during operation.

g) 245/145 kV CVTs shall 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 every50 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:

<u>for Oil filled CTs</u>

i) Measurement of Capacitance.
ii) Oil Leakage test
iii) Measurement of tan delta at 0.3, 0.7, 1.0 and 1.1 $U_m/\sqrt{3}$

<u>for SF6 filled CTs</u>

i) Dew point measurement

ii) SF6 alarm/ lockout check.

iii) SF6 leakage test. Gas leakage rate shall be maintained within 0.2% per annum.

b) **VOLTAGE TRANSFORMERS:**

Routine tests on Capacitive Voltage Transformer shall be done in line with IEC-60044-5.

7.0 SPARE PARTS AND MAINTENANCE EQUIPMENT:

The Bidder shall include in his proposal spare parts *equipment* in accordance with Section-Project.

8.0 TECHNICAL PARAMETERS:

A. 245 kV CURRENT TRANSFORMERS:

A 8.1	Rated Primary current	1600 A
A8.2	Rated short time thermal (as applicable)	40 kA for 1 sec/50 kA for 1 sec. current
A8.3	Rated dynamic current kA (peak)	100 / 125 (as applicable)
A8.4	Maximum temperature rise over design ambient temperature	As per IEC:60044-1
A8.5	One minute power frequency withstand voltage sec. terminal & earth	5 kV
A8.6	Number of terminals	All terminals of control circuits are to be wired upto marshaling box plus 20% spare terminals evenly distributed on all TBs.
A8.7	Type of insulation	Class A

Current transformers shall also comply with requirements of Table - IIA.

B. 145 kV CURRENT TRANSFORMERS:

B8.1	Rated Primary current	-1250A
B8.2	Rated short time thermal current	31.5 kA for 1 sec.
B8.3	Rated dynamic current	80 kA (peak)
B8.4	Maximum temperature rise over design ambient temperature	As per IEC:60044-1
B8.5	One minute power frequency withstand voltage sec. terminal & earth	5 kV
B8.6	Number of terminals	All terminals of control circuits are to be wired upto marshaling box plus 20% spare terminals evenly distributed on all TBs
B8.7	Type of insulation	Class A

Current transformers shall also comply with requirements of Table – IIB/ or IIC as applicable.

D. 245 KV VOLTAGE TRANSFORMERS:

D8.1	System fault level (for 1 second)	40 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 frequency capacitance **(for CVT only)** range	Within 80% to 150% of rated for entire carrier
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	As per IEC: 60044-2 or 60044-5 over design ambient temperature
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.

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	$\pm$ 10 minutes (For metering core)		
6.	Capacitance (pf)	4400/8800 (As applicable) + 10% - 5%		
		Secon-dary I	Secon-dary II	Secon-dary III
7.	Voltage Ratio	220/0.11	220/0.11	220/0.11
8.	Application	Protec-tion	Protec-tion	Meter-ing
9.	Accuracy	3 P	3 P	0.2
10.	Output burden (VA) (minimum)	50	50	50

TABLE - 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	$\pm$ 10 minutes (For metering core)		
6.	Capacitance (pf)	8800 + 10%/-5%		
		Secon-dary I	Secon-dary II	Secon-dary III
7.	Voltage Ratio	132/0.11	132/0.11	132/0.11
8.	Application	Protec-tion	Protec-tion	Meter-ing
9.	Accuracy	3 P	3 P	0.2
10.	Output burden (VA) (minimum)	50	50	50

TABLE - IIA

REQUIREMENTS FOR 245 KV CURRENT TRANSFORMERS

No.of Cores	Core No.	Application	Current ratio	Output burden (VA)	Accuracy Class as per IEC: 44-1	Min. knee pt. voltage (V_k)	Max. CT sec.wdg. resist-ance(ohms)	Max. Excitation Current at Vk (in mA)
5	1	BUS DIFF CHECK	1600-	-	-	1600/	8/4	25 on
		800/1	800/1 Tap		800 Tap; 50 on		1600/1	
	2	BUS DIFF MAIN	1600-	-	-	1600/	8/4	25 on
								1600/1
							Tap;	
		800/1	800/1					
								Tap
	3	METERING	1600-800/1	20	0.2s	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	1600-800/1	-	-	1600/ 800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	5	TRANS. DIFF/LINE PROTN	1600-800/1	-	-	1600/ 800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap

All relaying CTs shall be of accuracy class TPS as per IEC 60044-1

TABLE - IIB

REQUIREMENTS FOR 145 KV CURRENT TRANSFORMERS (Line)

No.of Cores	Core No.	Application	Current ratio	Output burden (VA)	Accuracy Class as per IEC: 44-1	Min. knee pt. voltage (V_k)	Max. CT sec.wdg. resist-ance(ohms)	Max. Excitation Current at Vk (in mA)
5	1	BUS DIFF CHECK	1200-600/1	- -	-	1200/ 600	12/6	25 on 1200/1 Tap; 50 on 600/1 Tap
	2	BUS DIFF MAIN	1200-600/1	-	-	1200/ 600	12/6	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	Tap on 1200/1 Tap; 50 on 600/1 Tap

TABLE – II C

REQUIREMENTS FOR 36 kV CURRENT TRANSFORMERS (16 MVA Transformer)

No.of Cores	Core No.	Application	Current ratio	Output burden (VA)	Accuracy class as per IEC: 44-1	Min. knee pt.voltage Vk	Max. CT resistance(ohms)	Max. Excitation current at Vk (in mA)
5	1	BUS DIFF CHECK	1200-600/1	-	-	1200/ 800	12/	25 on 1200/1 Tap; … on 800/1 Tap
		MAIN	600/1			800		25 on 1200/1 Tap; .. on 800/1 Tap
							-	-
	4	TRANS. BACK UP/LINE PROTN.	100-200/1		The values shall be designed and submitted for		; ..	
	5	TRANS. / DIFF/LINE PROTN	100-200/1		-	-		;

All relaying CTs shall be of accuracy class TPS as per IEC 60044-1.

REQUIREMENTS FOR 145 kV CURRENT TRANSFORMERS (63 MVA Transformer)

No.of Cores	Core No.	Application	Current ratio	Output burden (VA)	Accuracy class as per IEC: 44-1	Min. knee pt.voltage Vk	Max. CT sec.wdg. resistance(ohms)	Max. Excitation current at Vk (in mA)
5	1	BUS DIFF CHECK	1200-600/1	-	-	1200/ 800	12/	25 on 1200/1 Tap; … on 800/1 Tap
		MAIN	600/1			800		25 on 1200/1 Tap; .. on 800/1 Tap
							-	-
	4	TRANS. BACK UP/LINE PROTN.	300-600/1	The values shall be designed and submitted for			; ..	
	5	TRANS. / DIFF/LINE PROTN	300-600/1	-	-			;

All relaying CTs shall be of accuracy class TPS as per IEC 60044-1.

REQUIREMENTS FOR 145 kV CURRENT TRANSFORMERS (Bus Coupler)

No.of Excit- sec.wdg.	Core Cores No.	Appli- cation	Current ratio	Output burden (VA)	Accuracy class as per IEC: 44-1	Min. knee pt.volt- age Vk	Max. CT resist- ance(ohms)	Max. Excit- ation cur- rent at Vk (in mA)
5	1	BUS DIFF CHECK	1200-600/1	-	-	1200/ 800	12/	25 on 1200/1 Tap; … on 800/1 Tap
		MAIN	600/1			800		25 on 1200/1 Tap; .. on 800/1 Tap
			600/1				-	-
	4	TRANS. BACK UP/LINE PROTN.	1200-600/1	The values shall be designed and submitted for approval				; ..
	5	Spare	1200-600/1		-	-	/	;

All relaying CTs shall be of accuracy class TPS as per IEC 60044-1.

Ratio and Ratings of Current transformer will be decided during DDE. The design parameters of the CTs shall be provided during approval.

Table-1: Technical particulars of voltage transformer for 33 kV

1.	Type	Outdoor, oil immersed for protection and metering.
2.	Rated primary voltage	33 kV
3.	Max. system voltage	36 kV
4.	Impulse withstand voltage	170 kV (crest)
5.	Power frequency withstand voltage (1min,rms)	70 kV (rms)
6.	Rated frequency	50Hz
7.	Connection	Line to ground
8.	Number of secondary winding	2
9.	Voltage ratio	33/√3 / 0.11/√3/0.11/√3 kV
10.	Rated burden	50 VA
11.	Accuracy class	3P and 0.2 for metering
12.	Rated voltage factor	1.1 Continuous
13.	Creepage distance	900 mm
14.	Applicable standard	IEC 60044-2

Table-2: Technical particulars of 33 kV current transformer

1.	Type	Outdoor, oil immersed for protection and metering.
2.	Rated primary voltage	33 kV
3.	Maximum system voltage	36 kV
4.	Impulse withstand voltage	170 kV (crest)
5.	Power frequency withstand voltage (1min,rms)	70 kV (rms)
6.	Rated frequency	50Hz
7.		
8.	Number of core	*3*
9.	Short time thermal ratings	25 kA
10.	Current ratio	*400-800/1A for Feeder 400-800/1A & 1200-2400 for Transformer*
11.	Rated burden for each core	15 VA
12.	Accuracy class	5P20 for protection and 0.2 for metering
13.	Creepage distance	900 mm
14.	Applicable standard	IEC 60044-1

The ratio and ratings will be finalized during DDE

CHAPTER 3.4 - SWITCHGEAR

SURGE ARRESTERS

CONTENTS

CHAPTER 3 - SWITCHGEAR

SURGE ARRESTERS

1.0 GENERAL:

1.1 The Surge arresters shall conform to IEC: 60099-4 except to the extent modified in the specification and shall also be in accordance with requirements under Chapter 2 -GTR.

1.2 Arresters shall be of hermetically sealed units, self- supporting construction, suitable for mounting on tubular support structures to be supplied by the Con- tractor.

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. 245/145/36/12 kV class arrester shall be capable for discharging energy equivalent to class 3 of IEC for 245/145/36/12 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 alongwith quality checks.

c) The arresters shall not fail due to arrester porcelain contamination.

d) Seals shall be provided in such a way that these are always effectively maintained even when discharging rated lightning current.

e) Outer insulator shall be porcelain/polymer conforming to requirements stipulated in Chapter 2-GTR. Terminal connectors shall conform to requirements stipulated under Chapter 2-GTR.

The outer insulator housing shall be so coordinated that external flashover will not occur due to application of any impulse or switching surge voltage up to the maximum design value for arrester.

f) The end fittings shall be made of corrosion proof material and preferably be nonmagnetic.

g) The name plate shall conform to the requirements of IEC incorporating the year of manufacture.

h) The heat treatment cycle details alongwith necessary quality checks used for individual blocks alongwith insulation layer formed across each block are to be furnished. Metalizing coating thickness for reduced resistance between adjacent discs is to be furnished with additional information schedule of bid proposal sheets 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) 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 milli ammeter 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. The surge counter shall be provided with a potential free contact rated for 220 V (DC) which shall close whenever a surge is recorded by the surge monitor. Necessary arrangement shall be provided for extending the contact information to substation automation system.

c) Surge monitor consisting of discharge counters and milli-ammeters 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) Accelerated ageing 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 test for Zinc oxide Blocks as an acceptance test is to be carried out on 3 samples for 72 hours at maximum continuous over voltage (MOCV) and at a temperature of 115 degree C. Acceptance norm being Ir (resistive current)/ watt loss shall remain same or decrease at the end of 72 hours from the value taken after 1 hour of start of test.

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	10 kA of 8/20 microsecond current wave
A7.0(c)	Minimum discharge voltage corresponding to minimum discharge characteristics.	5kJ/kV (referred to rated capability) arrester
A7.0(d)	Continuous operating	168 kV rms voltage at 50 deg.C
A7.0(e)	Max. switching surge	500 kVp residual voltage (1kA)
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	650 kVp residual voltage at 10 kA.
A7.0(h)	Long duration discharge	3 class
A7.0(i)	High current short (4/10 micro second wave)	100 kAp duration test value
A7.0(j)	Current for pressure (as applicable)	40 kA rms / 50 kA rms relief test
A7.0(k)	Low current long duration	As per IEC. test value (2400 micro sec)
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	10 kA of 8/20 microsecond current 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	80 kVp
	(ii) 10 kA nominal discharge current	85 kVp
C7.0(g)	Long duration discharge class	2
C7.0(k)	Pressure relief class	A

D	**11kV Surge Arresters**	
C7.0(a)	Rated arrester voltage	9 kV
C7.0(b)	Nominal discharge capability	10 kA of 8/20 microsecond wave
C7.0(c)	Minimum discharge capability	4kJ/kV (referred to rated arrester voltage corresponding to minimum discharge characteristics).
C7.0(d)	Continuous operating voltage at 50 deg.C	7.2 kV rms
c7.0(e)	Max. switching surge residual voltage (0.5kA)	22.4 kVp
C7.0(f)	Max. residual voltage	
	(i) 5 kA	34 kVp
	(ii) 10 kA nominal discharge current	40 kVp
C7.0(g)	Long duration discharge class	2
C7.0(k)	Pressure relief class	25k A

8.0 PRE-COMMISSIONING TESTS

8.1 An indicative list of tests is given below.

(a) Operation check of LA counter.

(b) Insulation resistance measurement

(c) Capacitance and Tan delta measurement of individual stacks.

(d) Third harmonic resistive current measurement (to be conducted after energisation.)

Contractor shall perform any additional test based on specialties of the items as per the field Q.P./Instructions of the equipment Supplier or Purchaser without any extra cost to the Purchaser. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates and shall furnish the list of instruments to the Purchaser for approval.

CHAPTER 4: LT SWITCHGEAR

Table of contents

CHAPTER 4:
LT SWITCHGEAR

1.1 CONSTRUCTIONAL DETAILS OF SWITCHBOARDS AND DISTRIBUTION BOARDS

1.1.1. All boards shall be of metal enclosed, indoor, floor mounted, compartmentalized 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 at least 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 carry out 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 at least 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 draw out 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 draw out 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 throughout the length of Switchgear and shall be adequately supported and braced to withstand the stresses due to the specified short circuit currents.

1.3.4. All busbars shall be adequately supported by adequate numbers of high strength type Polyester fibre glass Moulded Insulators to withstand short circuit withstand capability of panel. Separate supports shall be provided for each phase and neutral busbar. If a common support is provided anti-tracking barriers shall be provided between the supports.

1.3.5. All busbars joints shall be provided with high tensile steel bolts. Belleville/spring washers and nuts, so as to ensure good contacts at the joints. Non-silver plated Busbars joints shall be thoroughly cleaned at the joint locations and a suitable contact grease shall be applied just before making a joint.

1.3.6. All busbars shall be colour coded as per IEC: 60446.

1.3.7. The Bidder shall furnish calculations, establishing the adequacy of busbar sizes for specified current ratings, On the basis of short circuit current and temperature rise consideration at specified ambient temp.

1.4 EARTH BUS

1.4.1. A galvanised steel earthing shall be provided at the bottom of each panel and shall extend throughout the length of each switchboard. It shall be welded/bolted to the frame work of each panel and breaker earthing contact bar vertical bus shall be provided in each vertical section which shall in turn be bolted/welded to main horizontal ground bus.

1.4.2. The earth bus shall have sufficient cross-section to carry the momentary short circuit and short time fault currents to earth without exceeding the allowable temperature rise.

1.4.3. Suitable arrangements shall be provided at each end of the horizontal earth bus for bolting to Purchaser's earthing conductors. The horizontal earth bus shall project out the switch- board ends and shall have predrilled holes for this connection. A joint spaced and taps to earth bus shall be made through at least two bolts.

1.4.4. All non-current metal work of the Switchboard shall be effectively bonded to the earth bus. Electrical conductivity of the whole switchgear enclosures frame work and the truck shall be maintained even after painting.

1.4.5. The truck and breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker frame shall be maintained in all positions. SERVICES & ISOLATED, as well as throughout the intermediate travel.

1.4.6. Air Circuit Breaker (ACB) module frame shall get engaged to the vertical earth bus, before the disconnecting contacts on these module are engaged to the vertical busbar.

1.4.7. All metallic cases of relays, instruments and other panel mounted equipments shall be connected to earth by independent stranded copper wires of size not less than 2.5 mm^2. Insulation colour code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable clamp connectors and soldering is not acceptable. Looping of earth Connection which would result in loss of earth connection to the devices when a device is removed is not acceptable. However, looping of earth connections between equipment to provide alternative paths or earth bus is acceptable.

1.4.8. VT and CT secondary neutral point earthing shall be at one place only, on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit shall be removed without disturbing the earthing of other circuit.

1.4.9. All hinged doors shall be earthed through flexible earthing braid.

1.4.10. Caution nameplate `Caution-Live Terminals' shall be provided at all points where the terminals are like to remain live and isolation is possible only at remote end.

1.5 AIR CIRCUIT BREAKERS

1.5.1. Circuit breakers shall be three-pole air break horizontal drawout type and shall have inherent fault making and breaking capacities as specified in "Technical Parameters". The circuit breakers which meet specified parameter only after provision of releases or any other devices shall not be acceptable.

1.5.2. Circuit breakers shall be mounted along with it operating mechanism on a wheeled carriage. Suitable guides shall be provided to minimise misalignment of the breaker.

1.5.3. There shall be `Service', `Test' and `Fully withdrawn positions for the breakers. In `Test' position the circuit breaker shall be capable of being tested for operation without energising the power circuits i.e. the power Contacts shall be disconnected while the Control circuits shall remain undisturbed. Locking facilities shall be provided so as to prevent movement of the circuit breaker from the `SERVICE', `TEST' OR FULLY WITHDRAWN' position. It shall be possible to close the door in TEST position.

1.5.4. All circuit breakers shall be provided with 4 NO and 4 NC potentially free auxiliary contacts. These contacts shall be in addition to those required for internal mechanism of the breaker. Separate limit switches each having required number of contacts shall be provided in both `SERVICE' & `TEST' position of the breaker. All contacts shall be rated for making continuously carrying and breaking 10 Amps at 230V AC and 1 Amp (Inductive) at 220V DC.

1.5.5. Suitable mechanical indications shall be provided on all circuit breakers to show `OPEN'.`CLOSE', `SERVICE', `TEST' and `SPRING CHARGED' positions.

1.5.6. Main poles of the circuit breakers shall operate simultaneously in such a way that the maximum difference between the instants of contacts touching during closing shall not exceed half cycle of rated frequency.

1.5.7. All circuit breakers shall be provided with the interlocks as explained in further clauses.

1.5.8. Movement of a circuit breaker between SERVICE AND TEST positions shall not be possible unless it is in OPEN position. Attempted with drawl of a closed circuit breaker shall trip the circuit breaker.

1.5.9. Closing of a circuit breaker shall not be possible unless it is in SERVICE, TEST POSITION or in FULLY WITHDRAWN POSITION.

1.5.10. Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage to cover the stationary isolated contacts when the breaker is withdrawn. It shall however, be possible to open the shutters intentionally, against spring pressure for testing purpose.

1.5.11. A breaker of particular rating shall be prevented from insertion in a cubicle of a different rating.

1.5.12. Circuit breakers shall be provided with electrical anti-pumping and trip free feature, even if mechanical anti-pumping feature is provided.

1.5.13. Mechanical tripping shall be possible by means of front mounted RED `Trip' push-button. In case of electrically operated breakers these push buttons shall be shrouded to prevent accidental operation.

1.5.14. Breaker controlled motors shall operate satisfactorily under the following conditions:

(i) Direct on-line starting of Induction Motors rated 110 kW to 220 kW with a locked rotor current of seven times the rated current, and starting time of up to 30 seconds.

(ii) Breaking on-load, full load and locked rotor currents of Induction Motors for rated 100 kW to 220 kW.

1.5.15. Means shall be provided to slowly close the circuit breaker in withdrawn position. If required for inspection and setting of Contacts, in service position slow closing shall not be possible.

1.5.16. Power operated mechanism shall be provided with a universal motor suitable for operation 220V DC Control supply with voltage variation from 90% to 110% rated voltage. Motor insulation shall be class `E' or better.

1.5.17. The motor shall be such that it requires not more than 30 seconds for fully charging the closing spring.

1.5.18. Once the closing springs are discharged, after the one closing operation of circuit breaker, it shall automatically initiate, recharging of the spring.

1.5.19. The mechanism shall be such that as long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. After failure of power supply at least one open-close-open operation shall be possible.

1.5.20. Provision shall be made for emergency manual charging and as soon as this manual charging handle is coupled, the motor shall automatically get mechanically decoupled.

1.5.21. All circuit breakers shall be provided with closing and trip coils. The closing coils shall operate correctly at all values of voltage between 85% to 110% at rated control voltage. The trip coil shall operate satisfactorily under all values of supply voltage between 70% to 110% of rated control voltage.

1.5.22. Provision for mechanical closing of the breaker only in `TEST' and `WITHDRAWN' positions shall be made.

1.5.23. **PROTECTION CO-ORDINATION**

1.5.23.1. It shall be the responsibility of the Contractor to fully co-ordinate the overload and short circuit tripping of the circuit breakers with the upstream and downstream circuit breakers/fuses/motor starters, to provide satisfactory discrimination.

1.6 MOULDED CASE CIRCUIT BREAKER (MCCB) and MCB

1.6.1. MCCB shall in general conform to IEC: 60947 Part-2. All MCCB offered shall have Ics =100% Icu rating.

1.6.2. MCCB shall be flush mounted on the AC/DC distribution boards and shall have extended handle.

1.6.3 MCCBs shall be provided with thermo-magnetic type release for over current and short circuit protection. The setting of the thermal release shall be adjustable between 80% to 100% of the rated current. The MCCB shall have breaking capacity not less than 20kA.

1.6.4 MCCBs used for ACDB incomers and Bus coupler shall be equipped with stored energy mechanism for electrical closing and tripping. All other MCCBs shall be manually operated. The operating handle should give a clear trip indication.

1.6.5 Miniature circuit breaker (MCB) shall conform to IEC: 60898.

1.7 RELAYS

1.7.1 All relays and timers in protective circuits shall be flush mounted on panel front with connections from the inside. They shall have transparent dust tight covers removable from the front. All protective relays shall have a drawout construction for easy replacement from the front. They shall either have built-in test facilities, or shall be provided with necessary test blocks and test switches located immediately below each relay. The auxiliary relays and timers may be furnished in non-drawout cases.

1.7.2 All AC relays shall be suitable for operation, at 50 Hz with 110 volts VT secondary and 1 amp or 5 amp CT secondary.

1.7.3 All protective relays and timers shall have at least two potentially free output contacts. Relays shall have contacts as required for protection schemes. Contacts of relays and timers shall be silver faced and shall have a spring action. Adequate number of terminals shall be available on the relay cases for applicable relaying schemes.

1.7.4 All protective relays auxiliary relays and timers shall be provided with hand reset operation indicators (Flags) for analysing the cause of operation.

1.7.5 All relays shall withstand a test voltage of 2 KV (rms) for one minute.

1.7.6 Motor starters shall be provided with three element, ambient temperature compensated, time lagged, hand reset type overload relays with adjustable settings. The setting ranges shall be properly selected to suit the motor ratings. These relays shall have a separate black coloured hand reset push button mounted on compartment door and shall have at least one changeover contact.

1.7.7 All fuse-protected contactor-controlled motors shall have single phasing protection, either as a distinct feature in the overload relays (by differential movement of bimetallic strips), or as a separate device. The single phasing protection shall operate even with 80% of the set current flowing in two of the phases.

1.8 CONTACTORS

1.8.1. Motor starter contactors shall be of air break, electromagnetic type rated for uninterrupted duty as per IEC: 60947 Part 4.

1.8.2 Contactors shall be double break, non-gravity type and their main contacts shall be silver faced.

1.8.3 Direct on line starter contactors shall be of utilisation category AC2. These contactors shall be as per IEC: 60947 Part 4.

1.8.4 Each contactor shall be provided with two (2) normally open (NO) and two (2) normally close (NC) auxiliary contacts.

1.8.5 Operating coils of contactors shall be of 230V AC unless otherwise specified elsewhere. The Contactors shall operate satisfactorily between 85% to 110% of the rated voltage. The Contactor shall drop out at 70% of the rated voltage.

1.9 INSTRUMENT TRANSFORMERS

1.9.1 All current and voltage transformers shall be completely encapsulated cast resin insulated type suitable for continuous operation at the temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated condition and the outside ambient temperature is 50°C.

1.9.2 All instrument transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary current ratings of the associated switchgear.

1.9.3 All instrument transformer shall have clear indelible polarity markings. All secondary terminals shall be wired to a separate terminal on an accessible terminal block where star- point formation and earthing shall be done.

1.9.4 Current transformers may be multi or single core type. All voltage transformers shall be single phase type. The Bus VTs shall be housed in a separate compartment.

1.9.5. All VTs shall have readily accessible MCBs on both primary and secondary sides.

1.10 INDICATING INSTRUMENTS

1.10.1 All indicating and integrating meters shall be flush mounted on panel front. The instruments shall be of at least 96 mm square size with 90 degree scales, and shall have an accuracy class of 2.5 or better. The covers and cases of instruments and meters shall provide a dust and vermin proof construction.

1.10.2 All instruments shall be compensated for temperature errors and factory calibrated to directly read the primary quantities. Means shall be provided for zero adjustment without removing or dismantling the instruments.

1.10.3 All instruments shall have white dials with black numerals and lettering. Black knife edge pointer with parallax free dials will be preferred.

1.10.4 Ammeters provided on Motor feeders shall have a compressed scale at the upper current region to cover the starting current.

1.10.5 Watt-hour meters shall be of 3 phase three element type, Maximum demand indicators need not be provided.

1.11 CONTROL & SELECTOR SWITCHES

1.11.1 Control & Selector switches shall be of rotary type with escutcheon plates clearly marked to show the function and positions. The switches shall be of sturdy construction suitable for mounting on panel front. Switches with shrouding of live parts and sealing of contacts against dust ingress shall be preferred.

1.11.2 Circuit breaker selector switches for breaker Controlled motor shall have three stay put positions marked `Switchgear', `Normal' and `Trial' respectively. They shall have two contacts of each of the three positions and shall have black shade handles.

1.11.3 Ammeter and voltmeter selector switches shall have four stayput position with adequate number of contacts for three phase 4 wire system. These shall have oval handles Ammeter selector switches shall have make before break type contacts to prevent open circuiting of CT secondaries.

1.11.4 Contacts of the switches shall be spring assisted and shall be of suitable material to give a long trouble free service.

1.11.5 The contact ratings shall be at least the following:

(i)	Make and carry continuously	10 Amp.
(ii)	Breaking current at 220V DC	1 Amp (Inductive)
(iii)	Breaking current at 230V AC	5 Amp (at 0.3 pf lagging)

1.12 AIR BREAK SWITCHES

1.12.1 Air breaker switch shall be of the heavy duty, single throw group operated, load break, fault make type complying with IEC: 60947 Part-3.

1.12.2 The Bidder shall ensure that all switches are adequately rated so as to be fully protected by the associated fuses during all abnormal operating conditions such as overload, locked motor, short circuit etc.

1.12.3 Switch operating handles shall be provided with padlocking facilities to lock them in `OFF' position.

1.12.4 Interlocks shall be provided such that it is possible to open the cubicle door only when the switch is in `OFF' position and to close the switch only when the door is closed. However suitable means shall be provided to intentionally defeat the interlocks explained above.

1.12.5 Switches and fuses for AC/DC control supply and heater supply wherever required shall be mounted inside and cubicles.

1.13 PUSH BUTTONS

1.13.1 Push-buttons shall be of spring return, push to actuate type. Their contacts shall be rated to make, continuously carry and break 10A at 230V and 0.5A (inductive) at 220V DC.

1.13.2 All push-buttons shall have one normally open and one normally closed contact, unless specified otherwise. The contact faces shall be of silver or silver alloy.

1.13.3 All push-buttons shall be provided with integral escutcheon plates marked with its function.

1.13.4 The colour of the button shall be as follows:

(i)	GREEN	:	For motor START, Breaker CLOSE
(ii)	RED	:	For motor TRIP, Breaker OPEN
(iii)	BLACK	:	For overload reset.

1.13.5 All push-buttons on panels shall be located in such a way that Red-push-buttons shall always be to the left of green push-buttons.

1.14 INDICATING LAMPS

1.14.1 Indicating lamps shall be of the panel mounting cluster LED type. The lamps shall have escutcheon plates marked with its function, wherever necessary.

1.14.2 Lamps shall have translucent lamp-covers of the following colours, as warranted by the application:

(i)	RED	:	For motor ON, Breaker CLOSED
(ii)	GREEN	:	For motor OFF, Breaker OPEN
(iii)	WHITE	:	For motor Auto-Trip
(iv)	BLUE	:	For all healthy conditions (e.g. control supply, and also for 'SPRING CHARGED"
(v)	AMBER	:	For all alarm conditions (e.g. overload) Also for `SERVICE' and `TEST' positions indicators.

1.14.3 Lamps shall be easily replaceable from the front of the cubicle.

1.14.4 Indication lamps should be located just above the associated push buttons/control switches. Red lamps shall invariable be located to the right of green lamps. In case a white lamp is also provided, it shall be placed between the red and green lamps along with the centre line of control switch/push button pair. Blue and Amber lamps should normally be located above the Red and Green lamps.

1.14.5 When associated with push-buttons, red lamps shall be directly above the green push button, and green lamps shall be directly above the red push-button. All indicating lamps shall be suitable for continuous operation at 90 to 110% of their rated voltage.

1.15 FUSES

1.15.1 All fuses shall be of HRC cartridge fuse link type. Screw type fuses shall not be accepted. Fuses for AC Circuits shall be of class 2 type, 20 kA (RMS) breaking current at 400 AC, and for DC circuits Class 1 type 4 kA breaking current.

1.15.2 Fuses shall have visible operation indicators.

1.15.3 Fuses shall be mounted on fuses carriers, which are mounted on fuse bases, wherever it is not possible to mount fuses on carriers fuses shall be directly mounted on plug in type of bases. In such cases one set of insulated fuse pulling handles shall be supplied with each switchgear.

1.15.4 Fuse rating shall be chosen by the Bidder depending upon the circuit requirements and these shall be subject to approval of PURCHASER.

1.16 TERMINAL BLOCKS

1.16.1 Terminal blocks shall be of 750 volts grade and have continuous rating to carry the maximum expected current on the terminals. It shall be complete with insulating barriers, clip-on-type/stud type terminals for Control Cables and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring on diagrams. It shall be similar to `ELEMEX' standard type terminals, cage clamp type of Phoenix or WAGO or equivalent

1.16.2 Terminal blocks for CT and VT secondary leads shall be provided with test links and isolating facilities. CT secondary leads shall be provided with short circuiting and earthing facilities. It shall be similar to `Elem.' `CATD' - Type.

1.16.3 In all circuit breaker panels at least 10% spare terminals for external connections shall be provided and these spare terminals shall be uniformly distributed on all terminal blocks. Space for adding another 10% spare terminals shall also be available.

1.16.4 All terminal blocks shall be suitable for terminating on each side, two (2) Nos. of 2.5 mm square size standard copper conductors.

1.16.5 All terminals shall be numbered for identification and grouped according to the function. Engraved white-on-black labels shall be provided on the terminal blocks.

1.16.6 Wherever duplication of a terminal block is necessary it shall be achieved by solid bonding links.

1.16.7 Terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal block. The minimum clearance between the first row of terminal block and the associated cable gland plate shall be 250 mm.

1.17 NAME PLATES AND LABELS

1.17.1 All switchgears, AC/DC distribution boards, shall be provided with prominent, engraved identification plates. The module identification plate shall clearly give the feeder number and feeder designation. For single front switchboards, similar panel and board identification labels shall be provided at the rear also.

1.17.2 All name plates shall be of non-rusting metal or 3-ply lamicoid with white engraved lettering on black back ground. Inscriptions and lettering sizes shall be subject to PURCHASER approval.

1.17.3 Suitable plastic sticker labels shall be provided for easy identification of all equipments, located inside the panel/module. These labels shall be positioned so as to be clearly visible and shall give the device number as mentioned in the module wiring drawings.

1.18 SPACE HEATER

1.18.1 Space heater shall be provided in all the boards for preventing harmful moisture condensation.

1.18.2 The space heaters shall be suitable for continuous operation on 230V AC, 50 Hz, single phase supply, and shall be automatically controlled by thermostats. Necessary isolating switches and fuses shall also be provided.

1.19 CONTROL AND SECONDARY WIRING

1.19.1 All switchboards shall be supplied completely wired internally upto the terminal blocks ready to receive Purchaser's control cables.

1.19.2 All inter cubicle and inter panel wiring and connections between panels of same switchboard including all bus wiring for AC and DC supplies shall be provided by the bidder.

1.19.3 All internal wiring shall be carried out with 1100 V grade, single core, 1.5 square mm or larger stranded copper wires having colour coded, PVC insulation. CT circuits shall be wired with 2.5 square mm copper wires. Voltage grade and insulation shall be same as above.

1.19.4 Extra-flexible wires shall be used for wiring to device mounted on moving parts such as hinged doors.

1.19.5 All wiring shall be properly supported, neatly arranged, readily accessible and securely connected to equipment terminals and terminals blocks.

1.20 POWER CABLES TERMINATION

1.20.1 Cable termination compartment and arrangement for power cables shall be suitable for stranded aluminium conductor, armoured XLPE/PVC insulated and sheathed, single core/three core, 1100 V grade cables.

1.20.2 All necessary cable terminating accessories such as Gland plates, supporting clamps and brackets, power cable lugs, hardware etc. shall be provided by the successful bidder, to suit the final cable sizes which would be advised later.

1.20.3 The gland plate shall be of removable type and shall cover the entire cable alley. Bidder shall also ensure that sufficient space is provided for all cable glands. For all single core cables, gland plates shall be of non-magnetic Material.

1.21 TYPE TESTS

1.21.1 Type tests reports on Panels (Switchgear and Control gear assemblies) as per IEC: 60439, Part-1 shall be submitted for the following tests in line with clause 9.0 of Chapter 2 GTR before the fabrication of switchgear is started:

i) Verification of temperature rise limits
ii) Verification of the dielectric properties
iii) Verification of short circuit strength
iv) Verification of the continuity of the protective circuit
v) Verification of clearances and creepage distances
vi) Verification of mechanical operation
vii) Verification of degree of protection

1.21.2 Contractor shall submit type test reports for the following Switchgear and Control gears before the fabrication of switchgear is started:

1. Circuit breakers/MCCB as per IEC: 60947 Part 2.
2. Protective Relays as per IEC: 60255.

3. Lighting transformers as per IEC:60076

For above equipments, test conducted once are acceptable (i.e. The requirement of test conducted within last five years shall not be applicable)

1.22 ERECTION, TESTING AND COMMISSIONING

1.22.1 The Contractor shall unload, erect, install, test and put into commercial use all electrical equipment included in this specification.

1.22.2 Equipment shall be installed in a neat, workman like manner so that it is level, plumb, square and properly aligned and oriented. Tolerance shall be as established in Contractor's drawings or as stipulated by purchaser. No equipment shall be permanently bolted down to foundations until the alignment has been checked and found acceptable by the purchaser.

1.22.3 Contractor shall furnish all supervision, labour tools equipment rigging materials, bolts, wedges, anchors, concrete inserts etc. in proper time required to completely install, test and commission the equipment.

1.22.4 Manufacturer's and purchaser's instructions and recommendations shall be correctly followed in handling, setting, testing and commissioning of all equipment.

1.22.5 Contractor shall move all equipment into the respective room through the regular door or openings specifically provided for this purpose. No part of the structure shall be utilised to lift or erect any equipment without prior permission of Purchaser.

1.22.6 All boards shall be installed in accordance with relevant code of practices and at Purchaser's instructions. All boards shall be installed on finished surfaces, concrete or steel stills. Contractor shall be required to install and align any channel sills which form part of foundations. In joining shipping sections of switchboards together adjacent housing of panel sections or flanged throat sections shall be bolted together after alignment has been completed. Power bus, enclosures ground and control splices of conventional nature shall be cleaned and bolted together being drawn up with torque spanner of proper size or by other approved means.

1.22.7 All boards shall be made completely vermin proof.

1.22.8 Contractor shall take utmost care in holding instruments, relaying and other delicate mechanism wherever the instruments and relays are supplied separately they shall be mentioned only after the associated panels have been erected and aligned. The packing materials employed for safe transit of instrument and relays shall be removed after ensuring that panel have been completely installed and to further movement of the same should be necessary. Any damage shall be immediately reported to Purchaser.

1.22.9 Equipment furnished with finished coats of paint shall be touched by up Contractor if their surface is specified or marred while handling.

1.22.10 After installation of panels, power and control wiring and connections, Contractor shall perform operational tests on all switchboards, to verify proper operation of switch-boards/panels and correctness of all equipment in each and every respect. The cable opening and cables entries for cables terminating to the panels shall be sealed with fire sealing materials.

1.23 COMMISSIONING CHECK TESTS

The Contractor shall carry out the following commissioning checks, in addition to the other checks and tests recommended by the manufacturers.

1.23.1 General

1.23.1.1 Check name plate details according to the specification.

1.23.1.2 Check for physical damage.

1.23.1.3 Check tightness of all bolts, clamps, joints connecting terminals.

1.23.1.4 Check earth connection.

1.23.1.5 Check cleanliness of insulators and bushings.

1.23.1.6 Check all moving parts for proper lubrication.

1.23.1.7 Check settings of all the relays.

1.23.2 Circuit Breakers

1.23.2.1 Check alignment of breaker truck for free movement.

1.23.2.2 Check correct operation of shutters.

1.23.2.3 Check control wiring for correctness of connections, continuity and IR values.

1.23.2.4 Manual operation of breaker completely assembled.

1.23.2.5 Power closing/opening operation, manually and electrically.

1.23.2.6 Breaker closing and tripping time.

1.23.2.7 Trip free and anti-pumping operation.

1.23.2.8 IR values, minimum pick up voltage and resistance of coils.

1.23.2.9 Contact resistance

1.23.2.10 Simultaneous closing of all the three phases.

1.23.2.11 Check electrical & mechanical interlocks provided.

1.23.2.12 Check on spring charging motor, correct operation of limit switches, and time of charging.

1.23.2.13 All functional checks.

1.23.3 Current Transformers

1.23.3.1 Megger between winding and winding terminals to body.

1.23.3.2 Polarity test

1.23.3.3 Ratio identification checking of all ratios on all cores by primary injection of current.

1.23.3.4 Spare CT cores, if available, to be shorted and earthed.

1.23.4 **Voltage Transformer**

1.23.4.1 Insulation resistance test

1.23.4.2 Ratio test on all cores.

1.23.4.3 Polarity test.

1.23.4.4 Line connections as per connection diagram.

1.23.5 **Cubicle Wiring**

1.23.5.1 Check all switch developments.

1.23.5.2 Each wire shall be traced by continuity tests and it should be made sure that the wiring is as per relevant drawing. All interconnections between panels/equipment shall be similarly checked.

1.23.5.3 All the wires shall be meggered to earth.

1.23.5.4 Functional checking of all control circuit e.g. closing, tripping control, interlock, supervision and alarm circuit.

1.23.6 **Relays**

1.23.6.1 Check connections and wiring.

1.23.6.2 Megger all terminals to body.

1.23.6.3 Megger AC to DC terminals.

1.23.6.4 Check operating characteristics by secondary injection.

1.23.6.5 Check minimum pick up voltage of DC coils.

1.23.6.6 Check operation of electrical/mechanical targets.

1.23.6.7 Relays settings.

1.23.6.8 Check CT and VT connections with particular reference to their polarities for directional relays, wherever required.

1.23.7 **Meters**

1.23.7.1 Check calibration by comparing it with a sub-standard.

1.23.7.2 Megger all insulated portions.

1.23.7.3 Check CT and VT connections with particular reference to their polarities for power type meters.

1.24 SPECIAL TOOLS AND TACKLES

1.24.1 The Bidder shall include in his proposal any special tools and tackles required for erection, testing commissioning and maintenance of the equipments offered.

1.24.2 The list of these special tools and tackles shall be given in the bid proposal sheets alongwith their respective prices.

1.24.3 The total price of the special tools and tackles shall be included in proposal sheets.

1.25 EQUIPMENT TO BE FURNISHED

1.25.1 The Bidder shall quote for various AC/DC distribution boards in accordance with this specification.

1.25.2 Standard scheme of interconnection of switchboards and distribution boards alongwith tentative feeder disposition for each board is indicated in Standard SLD of AC & DC system enclosed alongwith bid documents. The bidder shall quote board prices on the basis of standard SLD and their estimation of feeders for entire present and future bays requirement. Any other feeder required as per system requirement for efficient and reliable operation shall be deemed to be included in bidder's scope.

1.25.3 The Bill of Materials for each type of module shall be as under. These are minimum indicative requirement of the system. The necessary auxiliary relays, push buttons and indicating lamps shall be provided as per scheme requirement. Any other item/component required with in a module for efficient and reliable operation shall be deemed to be included in bidder's scope.

1.25.4 Module Type AE (Electrically controlled circuit breaker for incoming and Bus Coupler Circuit).

(i)	One (1)	Triple pole air circuit breaker complete with all accessories and power operated mechanism as specified.
(ii)	Two (2)	Neutral link.
(iii)	Three (3)	Current Transformer for metering.
(iv)	One (1)	Ammeter with selector switch.
(v)	Three (3)	Current Transformer for relaying.
(vi)	One (1)	Triple pole instantaneous over-current relay having the setting range of 200-800% or 500-2000% of CT secondary and adjustable definite minimum time.
(vii)	One (1)	Instantaneous earth fault relay having an adjustable setting range of 10-40% or 20 - 80% of CT secondary current and adjustable definite minimum time. The earth fault relay shall be provided with a stabilising resistor.
(viii)	One(1) set	Current and Voltage transducers.
(ix)	One(1) set	High speed tripping relays.

1.25.5 **Module Type - M1 (Circuit Breaker Controlled Motor Feeder)**

(i)	One (1)	Triple pole Air Circuit Breaker complete with accessories, and power operated mechanism as specified.
(ii)	One (1)	Three position 6 pole selector switch 'SWITCHGEAR/NORMAL /TRIAL'.
(iii)	Three (3)	Current Transformer for metering.
(iv)	One (1)	Ammeter with Ammeter Selector Switch
(v)	Three (3)	Current Transformer for relaying.
(vi)	One (1)	Triple pole instantaneous over-current relay for providing positive sequence current protection in all the three phases. The relay setting range shall be continuously adjustable between 200-800% or 400-1600% of CT secondary rated current as required.

(vii)	One (1)	Double pole inverse definite minimum time over current relays connected in R & B phases for over current protection of motor rated 110 kW - 200 kW. The relay shall have an adjustable setting range of 50% - 200% of CT Secondary current and time setting range of 0-30 Second. The relay shall be CDGM-22 of EE or equivalent.
(viii)	One (1)	Single pole adjustable definite time delay relay for motor overload alarm connected in Y-phase only. The relay shall have resetting ratio of not less than 90%. The relay shall have continuously adjustable time delay range of 2.5 to 25 Sec.
(ix)	One (1)	Instantaneous earth fault relay having an adjustable setting range of 10-40% or 20-80% of CT secondary current. The earth fault relay shall be provided with a stabilising resistor.
(x)	One(1) set	Current and Voltage transducers.
(xi)	One(1) set	High speed tripping relay.

1.25.6 **Module Type E**

(i)	One (1)	Four pole MCCB

1.25.7 **Module G-1 (VT Module with under Voltage Relay)**

(i)	Three (3)	$400/\sqrt{3}$/$_{110/\sqrt{3}}$ volts single phase voltage transformer star/star connect with star point solidly earthed mounted on common draw out chassis. Accuracy Class 0.5 for protection and metering with 50VA Burden.
(ii)	Six (6)	HRC Fuses mounted on the above chassis.
(iii)	One (1)	Four position voltmeter selector switch.
(iv)	One (1)	Voltmeter (0-500V)
(v)	One (1)	Double pole instantaneous under voltage relays with continuous variable setting range of 40-80% of 110 Volts.
(vi)	One (1)	Time delay pick up relay having a time setting range of 0.5 to 3 secs. with 3 `NO'. Self-reset contacts, suitable for 220V
(vii)	One (1)	Auxiliary relay 220V DC with 2 NO. Self-reset contacts.
(viii)	Three (3)	Indicating lamps with series resistor and colour lenses (Red, Blue & Yellow).

1.25.8 Module Type G-2

(i)	Three (3)	HRC Fuse
(ii)	One (1)	Voltmeter (0-500V)
(iii)	One (1)	Voltmeter selector switch four position (R-Y, Y-B, B-R OFF).
(iv)	Three (3)	Indication lamps (Red, Blue & Yellow)

1.25.9 **Module Type H & H (BC) (Isolating Switch Controlled Incoming Circuit)**

(i)	One (1)	Four pole MCCB
(ii)	One (1)	Red Indicating lamp to indicate isolating switch closed position.

1.25.10 **Module Type S : (DC Metering and Protection Module)**

(i)	One (1)	Voltmeter 300-0-300V DC for 220V DC DB/Voltmeter 0-75V DC for 50V DCDB
(ii)	One (1)	Three (3) position voltmeter selector switch
(iii)	One (1)	Instantaneous under voltage relay with 95% of 220V DC. The resetting ratio of relay of relay should not be more than 1.25. The relay shall be provided with a series resistor and a push button across if for resetting (pick up) the relay at about 105% of the drop out voltage.
(iv)	One (1)	Instantaneous over voltage relay with setting range of 110% of 220V DC. The resetting ratio of relay should not be less than 0.8. The relay shall have a push button in series of resetting the relay at about 95% of the operating voltage.
(v)	One (1)	Earth leakage relay only for 220V DC system having adjustable pick up range between 3 to 7 milliamps the relay shall be suitable for 220V DC/230V AC Auxiliary supply.

1.25.11 **Module Type X**

One (1) Double pole 250 V MCB

1.25.12 **Module Type-DC (Incomer from Battery & Chargers)**

(i)	One (1)	Double pole 250V DC MCCB for incomer from Battery.
(ii)	One (1)	DC ammeter with shunt and range of 90-0-400 Amps. For 220V DC DB and 90-0-200 Amp for 50V DC DB.
(iii)	Two (2)	Double pole 250V DC MCCB/MCB
(iv)	One (1)	Double pole single throw 250V DC air break switch connecting battery & charger sections to DC DB.
(v)	One(1) set	Voltage and Current Transducers

1.25.13 Module Type DG-1 (Electrically Controlled Circuit Breaker for Incomer from DG Set)

a)	One (1)	Triple pole circuit breaker complete with all accessories and power operated mechanism as specified.
b)	One (1)	Frequency meter.
c)	One (1)	Voltmeter with selector switch.
d)	One (1)	Remote/Local Selector switch.
e)	Three (3)	Current transformer for metering.
f)	Six (6)	Current Transformers for differential protection (out of this 3 Nos. will be supplied loose for mounting in DG set panel).
g)	Three (3)	Current transformer for relaying.
h)	One (1)	Ammeter Selector Switch.
i)	One (1)	Ammeter
j)	One (1)	Wattmeter of range 0-300 KW.
k)	One (1)	Three pole voltage controlled definite time delay relay having current setting range of 50-200% of CT secondary current and adjustable time delay 0.3 to 3 secs.
l)	One (1)	Watt hour meter with six (6) digits and minimum count of one (1) kwh.
m)	One (1)	Single pole definite time over current relay having a continuous setting range of 50-200% of CT secondary current and a time delay of 2.5-25 secs connected in CT of Y phase for overload alarm. The relay shall have a setting ratio of not less than 90%.
n)	One (1)	Three pole differential protection relay having an operating current setting range of 10-40% of generator full load current. The relay shall be of high impedance type, with necessary stabilizing resistors.
o)	Two (2)	Push buttons for Remote starting & stopping of DG Set (Red, Green).
p)	One (1) set	Current and Voltage transducers.
q)	One (1) set	High speed tripping relays.

1.25.14 Module Type H1

One (1) Double pole DC Switch with pad locking facility in off position.

1.25.15 Module Type EL

(i) One (1) Four pole MCCB

(ii) One (1) Contactor

(iii) Electronic Timer suitable for continuous operation, push button and selector switch be as per scheme requirement

1.26	**PARAMETERS**		
1.26.1	**Power Supply**		
1.26.1.1	AC System		3 phase, 4 wire, solidly earthed
	a)	Voltage	400 Volts, ± 10%
	b)	Frequency	50 Hz ± 2.5%
	c)	Combined variation	± 105% Absolute Sum in Voltage & frequency
	d)	Fault Level	20 kA (rms)
1.26.1.2	**DC System**		2 Wire, unearthed
	a)	System voltage	220V ± 10%
	b)	Fault Level	4 kA
	c)	System Voltage	48 V ± 10%
	d)	Fault Level	--
1.26.2	**Control Supply Voltage**		
	a)	Trip and closing	220V/110V DC Unearthed coils
	b)	Spring charging	220V/110V 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

1.26.3.3 **Circuit Breaker**

c)	Type	Air Break
d)	No. of poles	3
e)	Voltage & Frequency	400 Volts, ± 10%, 50 HZ + 2.5%
f)	Rated Operating Duty	As per IEC
g)	Rated service short-circuit	20 kA (RMS)
	Breaking capacity (Ics)	
h)	Short Circuit making current	45 kA (Peak)
i)	Short time withstand current for 1 sec duration	20 kA (RMS) for 1 sec.
j)	current for 1 sec.duration.	20 kA (RMS) for 1 sec
	Operating mechanism	
k)	No. of auxiliary contacts	4 NO & 4 NC contacts for Purchaser's use on fixed portion of the cubicle
	Short Circuit breaking current	
l)	AC Component	20 kA (RMS)
m)	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 &1 NC Contacts (only for incomer And bus-coupler MCCBs)	1 NO &1 NC	1 NO
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 (rms) Frequency withstand test	2 kV

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, 400/400 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.

<u>ANALOGUE INPUTS</u>:

i) Voltage R-Y, Y-B, B-R of Main Switch Board section-I
ii) Voltage R-Y, Y-B, B-R of Main Switch Board section-II
iii) Current from LT transformer-I
iv) Current from LT transformer-II
v) Voltage of 220V DCDB-I
vi) Voltage of 220V DCDB-II
vii) Current from 220V Battery set-I
viii) Current from 220V Battery set-II
ix) Voltage of 48V DCDB-I
x) Voltage of 48V DCDB-II
xi) Current from 48V Battery set-I
xii) Current from 48V Battery set-II

1.30 DIGITAL (Potential Free) INPUTS:

LT System shall have provision of following digital inputs for owner's substation automation purpose. These digital inputs shall be made available in the form of potential free contacts to be provided in respective modules. These potential free contacts shall be wired up to respective terminal blocks.

i) Main (MSB) Incomer-I breaker On/Off
ii) Main (MSB) Incomer-II breaker On/Off
iii) Main (MSB) 400V Bus-I/II U/V
iv) Main (MSB) bus coupler breaker on/off
v) DG set breaker on/off
vi) LT transformer-I Bunchholz Alarm & trip
vii) LT transformer-II Buchloz Alarm & trip
viii) LT transformer-I WTI Alarm & trip
ix) LT transformer-II WTI Alarm & trip
x) LT transformer-I OTI Alarm & trip
xi) LT transformer-II OTI Alarm & trip
xii) 220 V DC-I earth fault
xiii) 220V DC-II earth fault

CHAPTER 5: BATTERY AND BATTERY CHARGER

Table of contents

CHAPTER: BATTERY & BATTERY CHARGER

1.1. GENERAL TECHNICAL REQUIREMENTS

1.1.1. All materials/components used in battery chargers and batteries shall be free from flaws and defects and shall conform to the relevant Indian/IEC standards and good engineering practice.

1.1.2. DC System shall consist of two (2) float-cum-boost chargers and two(2) battery sets for each of 220V and 48 V systems respectively. The standard scheme drawing is enclosed with this specification.

1.1.3. Bidder shall select number of cells, float and Boost voltage to achieve following system requirement:

System Voltage	Maximum Voltage during Float operation	Minimum voltage available when no charger working and battery fully discharged upto 1.85V per cell.	Minimum Nos of cell
220 Volt	242 Volt	198 Volt	107
110 Volt	121 Volt	99 Volt	54
48 Volt	52.8 Volt	43.2 Volt	23

Bidder shall furnish calculation in support of battery sizing, selection of number of cells, float and Boost voltages during detailed engineering for Owners acceptance. Battery sizing calculations shall be done as per IEEE- 485 on the basis of following duty cycle:

	Load	**Duration**	**Type Of Loads**
220V DC system	Continuous Load	3 hours	Relays, IEDs, Station HMIs, spring charging, Isolator interlocking load, Miscellaneous permanently connected loads etc.
	Emergency Load	1 hour	Substation emergency lighting loads.
	Momentary Load	1 minute	Breaker closing, Tripping loads (taking simultaneous occurrence as per system)
48V DC	Continuous Load	3 hours	Continuous load associated with PLCs.(when speech is not working)
System	Momentary Load	15 minute	Loads associated with PLCs (when speech is working)

1.2. Battery

1.2.1. Type

The DC Batteries shall be VRLA (Valve Regulated Lead-Acid) type and shall be Normal Discharge type. These shall be suitable for a long life under continuous float operations and occasional discharges. Air-conditioning shall be provided in Battery room the requirement of which has been specified elsewhere in the Technical Specification. The 220 V DC system is unearth and 48 V DC system is + ve earth system.

1.2.2. Constructional Requirements

The design of battery shall be as per field proven practices. Partial plating of cells is not permitted. Paralleling of cells externally for enhancement of capacity is not permitted. Protective transparent front covers with each module shall be provided to prevent accidental contact with live module/electrical connections.

1.2.3. Containers

The container material shall have chemical and electro-chemical compatibility and shall be acid resistant. The material shall meet all the requirements of VRLA batteries and be consistent with the life of battery. The container shall be fire retardant and shall have an Oxygen Index of at least 28 %. The porosity of the container shall be such as not to allow any gases to escape except from the regulation valve. The tensile strength of the material of the container shall be such as to handle the internal cell pressure of the cells in the worst working condition. Cell shall not show any deformity or bulge on the sides under all working conditions. The container shall be capable of withstanding the rigours of transport, storage and handling. The containers shall be enclosed in a steel tray.

1.2.4. **Cell Covers**

The cell covers shall be made of suitable material compatible with the container material and permanently fixed with the container. It shall be capable to withstand internal pressure without bulging or cracking. It shall also be fire retardant. Fixing of Pressure Regulation Valve & terminal posts in the cover shall be such that the seepage of electrolyte, gas escapes and entry of electro-static spark are prevented.

1.2.5. **Separators**

The separators used in manufacturing of battery cells, shall be of glass mat or synthetic material having high acid absorption capability, resistant to sulphuric acid and good insulating properties. The design of separators shall ensure that there is no misalignment during normal operation and handling.

1.2.6. **Pressure Regulation Valve**

Each cell shall be provided with a pressure regulation valve. The valve shall be self resealable and flame retardant. The valve unit shall be such that it cannot be opened without a proper tool. The valve shall be capable to withstand the internal cell pressure specified by the manufacturer.

1.2.7. **Terminal Posts**

Both the +ve and –ve terminals of the cells shall be capable of proper termination and shall ensure its consistency with the life of the battery. The surface of the terminal post extending above the cell cover including bolt hole shall be coated with an acid resistant and corrosion retarding material. Terminal posts or any other metal part which is in contact with the electrolyte shall be made of the same alloy as that of the plates or of a proven material that does not have any harmful effect on cell performance. Both +ve and –ve posts shall be clearly and unambiguously identifiable.

1.2.8. **Connectors, Nuts & Bolts, Heat Shrinkable Sleeves**

Where it is not possible to bolt the cell terminals directly to assemble a battery, separate non-corroding lead or copper connectors of suitable size shall be provided to enable connection of the cells. Copper connections shall be suitably lead coated to withstand corrosion due to sulphuric acid at a very high rate of charge or discharge. Nuts and bolts for connecting the cells shall be made of copper, brass or stainless steel. Copper or brass nuts and bolts shall be effectively lead coated to prevent corrosion. Stainless steel bolts and nuts can be used without lead coating.

All inter cell connectors shall be protected with heat shrinkable silicon sleeves for reducing the environmental impact including a corrosive environment.

1.2.9. **Flame Arrestors**

Each cell shall be equipped with a Flame Arrestor to defuse the Hydrogen gas escaped during charge and discharge. Material of the flame arrestor shall not affect the performance of the cell.

1.2.10. **Battery Bank Stand**

All batteries shall be mounted in a suitable metallic stand/frame. The frame shall be properly painted with the acid resistant paint. The suitable insulation shall be provided between stand/frame and floor to avoid the grounding of the frame/stand.

1.2.11. **Capacity Requirements**

When the battery is discharged at 10 hour rate, it shall deliver 80% of C (rated capacity, corrected at 27º Celsius) before any of the cells in the battery bank reaches 1.85V/cell. The battery shall be capable of being recharged from the fully exhausted condition (1.75V/cell) within 10 hrs up to 90% state of charge. All the cells in a battery shall be designed for continuous float operation at the specified float voltage throughout the life.

The capacity (corrected at 27ºCelcius) shall also not be less than C and not more than 120% of C before any cell in the battery bank reaches 1.75V/cell. The battery voltage shall not be less than the following values, when a fully charged battery is put to discharge at C/10 rate:

(a) After Six minutes of discharge : 1.98V/cell
(b) After Six hours of discharge : 1.92V/cell
(c) After 8 hours of discharge : 1.85V/cell
(d) After 10 hours of discharge : 1.75V/cell

Loss in capacity during storage at an average ambient temperature of 35º Celcius for a period of 6 months shall not be more than 60% and the cell/battery shall achieve 85% of its rated capacity within 3 charge/discharge cycles and full rated capacity within 5 cycles, after the storage period of 6 months. Voltage of each cell in the battery set shall be within 0.05V of the average voltage throughout the storage period. Ampere hour efficiency shall be better than 90% and watt hour efficiency shall be better than 80%.

1.2.12. Expected Battery Life

The battery shall be capable of giving 1200 or more charge/discharge cycles at 80% Depth of discharge (DOD) at an average temperature of 27º Celsius. DOD (Depth of Discharge) is defined as the ratio of the quantity of electricity (in Ampere-hour) removed from a cell or battery on discharge to its rated capacity. The battery sets shall have a minimum expected life of 20 years at float operation.

1.2.13. **Routine Maintenance of Battery system**

For routine maintenance of battery system, the contractor shall supply 1 set of following tools:

a) Torque wrench.
b) Cell test voltmeter (-3-0-+3) volts with least count of 0.01Volt.

1.2.14. **Type Test of Battery**

1.2.14.1. Contractor shall submit type test reports of following tests as per IEC 60896-21 & IEC 60896-22, 2004. The type test reports shall be submitted in accordance with the requirements stipulated in clause no. 9.2 of Technical Specification, Chapter 2: GTR except that the requirement of tests having been conducted within last five years as mentioned therein shall not be applicable.

S.No.	Description of test
1.	Gas emission
2.	High current tolerance
3.	Short circuit current and d.c. internal resistance
4.	Protection against internal ignition from external spark sources
5.	Protection against ground short propensity
6.	Content & durability of required markings
7.	Material identification

8.	Valve operation
9.	Flammability rating of materials
10.	Intercell connector performance
11.	Discharge Capacity
12.	Charge retention during storage
13.	Float service with daily discharges for reliable mains power
14.	Recharge behaviour
15.	Service life at an operating temperature of 40^{0} C for brief duration
	exposure time.
16.	Impact of a stress temperature of 60^{0} C for brief duration exposure time with 3 h rate discharge test.
17.	Abusive over-discharge
18.	Thermal runaway sensitivity
19.	Low temperature sensitivity
20.	Dimensional sensitivity at elevated internal pressure and temperature
21.	Stability against mechanical abuse of units during installation

Tests shall be conducted in accordance with IEC 60896-21 & IEC 60896-22, 2004

1.2.14.2. List of Factory & Site Tests for Battery

Sl. No.	Test	Factory Tests	Site Tests
1.	Physical Verification		√
2.	C/10 Capacity test on the cell	√	
3.	8 Hrs. Charge and 15 minutes discharge test at full rated load		√

1.2.15. **Installation and commissioning**

1.2.15.1. Manufacturer of Battery shall supervise the installation and commissioning and perform commissioning tests as recommended in O&M manual / or relevant standards. All necessary instruments, material, tools and tackles required for installation, testing at site and commissioning are to be arranged by Battery manufacturer/ Contractor

1.2.16. Contractor shall be submitted following documents for approval:

a) Data sheet as per Annexure-I
b) GA of cell and layout drawing
c) Discharge Data for 10 Hour, 8 Hour, 3 Hour, 2 Hour, 1 Hour, 15 Minutes and One Minute indicating capacity factors for end cell voltage of 1.75 V & 1.85 V.
d) Temperature correction factors
e) Installation and commissioning Instructions
f) O & M Manual

1.3. **Battery Charger**

The DC system for 220 V DC is unearthed and for 48 V DC is +ve earthed. The Battery Chargers as well as their automatic regulators shall be of static type and shall be compatible with offered VRLA batteries. All battery chargers shall be capable of continuous operation at the respective rated load in float charging mode, i.e. float charging the associated Lead-Acid Batteries at 2.13 to 2.27 Volts per cell while supplying the DC load. The chargers shall also be capable of Boost charging the associated DC Battery at 2.28 to 2.32 volts per cell at the desired rate. Charger shall regulate the float/boost voltage in case of prescribed temperature rise of battery as per manufacturer's recommendation to avoid thermal runaway. Necessary temperature sensors shall be provided in mid location of battery banks and shall be wired up to the respective charger for feedback control. The manufacturer shall demonstrate this feature during testing of each charger.

1.3.1. All Battery Chargers shall be provided with facility for both automatic and manual control of output voltage and current. A selector switch shall be provided for selecting the mode of output voltage/current control, whether automatic or manual. When on automatic control mode during Float charging, the Charger output voltage shall remain within ±1% of the set value, for AC input voltage variation of ±10%, frequency variation of ±2.5%, a combined voltage and frequency variation of ±10%, and a DC load variation from zero to full load.

1.3.2. All battery chargers shall have a constant voltage characteristics throughout the range (from zero to full load) at the floating value of the voltage so as to keep the battery fully charged but without harmful overcharge.

1.3.3. All chargers shall have load limiters having drooping characteristic, which shall cause, when the voltage control is in automatic mode, a gradual lowering of the output voltage when the DC load current exceeds the Load limiter setting of the Charger. The Load-limiter characteristics shall be such that any sustained overload or short circuit in DC System shall not damage the Charger, nor shall it cause blowing of any of the Charger fuses. The Charger shall not trip on overload or external short circuit.

1.3.4. Uniform and step less adjustments of voltage setting (in both manual and automatic modes) shall be provided on the front of the Charger panel covering the entire float charging output range specified. Step less adjustments of the Load- limiter setting shall also be possible from 80% to 100% of the rated output current for Charging mode.

1.3.5. During Boost Charging, the Battery Charger shall operate on constant current mode (when automatic regulator is in service). It shall be possible to adjust the Boost charging current continuously over a range of 50 to 100% of the rated output current for Boost charging mode.

1.3.6. The Charger output voltage shall automatically go on rising, when it is operating on Boost mode, as the Battery charges up. For limiting the output voltage of the Charger, a potentiometer shall be provided on the front of the panel, whereby it shall be possible to set the upper limit of this voltage anywhere in the output range specified for Boost Charging mode.

1.3.7. The Charger manufacturer may offer an arrangement in which the voltage setting device for Float charging mode is also used as output voltage limit setting device for Boost charging mode and the Load-limiter of Float charging mode is used as current setting device in boost charging mode.

1.3.8. Suitable filter circuits shall be provided in all the chargers to limit the ripple content (Peak to Peak) in the output voltage to 1%, irrespective of the DC load level, when they are not connected to a Battery.

1.3.9. **MCCB**

All Battery Chargers shall have 2 Nos. MCCBs on the input side to receive cables from two sources. Mechanical interlock should be provided such that only one shall be closed at a time. It shall be of P2 duty and suitable for continuous duty. MCCB's should have auxiliary contacts for annunciation.

1.3.10. **Rectifier Transformer**

The rectifier transformer shall be continuously rated, dry air cooled (A.N) and of class F insulation type. The rating of the rectifier transformer shall have 10% overload capacity.

1.3.11. **Rectifier Assembly**

The rectifier assembly shall be fully/half controlled bridge type and shall be designed to meet the duty as required by the respective Charger. The rectifier shall be provided with heat sink having their own heat dissipation arrangements with natural air cooling. Necessary surge protection devices and rectifier type fast acting HRC fuses shall be provided in each arm of the rectifier connections.

1.3.12. **Instruments**

One AC voltmeter and one AC ammeter alongwith selector switches shall be provided for all chargers. One DC voltmeter and DC ammeter (with shunt) shall be provided for all Chargers. The instruments shall be flush type, dust proof and moisture resistant. The instruments shall have easily accessible means for zero adjustment. The instruments shall be of 1.5 accuracy class. In addition to the above a centre zero voltmeter with selector switch shall also be provided for 220 V chargers for testing purpose.

1.3.13. **Air Break Switches**

One DC output switch shall be provided in all chargers. They shall be air break type suitable for 500 volts AC/ 250 DC. The contacts of the switches shall open and close with a snap action. The operating handle of the switch shall be fully insulated from circuit. `ON' and `OFF' position on the switch shall be clearly indicated. Rating of switches shall be suitable for their continuous load. Alternatively, MCCB's of suitable ratings shall also acceptable in place of Air Break Switch.

1.3.14. **Fuses**

All fuses shall be HRC Link type. Fuses shall be mounted on fuse carriers which are in turn mounted on fuse bases. Wherever it is not possible to mount fuses on carriers, fuses shall be directly mounted on plug-in type base. In such case one insulated fuse pulling handle shall be supplied for each charger. Fuse rating shall be chosen by the Bidder depending on the circuit requirement. All fuses in the chargers shall be monitored. Fuse failure annunciation shall be provided on the failure of any fuse.

.

1.3.15. **Blocking Diode**

Blocking diode shall be provided in the positive pole of the output circuit of each charger to prevent current flow from the DC Battery into the Charger.

1.3.16. **Annunciation System**

Audio-visual indications through bright LEDs shall be provided in all Chargers for the following abnormalities:

a) AC power failure
b) Rectifier/chargers fuse blown.
c) Over voltage across the battery when boost charging.
d) Abnormal voltage (High/Low)
e) Any other annunciation if required.

Potential free NO Contacts of above abnormal conditions shall also be provided for common remote indication "CHARGER TROUBLE" in Owner's Control Board. Indication for charger in float mode and boost mode through indication lamps shall be provided for chargers. A potential free contact for float/boost mode shall be provided for external interlocks.

1.3.17. **Name Plates and Marking**

The name plates shall be white with black engraved letters. On top of each Charger, on front as well as rear sides, larger and bold name plates shall be provided to identify the Charger. Name plates with full and clear inscriptions shall also be provided on and inside of the panels for identification of the various equipments and ease of operation and maintenance.

1.3.18. **Charger Construction**

The Chargers shall be indoor, floor-mounted, self-supporting sheet metal enclosed cubicle type. The Contractor shall supply all necessary base frames, anchor bolts and hardware. The Chargers shall be fabricated from 2.0mm cold rolled sheet steel and shall have folded type of construction. Removable gland plates for all cables and lugs for power cables shall be supplied by the Contractor. The lugs for power cables shall be made of electrolytic copper with tin coat. Power cable sizes shall be advised to the Contractor at a later date for provision of suitable lugs and drilling of gland plates. The Charger shall be tropicalised and vermin proof. Ventilation louvers, if provided shall be backed with screens. All doors and covers shall be fitted with synthetic rubber gaskets. The chargers shall have hinged double leaf doors provided on front and on backside for adequate access to the Charger's internals. All the charger cubicle doors shall be properly earthed.
The degree of protection of Charger enclosure shall be at least IP-42 as per IEC: 60947 Part 1.

1.3.18.1. All indicating instruments, control switches and indicating lamps shall be mounted on the front side of the Charger.

1.3.18.2. Each Charger shall be furnished completely wired upto power cable lugs and terminal blocks and ready for external connections. The control wiring shall be carried out with PVC insulated, 1.5 sq.mm. stranded copper wires. Control terminals shall be suitable for connecting two wires, with 2.5 sq.mm stranded copper conductors. All terminals shall be numbered for ease of connections and identification. Each wire shall bear a ferrule or tag on each end for identification. At least 20% spare terminals shall be provided for control circuits.

1.3.18.3. The insulation of all circuits, except the low voltage electronic circuits shall withstand test voltage of 2 KV AC for one minute. An air clearance of at least ten (10) mm shall be maintained throughout for such circuits, right up to the terminal lugs. Whenever this clearance is not available, the live parts shall be insulated or shrouded.

1.3.19. **Painting**

All sheet steel work shall be pre-treated, in tanks, in accordance with IEC/International Standards. Degreasing shall be done by alkaline cleaning. Rust and scale shall be removed by pickling with acid. After pickling, the parts shall be washed in running water. Then these shall be rinsed in slightly alkaline hot water and dried. The phosphate coating shall be in accordance with IEC/International Standards. Welding shall not be done after phosphating. The phosphating surfaces shall be rinsed and passivated prior to application of stoved lead oxide primer coating. After primer application, two coats of finishing synthetic enamel paint of shade-692 (smoke grey) shall be applied, unless required otherwise by the Owner. The inside of the chargers shall be glossy white. Each coat of finishing synthetic enamel paint shall be properly staved. The paint thickness shall not be less than fifty (50) microns.

1.3.20. **TESTS**

1.3.20.1. Battery chargers shall conform to all type tests as per relevant International Standard. Performance test on the Chargers as per Specification shall also be carried out on each Charger as per specification. Rectifier transformer shall conform to all type tests specified in IEC: 60146 and short circuit test as per IEC:60076. Following type tests shall be carried out for compliance of specification requirements:

i) Voltage regulation test
ii) Load limiter characteristics test
iii) Efficiency tests
iv) High voltage tests
v) Temperature rise test
vi) Short circuit test at no load and full load at rated voltage for sustained short-circuit.
vii) Degree of protection test
viii) Measurement of ripple by oscilloscope.
ix) Temperature compensation feature demonstration

1.3.20.2. The Contractor may be required to demonstrate to the OWNER that the Chargers conform to the specification particularly regarding continuous rating, ripple free output, voltage regulation and load limiting characteristic, before dispatch as well as after installation at site. At site the following tests shall be carried out :

i) Insulation resistance test
ii) Checking of proper annunciation system operation.

1.3.20.3. If a Charger fails to meet the specified requirements, the Contractor shall replace the same with appropriate Charger without affecting the commissioning schedule of the Sub-station, and without any extra cost to the OWNER.

1.3.20.4. The Contractor shall present for inspection, the type and routine test certificates for the following components whenever required by the OWNER.

(i) Switches.
(ii) Relays/ MCCBs
(iii) Instruments.
(iv) DC fuses.
(v) SCR.
(vi) Diodes.
(vii) Condensers.
(viii) Potentiometers.
(ix) Semiconductor
(x) Annunciator.
(xi) Control wiring
(xii) Push buttons and contactors.

Makes of above equipment shall be subject to Owner's approval.

BATTERY SYSTEM DATA SHEETS **Annexure-I**

S.No.	Description of Data	Unit	220 V/ 110 V	48 V
1	General Data			
a)	Battery Type:			
	Grid alloy: Pure lead(Pb), lead calcium (Pb-Ca),lead antimony (Pb-Sb), or lead selenium (Pb-Se) or other pl. specify			
	Cell type: Absorbed glass mat or gel cell or other please specify			
	Seller's type number			
	Number of positive plates per cell			
b)	Does each battery and battery [rack]/ [cabinet] meet the seismic requirements	[Yes] [No]		
c)	Manufacturer's Designed Life of Battery	Yrs		
d)	Recommended Battery Charger Data:			
	Floating voltage range	V		
	Boost charge	V		
	Current rating	Amps.		
	Recharge time	hr		
e)	Heat Released During:			
	Discharge duty cycle	Watt		
	Float charge	Watt		
	Boost Charge	Watt		
f)	Maximum Amount of Hydrogen Gas Evolved			
	During Battery-Boost Charge (2.33 V per cell) at Maximum Battery Temperature	(Litre /h)		
	Hydrogen Gas Evolution at Float	(Litre /h)		
g)	Time Battery may be Stored Without a Freshening Charge	months		
h)	Temperature Compensation Provided and its Details			

S.No.	Description of Data	Unit	220 V/ 110 V		48 V	
2.	Physical Description.					
a)	Battery Cell:					
	Size (L x W x H)	mm				
	Weight	Kg				
	Volume of electrolyte gal	L				
	Jar cover material					
	Jar container material					
	Separator material					
	Retainer material					
	Limiting-oxygen index (LOI)					
b)	Battery [Rack] [Cabinet]:					
	Outline or catalog number					
	Quantity of [racks][cabinets] for the battery					
	Description (tier or step type)					
c)	Total Net Weight of Battery Including [Racks] [Cabinets]	kg				
d)	Total Shipping Weight of Each Battery Jar and Associated Equipment	kg				
e)	Connectors:					
	Intercell:					
	Type					
	Material					
	No. per connection					
	Inter-[Tier] [Step]:					
	Type					
	Material					
	No. per connection					
	Terminal Detail:					
	Type					
	Material					
f)	Terminal Lugs for Power Cable:					
g)	Torque Data:		**Initial Torque Value**	**Re-torque Value**	**Initial Torque Value**	**Re-torque Value**
	Intercell Connectors					
	Inter-[Tier] [Step]:					

S.No.	Description of Data	Unit	220 V/ 110 V	48 V
3.	Performance Data.			
	Battery String Designation No. [1] [ ]			
	Float Voltage Without Boost	V/cell		
	Float Voltage With Boost	V/cell		
	Boost Charge Voltage	V/cell		
	Recommended Frequency of Boost Charge			
	Recommended Duration of Boost Charge			
	Open-Circuit Voltage	V/cell		
	Short-Circuit Current at Battery Terminals at Float Voltage at (27°C):			
	Battery Discharge Characteristics	A or A /positive plate		
	Guaranteed Amp-Hour Capacity (at the 10-hr rate) to Specified Final Voltage	AH		
	One-minute	A/cell		
	Fifteen-minute	A/cell		
	One-hour	A/cell		
	Two-hour	A/cell		
	Three-hour	A/cell		
	Eight-hour	A/cell		
	Ten-hour	A/cell		
4.	Required operating environment.			
	Battery Room Ambient Temperature Range	(°C to °C)		
	Battery Room Ambient Design Temperature	°C		
	Battery Room Minimum/Maximum Design Temperature	(°C to °C)		
	Maximum temperature at which battery can be stored	°C		

CHAPTER 6: LIGHTING SYSTEM

Table of contents

1.0 LIGHTING SYSTEM

1.1 LIGHTING SYSTEM FOR SUBSTATION

The scope of work comprises of design, engineering, testing, supply, installation, testing and commissioning of various lighting fixtures complete with lamps, supports and accessories, ceiling fans complete with electronic regulators, exhaust fans for toilets and pantry & accessories, lighting panels, lighting poles complete with distribution boxes, galvanized rigid steel /rigid PVC conduits, lighting wires, G.I. Earthwire, receptacles, tag block & telephone socket, switchboards, switches, junction boxes, pull out boxes complete with accessories, for control room cum administrative building, Township, Indoor Switchgear room, Fire Fighting pump house, Switchyard and street lighting, GIS Building.

The entire control room building, fire-fighting pump house, Indoor Switchyard Building lighting shall be done by LED based low power consumption luminaries to achieve desired lux level specified. The bidder shall quote on lumpsum basis on the basis of design criteria specified for each control room building and fire-fighting pump house.

1.1.1 SYSTEM DESCRIPTION

The lighting system shall comprise of the following:

1.1.2 AC Normal Lighting

AC lights will be connected to AC lighting panels. All the lights connected to the AC lighting system in different areas will be connected to the main lighting distribution boards.

1.1.3 AC Emergency Lighting

This system will be available in control room building, Fire-fighting pump house,& switchyard. AC lighting load will be connected to this system which will be normally ‘ON’. The lighting panels of this system will be connected to the Emergency lighting board which is fed from diesel generator during the emergency. 25% of lighting fixtures shall be connected on AC emergency lighting.

1.1.4 D.C. Emergency lighting

A few DC emergency lighting fixtures operated on the DC system will be provided in the strategic locations including staircase, corridors, electrical rooms, Battery charger room, LT switchgear room in control room building, and Fire-fighting pump house so that the operating personnel can safely find their way even during emergency of a total AC failure. These lights will be normally 'OFF' and will be switched 'ON' automatically when under voltage occurs in the AC main lighting distribution board. GLS lamp down lighters in false ceiling area and Bulkhead fixtures in non false ceiling area to be used.

1.1.5 Exit Lightings

All Exit lightings in the buildings shall be fed by DC lighting panels. All necessary wiring and its termination shall be in the contractor’s scope.

1.1.6 The lighting layout for and around Control Room Cum Administrative Office Building & Fire fighting Pump House indicating the type & BOQ for items shall be prepared and submitted by the contractor for owner’s approval during detailed engineering.
The lux levels to be maintained in the switchyard shall be as per following:

Sl No	Area	Average Lux Level
1.	Control Room Building, Firefighting pump house, GIS Building and Indoor Switchyard Building	**SN. Area Average Lux level at floor level** i) Control Room & Conference room - 350 Lux ii) Battery room, Passage, Pantry, Toilets, Corridors etc. - 100 Lux iii) All other rooms and Buildings including township - 200 Lux
2.	Switchyard	-50 lux on main Equipments (i.e,Transformer, Reactor ISO, CB, CT, CVT, SA) at first level (Equipment connections level.) -20 lux on balance area of switchyard and street / Road at ground level. --10 lux (Area between fence and peripheral roads around the switchyard). The lighting between the fence and the peripheral road around switchyard shall be done by providing the lighting fixtures on lighting pole of suitable height, if required.

The minimum lux level to average lux level ratio should not be less than 0.6 (i.e Emin/Eav>0.6). The maintenance factor for indoor illumination design shall be considered as 0.8. The surface reflectance for ceiling/wall/floor shall be 50/30/10

For achieving the specified lux levels in the switchyard, the contractor can provide luminaries of 1x400 W/1x250 W and 2x400 W/ 2x250 W flood light as per requirement.
The contractor shall submit detailed calculation for reaching the above Lux level. Contractor shall conform the Lux levels at different locations of the switch yard and street lighting by measurement.
In addition to the normal lighting provided in the switchyard area to maintain the desired lux levels, high beam fixtures(Type SF4- 8 nos) on swivel support shall be provided in strategic locations near equipments for new substations which shall be kept normally OFF and these shall be switched ON in case of maintenance work.

1.1.7 Ceiling fans (1400 mm sweep, AC 230 volts) shall be provided in, fire-fighting pump house and non AC rooms in the control room building and township buildings as per the requirements. Wall mounted fans shall be provided in the conference room, control room, shift manager and substation incharge rooms in control room building. Exhaust fans shall be provided in toilets and pantry.

1.1.8 One no. of aluminum ladder of each size shall be supplied by the contractor for maintenance purpose.

1.1.9 The following specific areas are included in the scope of lighting:

(i) Switchyard Area.
(ii) Switchyard Control Room cum Administrative Office Building
(iii) Fire fighting pump house
(iv) Street lighting (peripheral) inside switchyard fencing (Street lighting shall be done using street lighting poles)
v) DG area lighting
vi) LT Transformer area
vii) GIS Building and Indoor Switchyard Building

viii) Township

1.1.10 **For Outdoor Illumination**

The switchyard and street lighting design including lux level calculations, surface illuminance diagram at varying equipment surface levels , detailed drawings showing the lighting layout and Electrical distribution diagram and BOQ for items shall be prepared by the Contractor and submitted for approval. The above layout drawings will include disposition and location of lighting fixtures, receptacles, etc.

1.1.11 **For Indoor Illumination**

The conduit layout drawing for substation buildings, Electrical distribution diagram for substation buildings, & for substation yard etc. shall be prepared by the Contractor. All wiring including telephone wiring (tinned two pair copper) shall be in concealed conduit. Concealed MS junction boxes for sockets and light points shall be provided in all the rooms of Control Room cum Administrative Office Building and Fire Fighting pump house. In case where false ceiling surface conducting is permissible, all down run conduits will be concealed in wall below the false ceiling.

1.1.12 Each cable run shall be tagged with number that appear in the cable schedules. Cables shall be tagged at their entrance and/or exit from any piece of equipment, junction or pull box, floor opening etc.

1.1.13 The tag shall be made up of aluminum with the number punched on it and securely attached to the cable by not less than two turns of G.I. wire. Cable tags shall be rectangular in shape for power cables and circular shape for control cables.

1.1.14 Location of cables laid directly under ground shall be indicated clearly by cable marker made of galvanised iron plate embedded in concrete block.

1.1.15 The location of underground cable joints if any, shall be clearly indicated with cable marker with an additional inscription "cable joint".

1.1.16 The marker, which is a concrete block, shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change of direction. It shall also be located on both sides of the road or drain crossing.

1.2 LIGHTING SYSTEM FOR TOWNSHIP

1.2.1 The scope of work comprises of design, engineering, testing, supply, installation, testing and commissioning of 400 V, 400Amp, Main Township Distribution board/Energy meter Boards/Flat DBs etc., Power and Control cables, various lighting fixtures complete with lamps, supports and accessories, ceiling fans complete with electronic regulators, exhaust fans for toilets and pantry & accessories, lighting panels, lighting poles complete with distribution boxes, galvanized rigid steel/PVC conduits, lighting wires, G.I. Earthwire, receptacles, tag block & telephone socket, bells, boxes for telephone/television & Air- conditioners points, switchboards, switches, junction boxes, pull out boxes complete with accessories for various type of quarters, parking, pump house, recreation centre and transit camp associated with township.

The township lighting design including lux level calculations, surface illuminance diagram at varying equipment surface levels, detailed drawings showing the lighting layout and Electrical distribution diagram and BOQ for items shall be prepared by the Contractor and submitted for approval. The above layout drawings will include disposition and location of lighting fixtures, receptacles, etc.

1.2.2 SYSTEM DESCRIPTION

The township lighting system shall comprise of the following:

1.2.3 EXTERNAL ELECTRIFICATION WORKS

The entire External Electrification work including connection to various quarters, recreation centres & transit camp associated with township including street lighting of township shall be in the scope of the contractor. 400V,400A, MainTownship distribution board shall be fed from 400V, Main switchboard (being supplied under LT switchgear package) through 2-3 ½ x300 sqmm XLPE insulated power cable from each source. Supply of MainTownship DB & associated 3 ½ x300 sqmm XLPE cable alongwith its interconnection, installation etc shall be in the scope of contractor.

The entire external electrification work comprising of feeder pillars, Cables and associated glands and lugs, steel tubular poles, street lights, MS junction boxes, GI pipes for cable protection, danger plates, Hume pipes, fire extinguishers, cable route markers etc as required shall be in the scope of the contractor

1.2.4 INTERNAL ELECTRIFICATION WORKS

The scope shall broadly consist of entire concealed conduit work, wiring for lights/power/fans/telephones/cables & air-conditioners, supply and fixing of metal boxes, plates, switches, sockets, call bells, buzzers, exhaust fans, ceiling fans, MCBs, MCCBs, light fittings, energy meters boards & flat DBs etc as per the requirements of various quarters, recreation centres and transit camps.

In addition to above complete earthing (through separate earth pit) and lightning protection for each type of quarters ,recreation centre and transit camp shall be provided as per standard guidelines given in relevant Indian standards and code of practices. The complete drawing for earthing and lightning protection shall be submitted to owner for approval. The loop earthing inside the buildings shall be carried out with minimum 1Cx1.5 sqmm PVC stranded Copper wire. All materials required or earthing and lightning protection of township buildings shall be in the scope of contractor.

2.0 DESCRIPTION OF ITEMS

2.1 DESCRIPTION OF ITEMS FOR SUBSTATION LIGHTING

The Contractor shall supply and install the following equipment and accessories in accordance with the specification.

2.1.1 LIGHTING PANELS

2.1.1.1 OUTDOOR

400 AC lighting panel with 400V, 63A, 3 phase 4 wire bus and one no. 63A, TPN, MCB with neutral unit as incomer and 20A, SP MCB as outgoing feeders, the details are as follows.

Type Of Panel	Description	Detail Of Outgoing Feeders
ACP 2	Outdoor	6 nos- 20 A single pole MCB and 3 No. 32 A Triple pole MCB with Neutral and suitable timer and contactor for automatic switching.
ACP 3	Outdoor Street lighting Panel	3 nos.-32A Triple pole MCB with Neutral with suitable timer and contactor for automatic switching

Note: The number of outgoing feeders indicated above are the minimum.

2.1.1.2 INDOOR

400 V indoor AC lighting panel ,63 A 3 phase 4 wire bus and one number 63 amp FP MCB with 300ma 63 A FP RCCB. Flush mounted with per phase isolation and LED indication lamps. The DB will be flush mounted and double door type.

Type Of Panel	Description	Detail Of Outgoing Feeders
ACP 1	Indoor	18 nos outgoing ,16 Amps SP MCB

220V DC indoor type change over board and 220V DC 32A two wire bus and one 32A contractor backed up by 32A double pole MCB as incomer. The panel shall have local push button controls. Following are the various types of panels required with control timer.

Type Of Panel	Description	Detail Of Outgoing Feeders
DCP	Indoor	6 nos outgoing ,16 Amps DP MCB

2.1.1.3 Sub-Lighting Panels

Type Of Panel	Description	Detail Of Outgoing Feeders
SLP	Outdoor	4 pole 32A Isolator suitable for 400V,

		50 cycles AC supply, wlith LILO facility using 8 nos terminal blocks suitable for cable upto 16 mm sq cable Enclosure shall be suitable for outdoor use with IP-55 degree of protection as per IEC:60529.

2.1.2 **Lighting Fixtures**

Please Refer Annexure-1

2.1.3 **RECEPTACLES**

	Description	Detail Of Outgoing Feeders
RO	Outdoor	15A, 230V, Receptacle 2 pole, 3- pin type
RP	Outdoor	63A, 400V, Interlocked switch socket, receptacle
RI	Indoor	5/15A, 230V, Receptacle 3-pin type (Modular)

2.1.4 (a) **SWITCH BOARDS**

Modular type switches, 5/15 Amp. Receptacles.

2.1.4 (b) **CONDUITS AND ACCESSORIES**

Galvanised Rigid steel or Rigid PVC conduits of 20/25 /32 mm for Lighting and Telephone wiring

2.1.5 **JUNCTION BOXES -** with 5 Nos. of terminal blocks

2.1.6 **LIGHTING POLES -** (Type A1 poles & Type E1 poles)

2.1.7 **FANS-**1400 mm Sweep with Electronic regulator and 450 mm Wall Mounted fans

2.1.8 **MAINTENANCE EQUIPMENT**

i) A type Aluminium ladder of 3 mtr vertical height.

ii) Cartwheel mounted aluminium ladder Vertical Extendable from 5.1m to 11m.

2.1.9. **RECEPTACLES**

a) All receptacles shall be of cast steel/aluminium, heavy duty type, suitable for fixing on wall/column and complete with individual switch.

b) In general the receptacles to be installed are of the following types:

i) **Type RO**-15A, 230V, 2 pole, 3 pin type with third pin grounded, metal clad with gasket having cable gland entry suitable for 2Cx6 sq.mm. PVC/aluminum 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 out door panels, removable covers, doors and plates shall be gasket all around with neoprene gaskets.

e) The outdoor panels shall be suitable for cable/conduit entry from the top and bottom. Suitable removable cable gland-plate shall be provided on the top and bottom of panels. Necessary number of double compression cable gland shall be supplied, fitted on to this gland plate. The glands shall be screwed on top and made of tinned brass.

f) The panels shall be so constructed as to permit free access to connection of terminals and easy replacement of parts.

g) Each panel shall have a caution notice fixed on it.

h) Each panel will be provided with directory holder in which printed and laminated as built circuit directory would be kept inside a document holder/pasted at site.

i) Each Outdoor lighting panel shall be provided with one no. 'ON' indicating lamp for each phase alongwith fuses. For indoor lighting panels din mounted phase indication lamps will be provided, mounted alongside of the MCB

j) **Main Bus Bars**

Bus bars shall be of aluminium alloy conforming to IEC: 60114/60105 and shall have adequate cross-section to carry the rated continuous and withstand short circuit currents. Maximum operating temperature of the bus bars shall not exceed 85 deg. C. The bus bars shall be able to withstand a fault level of 9 kA for 1 sec. for AC panels and 4 KA for 1 sec. for DC panels. The Indoor lighting panels shall have copper bus bar

2.1.10.3 **JUNCTION BOXES**

a) The junction boxes shall be concealed type for indoor lighting and suitable for mounting on columns, lighting poles, structures etc., for outdoor lighting.

b) Junction boxes shall be of square/rectangular type of 1.6 mm sheet steel with minimum 6 mm thick pressure diecast aluminium material LM-6 and shall have bolted cover with good quality gasket lining.

c) The junction box and cover of sheet steel construction shall be hot dip galvanised.

d) The junction boxes shall be complete with conduit knockouts/threaded nuts and provided with terminal strips .The junction boxes shall be suitable for termination of Cable glands of dia 20 mm, 25 mm, 32 mm, 40 mm on all sides. The junction boxes shall be provided with 4 way terminals suitable for two numbers 10 sq. mm. wire & for street lighting/switchyard lighting suitable for 2 numbers 4C x 16 Sq.mm Al. cable.

e) The junction boxes shall have the following indelible markings

(i) Circuit Nos. on the top.
(ii) Circuit Nos. with ferrules (inside) as per drawings.
(iii) DANGER sign in case of 400 volt junction box.

f) The junction boxes shall be weather proof type with gaskets conforming to IP 55 as per IEC: 60529.

2.1.10.4 **Occupancy Sensors:**

Sufficient number of occupancy sensors shall be provided in the stairs area and corridors of control room cum administrative building and GIS Building. Each occupancy sensor shall be used for indoor use with time delay programmable in the minimum range of 1 sec. to 2 Hour to control the illumination in the area.

2.2 **DESCRIPTION OF FCOMMON ITEMS FOR LIGHTING**

2.2.1 **LIGHTING FIXTURES AND ACCESSORIES**

2.2.1.1 **General**

All lighting fixtures and accessories shall be designed for continuous operation under atmospheric conditions existing at site, without reduction in the life or without any deterioration of materials, internal wiring.

2.2.1.2 **Temperature Rise**

All lighting fixtures and accessories shall be designed to have a low temperature rise according to the relevant International standard. The design ambient temperature shall be taken as 50 deg.C.

2.2.1.3 **Supply Voltage**

Lighting fixtures and accessories meant for 230V A.C. operation shall be suitable for operation on 230V A.C. 50Hz, supply voltage variation of ± 10%, frequency variation of ± 2.5% and combined voltage and frequency variation of ± 10%.
Lighting fixture and accessories meant for 220V DC operation shall be suitable for operation on 220V DC with variation between 190 to 230 Volts.

2.2.1.4 **Lighting Fixtures**

a) The lighting fixtures shall be Philips or equivalent International make except for fixtures type 'DSM' & 'HL' for which make has been specified elsewhere in this chapter. The different types of lighting fixtures are also indicated elsewhere in this Chapter.

b) All fixtures shall be designed for minimum glare. The finish of the fixtures shall be such that no bright spots are produced either by direct light source or by reflection.

c) All lighting fixtures shall be complete with fluorescent tubes/ incandesent lamps/mercury vapour/sodium vapour lamps as specified and shall be suitably wired up.

d) All flourescent lamp fixture shall be complete with all accessories like ballasts, power factor improvement capacitors, lamps, starters, holders etc.

e) High beam fixtures shall be suitable for pendant mounting and flood lights shall have suitable base plate / frame for mounting on steel structural member. Hook mounted high beam fixtures are not acceptable.

f) Each lighting fixture shall be provided with an earthing terminal suitable for connection to 16 SWG GI earthing conductors.

g) All light reflecting surfaces shall have optimum light reflecting co-efficient such as to ensure the overall light output as specified by the manufacturer.

h) Height of fixtures should be such that it is easy to replace the lamps with normal ladder/stool. In case the ceiling height is very high, the fixtures may be placed on the walls for ground lighting.

2.2.1.5 **ACCESSORIES**

2.2.1.5.1 **Lamp holders and Starter Holders**

(a) Lamp holders/starter holders for fluorescent tubes shall be of the spring loaded, low contact resistance, bi-pin rotor type, resistant to wear and suitable for operation at the specified temperature, without deterioration in insulation value, contact resistance or retention of the lamp/starter. They shall hold the lamp/starter in position under normal condition of shock and vibration.

(b) Lamp holders/starter for incandescent lamps and HPMV/HPSV lamps shall be of screwed type, manufactured in accordance with relevant standard and designed to give long and satisfactory service.

2.2.1.5.2 **Ballasts**

a) All HPSV/HPMV/Metal halide lamp fixtures shall be provided with wire wound ballasts. All fluorescent fixtures shall be provided with high frequency electronic ballasts. The Ballasts shall be designed, manufactured and supplied in accordance with relevant standard and function satisfactorily under site condition specified. The ballasts shall be designed to have a long service life and low power loss.

b) Ballasts shall be mounted using self-locking anti-vibration fixing and shall be easy to remove without dismantling the fixtures. They shall be totally enclosed units.

c) The wire-wound ballasts shall be of the inductive, heavy duty type, filled with thermosetting insulating moisture repellent polyester compound filled under pressure or vacuum. The ballast wiring shall be of copper wire. They shall be free from hum. Ballasts which produce humming sound shall be replaced free of cost by the Contractor. Ballasts for high pressure mercury vapour/ HPSV lamps shall be provided with suitable tappings to set the voltage within the range specified. End connections and taps shall be brought out in a suitable terminal block, rigidly fixed to the ballast enclosure.

d) Separate ballast for each lamp shall be provided in case of multi-lamp fixtures.

e) High frequency electronic ballasts shall be capable of satisfactory performance in adverse environment like that of EHV substation. Ballasts shall consist of AC/DC converter, high frequency power oscillator and low pass filter. The ballasts shall be suitable for use of nominal voltage of 230V +/- 10%, 50 Hz supply. The filter circuit shall suppress the feedback of high frequency signals to the mains. The ballast shall be rated for 36/40W fluorescent fixtures. The ballasts shall confirm to IEC 68-2-6FC, IEC 60929 for performance, IEC 60928 for safety and EN 55015, EN 55022A for RFI and EN 61003.

2.2.1.5.3 **Capacitors**

a) The capacitors shall have a constant value of capacitance and shall be connected across the supply of individual lamp circuits.

b) Power factor of fluorescent lamp fixtures with HF electronic ballast shall not be less than 0.90 and that of High pressure Sodium Vapour, Mercury Vapour and Metal Halide lamp fixtures shall not be less than 0.85. The capacitors shall be suitable for operation at supply voltage as specified and shall have a value of capacitance so as to correct the power factors of its corresponding lamp circuit to the extent of 0.98 lag.

c) The capacitors shall be hermetically sealed in a metal enclosure.

2.2.1.5.4 **Lamps**

a) General Lighting Services (GLS) lamps shall be provided with screwed caps and shall be of 'clear' type unless otherwise specified.

b) The Bidder shall furnish typical wiring diagram for Fluorescent, HPMV & HPSV fitting including all accessories. The diagram shall include technical details of accessories i.e. starters, chokes, capacitors etc.

c) Flexible conduits if required, for any fixture shall be deemed to be included in Contractor's scope.

2.2.1.5.5 **SWITCH AND SWITCHBOARD**

(a) All Switch board/boxes, 5/15 Amp Receptacles and electronic fan regulators located in office/building areas shall be 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 galvanised.

b) Flexible conduits wherever required shall be made with bright, cold rolled annealed and electro-galvanised mild steel strips or PVC/Plastic.

c) All conduits accessories shall conform to relevant IEC and shall be hot dip galvanized or High quality virgin PVC.

2.2.1.5.7 **TERMINAL BLOCKS**

Each terminal shall be suitable for terminating upto 2 Nos. 10 sq.mm. stranded Aluminium Conductors without any damage to the conductors or any looseness of connections. Terminal strips provided in street-lighting poles shall be suitable for terminating upto 2 nos. 4C x 16 sq. mm aluminium cables.

2.2.1.5.8 **PULL OUT BOXES**

a) The pull out boxes shall be concealed type for indoor lighting and suitable for mounting on column, structures etc., for outdoor lighting. The supply of bolts, nuts and screws required for the erection shall be included in the installation rates.

b) The pull out boxes shall be circular of cast iron or 16 SWG sheet steel and shall have cover with good quality gasket lining.

c) The pull out boxes and cover shall be hot dip galvanised.

d) The pull out boxes shall be completed with conduit knock outs/threaded hubs and provided at approximately 3 meters intervals in a conduit run.

2.2.1.5.9 **Residual Current Circuit Breakers** (**RCCB)**

For indoor panels 63A 4pole 300 ma RCCB conforming IEC 13947 will be provided along with incomer.

2.2.1.5.10 **Miniature Circuit Breaker (MCB)**

a) The miniature circuit breakers shall be suitable for manual closing, opening, automatic tripping under overload and short circuit. The MCBs shall also be trip free. MCB of Type C tripping characteristics as per IEC: 60898 will be used for Switchyard lighting.

b) Single pole as well as three pole versions shall be furnished as required in the Schedule of Lighting Panels.

c) The MCBs and panel MCCB together shall be rated for full fault level. In case the MCB rating is less than the specified fault level the bidder shall co-ordinate these breaker characteristics with the back-up MCCB in such a way that if fault current is higher than breaker rating, the MCCB should blow earlier than the breaker If the fault current is less than MCB breaking capacity, MCB shall operate first and not the incomer MCCB.

d) The MCBs shall be suitable for housing in the lighting panels and shall be suitable for connection with stranded copper wire connection at both the incoming and outgoing side by copper lugs or for bus bar connection on the incoming side.

e) The terminals of the MCBs and the 'open' 'close' and 'trip' conditions shall be clearly and indelibly marked.

f) The tenderer shall check and co-ordinate the ratings of MCBs with respect to starting characteristics of discharge lamps. The vendor has to furnish overload and short circuit curve of MCB as well as starting characteristics curves of lamps for Employer's approval.

g) The MCB shall generally conform to IEC: 60898.

2.2.1.5.11 **Contactors**

Contactors shall be of the full voltage, direct-on line air break, single throw, electro-magnetic type. They shall be provided with atleast 2-'NC' and 2'NO' auxiliary contacts. Contactor shall be provided with the three element, positive acting, ambient temperature compensated time lagged, hand reset type thermal overload relay with adjustable settings to suit the rated current. Hand reset button shall be flush with the front of the cabinet and suitable for resetting with starter compartment door closed. The Contactor shall be suitable for switching on Tungsten filament lamp also. The bidder shall check the adequacy of the Contactors rating wire with respect to lighting load.

2.2.1.5.12 **Push Buttons**

All push buttons shall be of push to actuate type having 2 'NO' and 2 'NC' self-reset contacts. They shall be provided with integral escutcheon plates engraved with their functions. Push buttons shall be of reputed make.

2.2.1.5.13 **Labels**

a) The lighting panels shall be provided on the front with panel designation labels on a 3 mm thick plastic plate of approved type. The letter shall be black engraved on white back ground.

b) All incoming and outgoing circuits shall be provided with labels. Labels shall be made of non-rusting metal or 3 ply lamicold. Labels shall have white letters on black or dark blue background.

2.2.1.5.14 **Earthing Terminals**

Panels shall be provided with two separate and distinct earthing terminals suitable to receive the earthing conductors of size 50x6 G.S. Flat.

2.2.1.5.15 Type test reports for following tests on all lighting panels shall be submitted for approval as per clause 9.2 of Chapter 2: GTR.

(i) Wiring continuity test
(ii) High voltage (2.5 KV for 1 minute) and insulation test
(iii) Operational test
(iv) Degree of protection (not less than IP-55 test on outdoor Lighting Panels and IP-52 test on indoor Lighting Panels as per IEC: 60947 (part 1)
(v) Heat run test

2.2.1.5.16. **LIGHTING POLES**

a) The Contractor shall supply, store and install the following types of steel tubular lighting poles required for street lighting.

i) Type A1 Street Lighting Pole - for one fixture
ii) Type E1 Post top lantern pole - for one fixture

b) Street/flood light poles shall conform to the enclosed drawings. In front of control room building, and Fire Fighting Buildings, decorative post top lantern (Type E1) poles and Bollards shall be installed.

c) Lighting poles shall be complete with fixing brackets and junction boxes. Junction boxes should be mounted one meter above ground level.

d) The lighting poles shall be coated with bituminous preservating paint on the inside as well as on the embedded outside surface. Exposed outside surface shall be coated with two coats of metal primer (comprising of red oxide and zinc chromate in a synthetic medium).

e) The galvanised sheet steel junction box for the street lighting poles shall be completely weather proof conforming to IP-55 and provided with a lockable door and HRC fuse mounted on a fuse carrier and fuse base assembly. The fuses & junction box shall be as specified in the specification. However, terminals shall be stud type and suitable for 2 nos. 16 sq.mm. cable.

f) Wiring from junction box at the bottom of the pole to the fixture at the top of the pole shall be done through 2.5 sq. mm wire.

g) Distance of centre of pole from street edge should be approximately 1000 to 1200 mm.

h) Earthing of the poles should be connected to the switchyard main earth mat wherever it is available and the same should be earthed through 3M long, 20 mm dia, earth electrode.

2.2.1.5.17 **CEILING & WALL MOUNTED FANS AND REGULATORS**

a) The contractor shall supply and install 1400 mm sweep ceiling fans complete with electronic regulator and switch, suspension rod, canopy and accessories. The wall mounted fans shall be of 400 mm sweep

b) The contractor shall supply and install the switch, electronic regulator and board for mounting switch and electronic regulator for celling fans. The regulator will be housed in common switchboard for lighting and shall be of similar make and model as that of modular switches.

c) Winding of the fans and regulators shall be insulated with Class-E insulating material. Winding shall be of copper wire.

d) Electronic regulator with stepped control shall be provided.

2.2.1.5.18 **LIGHTING WIRES**

a) The wiring used for lighting shall be standard products of reputed manufacturers.

b) The wires shall be of 1100 V grade, PVC insulated product of reputed manufacturers.

c) The conductor sizes for wires used for point wiring beyond lighting panels shall be 2.5 sq.mm, 4 sq.mm, 6 sq.mm and 1.5 sq.mm stranded copper wire.

d) The wires used for connection of a lighting fixture from a nearest junction box or for loop-in loop-out connection between two fluorescent fixtures shall be single core copper stranded conductor, 1100V grade flexible PVC insulated cords, unsheathed, conforming to IEC:60502 with nominal conductor cross sectional areas of 2.5 sq. mm.

e) The wires shall be colour coded as follows: Red for R - Phase

Yellow for Y - Phase
Blue for B - Phase
Black for Neutral
White for DC (Positive)
Grey for DC (Negative)

2.2.1.5.19 LIGHTING SYSTEM INSTALLATION WORKS

2.2.1.5.19.1 General

In accordance with the specified installation instructions as shown on manufacturer's drawings or as directed by Employer, Contractor shall unload, erect, install, test and put into commercial use all the electrical equipment included in the contract. Equipment shall be installed in a neat, workmanship manner so that it is level, plumb square and properly aligned and oriented. Tolerances shall be as established in manufacturers drawing or as stipulated by Purchaser.
All apparatus, connections and cabling shall be designed so as to minimize risk of fire or any damage which will be caused in the event of fire.

2.3.1.5.19.2 Conduit System

a) Contractor shall supply, store and install conduits required for the lighting installation as specified. All accessories/fittings required for making the installation complete, including but not limited to pull out boxes (as specified in specification ordinary and inspection tees and elbow, checknuts, male and female bushings (brass or galvanised steel), caps, square headed make plugs, nipples, gland sealing fittings, pull boxes, conduits terminal boxes, glands, gaskets and box covers, saddle terminal boxes, and all steel supporting work shall be supplied by the Contractor. The conduit fittings shall be of the same material as conduits. The contractor shall also supply 20 mm PVC conduit and accessories for telephone wiring.

b) All unarmoured cables/wires shall run within the conduits from lighting panels to lighting fixtures, receptacles. etc.

c) Size of conduit shall be suitably selected by the Contractor.

d) Conduit support shall be provided at an interval of 750 mm for horizontal runs and 1000 mm for vertical runs.

e) Conduit supports shall be clamped on the approved type spacer plates or brackets by saddles or U-bolts. The spacer plates or brackets in turn, shall be securely fixed to the building steel by welding and to concrete or brick work by grouting or by nylon rawl plugs. Wooden plug inserted in the masonary or concrete for conduit support is not acceptable.

f) Where conduits are along with cable trays they shall be clamped to supporting steel at an interval of 600 mm.

g) For directly embedding in soil, the conduits shall be coated with an asphalt-base compound. Concrete pier or anchor shall be provided wherever necessary to support the conduit rigidly and to hold it in place.

h) For long conduit run, pull boxes shall be provided at suitable intervals to facilitate wiring.

i) Conduit shall be securely fastened to junction boxes or cabinets, each with a lock nut inside and outside the box.

j) Conduits joints and connections shall be made through water-tight and rust proof by application of a thread compound which insulates the joints. White lead is suitable for application on embedded conduit and red lead for exposed conduit.

k) The entire metallic/PVC conduit system, shall be embedded, electrically continuous and thoroughly grounded. Where slip joints are used, suitable bounding shall be provided around the joint to ensure a continuous ground circuit.

l) Conduits and fittings shall be properly protected during construction period against mechanical injury. Conduit ends shall be plugged or capped to prevent entry of foreign material.

2.2.1.5.19.3 **Wiring**

a) Wiring shall be generally carried out by PVC insulated wires in conduits. All wires in a conduit shall be drawn simultaneously. No subsequent drawings of wires is permissible.

b) Wires shall not be pulled through more than two equivalent 90 deg. bends in a single conduit run. Where required, suitable junction boxes shall be used.

c) Wiring shall be spliced only at junction boxes with approved type terminal strip.

d) For lighting fixtures, connection shall be teed off through suitable round conduit or junction box, so that the connection can be attended without taking down the fixture.

e) For vertical run of wires in conduit, wires shall be suitably supported by means of wooden/hard rubber plugs at each pull/junction box.

f) Maximum two wires can be terminated to each way of terminal connections.

g) Separate neutral wires are to be provided for each circuit.

h) AC and DC wiring should not run through the same conduit.

2.2.1.5.19.4 **Lighting Panels**

a) The lighting panels shall be erected at the locations to be finalised during detailed engineering.

b) Suitable foundations/supporting structures for all outdoor type lighting panels shall be provided by the Contractor.

2.2.1.5.19.5 **Foundation & civil works**

a) Foundation for street lighting poles, panel foundation and transformer foundation shall be done by the Contractor. The payment towards execution, PCC & RCC shall be made under relevant items of civil work mentioned in Bid Price schedule.

b) All final adjustment of foundation levels, chipping and dressing of foundation surfaces, setting and grouting of anchor bolts, sills, inserts and flastening devices shall be carried out by the Contractor including minor modification of civil works as may be required for erection.

c) Any cutting of masonary / concrete work, which is necessary shall be done by the Contractor at his own cost and shall be made good to match the original work.

ANNEXURE-1

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

CHAPTER-7: LT TRANSFORMER

Table of contents

CHAPTER 7: LT TRANSFORMER

1.0 INTENT

This specification is intended to cover outdoor type oil filled 200 kVA, 11/0.400kV, transformers.

2.0 SCOPE OF WORK

2.1 Scope of Supply

- Transformers as listed above, with insulating oil, all materials and accessories, and complete in all respects.
- Gland plates, power cable, lugs, anchor bolts and hardwares.
- Mandatory & optional spares and special maintenance equipments if any.

2.2 Scope of Service

The scope includes but is not limited to the following items of work to be performed for all equipment and materials furnished under this chapter:

a) Design, manufacturing, shop testing, packing & dispatch

b) Transportation inclusive of insurance and delivery, FOR site basis

c) Unloading, handling, storing, transportation at site up to foundations, oil filling and treatment, erection, testing and commissioning

d) Civil Works

e) Supply of external cables and termination as required.

f) Fire protection system.

3.0 General Information

3.1 All temperature indicators, Buchholz relays and other auxiliary devices shall be suitable for 220 V DC Control supply. All alarm and trip Contacts shall also be suitable for connection in 220V DC Circuits.

3.2 Bidders may specifically note that transformers offered shall conform to dynamic short circuit test and dielectric test as per IEC: 60076. Test report for the same shall be submitted during detail engineering for approval.

4.0 TECHNICAL REQUIREMENTS

4.1 Core

The core shall be constructed from high grade, non-aging, cold rolled grain-oriented silicon steel laminations. The maximum flux density in any part of the cores and yoke at normal voltage and frequency shall be such that the flux density at any tap position with 10% voltage variation from the voltage corresponding to the tap shall not exceed 1.9 Wb/sq-m.

4.2 Windings

The conductor shall be of electrolytic copper, free from scales and burrs.

4.3 Insulating Oil

The oil supplied with transformer shall be unused and have the parameters for unused new oil conforming to IEC: 60296 while tested at oil Contractor's premises, No inhibitors shall be used in oil. Ten percent extra oil shall be supplied for topping up after commissioning in nonreturnable containers suitable for outdoor storage.

4.4 Terminal Arrangement

a) Bushing terminals shall be provided with suitable terminal connectors of approved type and size for cable/overhead conductors' termination of HV side and cable termination on LV side.

b) The neutral terminals of 400V winding shall be brought out on a bushing along with the 433 volt phase terminals to form a 4 wire system for the 400 volt. Additional neutral bushing shall also be provided for earthing.

4.5 Off Circuit Tap Changing Equipment

The tap change switch shall be three phase, hand operated for simultaneous switching of similar taps on the three phases by operating an external hand wheel.

4.6 Marshalling Box

A metal enclosed, weather, vermin & dust proof marshalling box shall be provided with each transformer to accommodate temperature indicators, terminal blocks etc. It shall have a degree of protection of IP 55 as per IEC: 60947 Part-1.

4.7 Cable boxes

Whenever cable connections are required, suitable cable boxes shall be provided and shall be air insulated. They shall be of sufficient size to accommodate Purchaser's cables and shall have suitable removable side/top cover to facilitate cable termination and inspection. Cable boxes shall be dust & vermin proof.

5.0 Inspection and Testing

a) The Contractor shall draw up and carry out a comprehensive inspection and testing program during manufacture and commissioning of the transformer. The programme shall be duly approved by the Purchaser.

b) The Contractor shall carryout all routine tests on all the transformers as per relevant standards. Type test report shall be submitted for approval during detail engineering.

6.0 **Inspection**

6.1 **Tank and Accessories**

a) Physical and dimensional check of transformer tank and accessories.

b) Crack detection of major strength weld seams by dye penetration test.

6.2 **Core**

a) Physical inspection and check of quality of varnish, if used.

b) Sample testing of core material for checking specific loss, bend properties, magnestisation, characteristics and thickness.

c) Check on completed core for measurement of iron loss and check for any hot spot by exciting the core so as to induce the designed value of flux density in the core.

d) HV Test

6.3 **Insulating Material**

a) Sample checks for physical properties of the material

b) Check for dielectric strength

c) Check for the reaction of hot oil on insulating material

6.4 **Winding**

a) Sample check on winding conductor for mechanical properties and electrical conductivity and on installation covering.

b) Sample check on insulation paper for pH value, Bursting strength, Electric strength.

6.5 **Assembled Transformer**

a) Check complete transformer against approved outline drawing provision for all fittings, finish etc.

b) Jacking test on all the assembled transformers.

6.6 **Oil**

All Standard tests in accordance with relevant Standards shall be carried out on oil samples taken from the transformer before and after testing of the transformer. PCB materials are prohibited.

The contractor shall also prepare a comprehensive inspection and testing programme for all bought out sub-contracted items and shall submit the same to the Purchaser for approval. Such programme shall include the following components:

a) Buchholz Relay

b) Winding temperature Indicator

c) Bushings

d) Marshaling Box

e) Tap changer switch

f) Oil temperature indicator

7.0 **Factory Test**

7.1 All standard routine tests in accordance with latest issue of IEC: 60076 shall be carried out on each transformer.

7.2 The transformer shall conform to all the type tests in accordance with latest issues of IEC: 60076. The manufacturer shall submit type tests & additional test reports as listed above as already carried out on transformers of identical design for owner's acceptance. In such a case validity of type test reports shall be in line with clause 9.2 of Chapter 2-GTR of technical specifications. Following parameters in general shall be ensured for establishment of identical design as per IEC 60076, Part-V.

a) Same Voltage ratio, KVA rating, vector group & impedance.

b) Same conceptual design of core and winding.

c) Same arrangement and geometrical sequence of the main windings.

d) Same type of winding conductors.

e) Same type of main windings.

f) Absorbed power at short circuit (ie rated power/per unit short circuit impedance) between 30% and 130% of that relating to the reference transformer.

g) Axial forces and winding stresses occurring at short circuit not exceeding 120% of those relating to the reference transformer.

h) Same manufacturing process.

i) Same Clamping and winding support arrangement.

7.3 In addition to all type and routine tests, transformer shall also conform to following additional type tests as per IEC: 60076.

a) Measurement of zero sequence impedance

b) Short circuit test

c) Measurement of acoustic noise level. This shall conform to NEMA standard publication TR-1.

d) Measurement of capacitance and tan delta of transformer winding.

e) Test on oil samples as per IS 60296

7.4 All auxiliary equipment shall be tested as per the relevant IS Test Certificates shall be submitted for bought out items.

7.5 High voltage withstand test shall be performed on auxiliary equipment and wiring after complete assembly.

7.6 Tank Tests:

i) Routine Tests: As per IEC: 60076 Part-1 including

ii) Vacuum Tests: As per IEC: 60076 Part-1

iii) Pressure Test: As per IEC: 60076 Part-1

7.7 In addition to the above, the following checks should be carried out at manufacturer's works before despatch for all transformers:

a) Check for interchangeability of components of similar transformers and for mounting dimensions.

b) Check for proper packing and preservation of accessories like radiators, bushings explosion vent, dehydrating breather, Buchholz relay, conservator etc.

c) Check for proper provision of bracings to arrest the movements of core and winding assembly inside the tank.

d) Test for gas tightness and derivation of leakage rate. To ensure adequate reserve gas capacity during transit and storage.

7.8 The Contractor shall submit a detailed inspection and testing programme for field activities, covering areas right from the receipt of material stage upto commissioning stage as per IS : 1886 - Code of practice for installation and maintenance of transformers. The indicative checks and tests are given below.

a) Physical checks on each transformer on receipt at site for any damage or short supply.

b) Tests on oil samples

c) Oil leakage test

d) Physical checks for colour of silica in breather

e) Check for oil level in breather housing, conservator tank, etc.

f) Check for correct operation of all protections and alarms.

g) Insulation Resistance Measurement for Main Winding, control wiring etc.

h) Continuously observe the transformer operation at no load for 24 hours.

8.0 Fittings

The following fittings shall be provided with each transformer covered under this specification.

i) Conservator with drain plug and oil filling hole with blanking plate

ii) Plain oil Gauge

iii) Silica gel Breather

iv) Pressure Relief vent

v) Pocket on tank cover for Thermometer

vi) Valves

vii) Earthing Terminals

viii) Rating & Terminal Marking Plates

ix) Lifting Lugs

x) Rollers

xi) Air Release Plug

The fittings listed above are only indicative and any other fittings which generally are required for satisfactory operation of transformer are deemed to be included.

9.0 Spare Parts

9.1 The list of spares for outdoor type transformers covered under this chapter shall be as specified in Chapter 1- PSR

9.2 In addition, the Bidder shall also recommend optional spare parts and maintenance equipment necessary for three (3) years of successful operation of the equipment. The prices of these shall be indicated in respective schedules and these shall not be considered for the purpose of evaluation.

10.0 Technical Specification

S.No	Description	Unit	Parameters
1	Rated Capacity	KVA	200
2	Rated Voltage		
a.	HV	kV	33
b.	LV	kV	0.4
3	Type of Winding		Two winding
4	Service		Outdoor
5	No. of Phases		Three
6	Frequency	Hz	50
7	Type of Cooling		ONAN
8	Impedance at 75 Deg C	%	0.05
9	Tolerance on Impedence	%	±10
10	Duty		Continuous
11	Overload		IEC:60076-7
12	Max. Temp. Rise over an ambient of 50 Deg C		
a)	Oil(Temperature rise measurement by thermometer)	deg.C	50
b)	Winding Temperature rise measurement by resistance method)	deg.C	55
13	Windings		
a)	System Apparent Short circuit level (kA)	kA	As per IEC: 60076-Part 1
b)	Winding Connection		
(i)	HV		Delta
(ii)	LV		Star
14	Vector Group		Dyn11
15	Insulation		Uniform
16	Insulation Level		
a)	Power Frequency Test Level		
(i)	HV	kVrms	28
(ii)	LV	kVrms	2
17	Basic Impulse Level		
(i)	HV	kVp	75

(ii)	LV	kVp	-
18	Highest voltage (kV) for each winding	kV	12
19	Method of earthing		Solidly earthed
20	Tap changer		
(i)	Tap Change		+5% to -10% in step of 2.5% on HV side
(ii)	Tap control		Off Circuit Tap Change Switch
21	HV Bushing		
a)	Rated Voltage	kV	12
b)	Rated current	A	100
c)	Basic Impulse Level	kVp	75
d)	Wet & Dry Power frequency Withstand Voltage	kV_{rms}	28
e)	Min. Total Creepage distance	mm	300
f)	Mounting		Tank / Transformer Body
22	LV & Neutral Bushing		
a)	Rated Voltage	kV	1.1
b)	Rated current	A	1000
c)	Basic Impulse Level (kVp)		-
d)	Wet & Dry Power frequency Withstand Voltage	kV_{rms}	2
e)	Mounting		Tank / Transformer Body
23	Terminal Details		
a)	HV		Suitable for11kV Cable or Over Head Conductor
b)	LV & Neutral		Cable Box
24	Min. clearance in air		
a)	Ph-Ph (HV/LV)	mm	280/25
b)	Ph-Earth (HV/LV)	mm	140/25

CHAPTER 08 – TECHNICAL SPECIFICATIONS FOR TRANSFORMERS

(Transformer up to 132 kV class)

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

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.

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 ±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 fault on 11kV).

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 132 kV Class Transformer:

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on any rating of 132 kV or above voltage class transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report / Certificate along with bid.. Further design review of offered 132 kV class transformers shall be carried out based on design of short circuit tested 132 kV or above voltage class transformer.

(ii) For 132 kV Class Transformer:

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on any rating of 132 kV or above voltage class transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report / Certificate along with bid. Further design review of offered 132 kV class transformers shall be carried out based on design of short circuit tested 132 kV or above 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 provide 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/consultant 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 finalised 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 123kV 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 localised 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 for approval in case of award .

	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thick-ness (DFT)	Colour shade
Main tank, pipes, conservator tank, oil storage tank etc. (external surfaces)	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy high build Micaceous iron oxide (HB MIO) (75µm)	Aliphatic polyurethane (PU) (Minimum 50µm)	Minimum 155µm	RAL 7035
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 upto 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 **Maintenance-free Dehydrating Breather**

Conservator of Main Tank and OLTC each shall be fitted with a maintenance-free dehydrating breather in which only pure silica gel has been filled as dehydrating agent. Connection shall be made to a point in the oil conservator not less than 50 mm above the maximum working oil level by means of a pipe with a minimum diameter of 25 mm. Breathers and connecting pipes shall be securely clamped and supported to the transformer, or other structure supplied by the contractor, in such a manner so as to eliminate undesirable vibration and noise. The design shall be such that:

a) Incoming air is directed toward the desiccant (silica gel) and dried.

b) The desiccant is regenerated/de-humidified by an installed heating element that shall be sensor-controlled and self- regulating.

c) Silica gel is isolated from atmosphere by an oil seal.

d) Moisture absorption indicated by a change in color of the crystals.

e) Breather is mounted approximately1200mm above rail top level.

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

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, M 10 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, 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 equalise 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 KVp @ 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	IEC 61125 (method c) Test duration 500 hour	Max 0.3 mg KOH/g

	-Sludge -Dielectric dissipation factor (tan delta) at 90degC	IEC 60247	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 energisation 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. PCB Content is prohibited in transformer oil.

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 11 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.

3.5.1.11 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

i) For 3-Phase Unit

The neutral of the transformer shall be brought out through bushing. The neutral terminal of 3-phase transformer shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to two (2) 75 x 12 mm galvanised steel flats connected to Employer's grounding mat.

ii) 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.

iii) Spare Unit connection arrangement (as applicable for 1-Phase Transformer)

Connection arrangement of spare unit of transformer with other units shall be made by isolator switching (Isolators are not part of this specification). Neutral formation for spare unit of transformer shall be done by manual connection. The contractor shall make connection arrangement as well as control scheme of OLTC and Cooler in such a way that spare unit of transformer can be connected in place of faulty unit without physically shifting it from its location. For this purpose, HV , LV and Neutral Connections of spare unit are to be extended upto the other unit by forming auxiliary buses 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. The detail configuration and actual sizes of various items shall be finalised during detailed engineering and shall be subject to Employer's approval. All associated materials like Bus post insulators, Aluminium tube, conductors, clamps & connectors, insulator strings, hardware, cables, support structures, required for the above- mentioned arrangement shall be provided by the contractor.

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 galvanized 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 replace any designated unit). To facilitate change-over of spare unit signals with faulty unit in CMB, male-female plug-in connector or better arrangement shall be provided to reduce the outage time

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 finalised 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 Off load tap / On Load Tap changing equipment as specified elsewhere.

3.7.1 Off load tap Changer equipment (if applicable)

The off load / Off Circuit tap changer (OCTC) equipment shall be handle operated with a locking arrangement along with tap position indicator. The external handle shall be situated in an unobstructed position. The contacts are positively self-locating in each tapping position without constraint from the operating mechanism. The rating of the contacts shall be suitable to carry maximum current of the transformer. For three phase transformer the tap change switch shall simultaneous switch the similar taps on the three phases. A warning plate indicating that OCTC shall be operated only when the transformer is de-energized, shall be fitted.

3.7.2 ON Load Tap Changing (OLTC) Equipment

The On Load Tap Changer (OLTC) shall be of high speed resistor type with vacuum technology include the following:

3.7.2.1 Main OLTC Gear Mechanism

3.7.2.1.1 Each single / three phase transformer shall be provided with voltage control equipment of the tap changing type for varying its effective transformation ratio whilst the transformers are on load.

3.7.2.1.2 OLTC shall be motor operated suitable for local as well as remote operation. The diverter switch or arcing switch shall be designed so as to ensure that its operation once commenced shall be completed independently of the control relays or switches, failure of auxiliary supplies etc. To meet any contingency which may result in incomplete operation of the diverter switch, adequate means shall be provided to safeguard the transformer and its ancillary equipment. The current diverting contacts shall be housed in a separate vacuum interrupter chamber not communicating with the oil in main tank of the transformer. The contacts shall be accessible for inspection without lowering oil level in the main tank and the contacts shall be replaceable. Electrical arcing took place in a vacuum interrupter only.

3.7.2.1.3 Necessary safeguards shall be provided to avoid harmful arcing at the current diverting contacts in the event of operation of the OLTC gear under overload conditions of the transformer.

3.7.2.1.4 Tap changer shall be so mounted that bell cover of transformer can be lifted without removing connections between windings and tap changer

3.7.2.2 Local OLTC Control Cabinet (Drive Mechanism Box)

Each transformer unit of OLTC gear shall have following features: OLTC shall be suitable for manually handle operated and electrically motor operated. For local manual operation from Local OLTC Control cabinet (Drive Mechanism Box), an external handle shall be provided.

Modular integrated Transformer monitoring system within the OLTC motor drive enclosure shall have status monitoring of the OLTC motor drive signaling, OLTC tap position statistics, Maintenance recommendations and maintenance intervals calculations for the OLTC, Tap position statistics of the OLTC, Digital Tap position

3.7.2.2.1 Output signal (BCD), capability of a web based visualization.

3.7.2.2.2 OLTC's Local control cabinet shall be mounted on the tank in accessible position. The cranking device/handle for manual operation for OLTC gear shall be removable and suitable for operation by a man standing at ground level. The mechanism shall be complete with the following:

- Mechanical tap position indicator which shall be clearly visible from near the transformer.
- A mechanical operation counter of at least five digits shall be fitted to indicate the number of operations completed and shall have no provision for resetting. Mechanical stops to prevent over- cranking of the mechanism beyond the extreme tap positions.
- The manual control considered as backup to the motor operated on load tap changer control shall be interlocked with the motor to block motor start-up during manual operation.
- The manual operating mechanism shall be labeled to show the direction of operation for raising the voltage and vice-versa.
- An electrical interlock to cut-off a counter impulse for reverse step change being initiated during a progressing tap change and until the mechanism comes to rest and resets circuits for a fresh position.

3.7.2.2.3 For electrical operation from local as well as remote, motor operated mechanism shall be provided. It shall not be possible to operate the electric drive when the manual operating gear is in use. It shall not be possible for any two controls to be in operation at the same time. Transfer of source in the event of failure of one AC supply shall not affect the tap changer. Thermal device or other means shall be provided to protect the motor and control circuit.

3.7.2.2.4 The Local OLTC Drive Mechanism Box shall house all necessary devices meant for OLTC control and indication. It shall be complete with the followings:

i. A circuit breaker/contactor with thermal overload devices for controlling the AC Auxiliary supply to the OLTC motor
ii. Emergency Push Button to stop OLTC operation
iii. Cubicle light with door switch
iv. Provided with anti-condensation metal clad heaters to prevent condensation of moisture
v. Padlocking arrangement for hinged door of cabinet
vi. All contactors relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.
vii. The cabinet shall be tested at least IP55 protection class.

3.7.2.2.5 All relays and operating devices shall operate correctly at any voltage within the limits specified in Chapter-GTR. Incase auxiliary power supply requirement for OLTC DM Box is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor.

3.7.2.2.6 Operating mechanism for on load tap changer shall be designed to go through one step of tap change per command only, until the control switch is returned to the off position between successive operations/repeat commands.

3.7.2.2.7 Limit switches shall be provided to prevent over running of the mechanism and shall be directly connected in the control circuit of the operating motor provided that a mechanical de-clutching mechanism is incorporated. In addition, a mechanical stop shall be provided to prevent over-running of the mechanism under any condition. An interlock to cut-out electrical control when it tends to operate the gear beyond either of the extreme tap positions.

3.7.2.2.8 OLTC local control cabinet shall be provided with tap position indication for the transformer. Drive Mechanism shall be equipped with a fixed resistor network capable of providing discrete voltage steps or provide 4-20mA transducer outputs for tap position indication in CMB (for single phase unit) and input to Digital RTCC/SCADA system.

3.7.2.2.9 'Local-remote' selector switch shall be provided in the local OLTC control cabinet. In Local mode, all electrical commands from remote (i.e. from CMB, Digital RTCC, SCADA etc.) shall be cut-off/blocked.

Electrical operations to change tap positions shall be possible by using raise/lower push buttons under local mode from DM Box. In remote mode electrical commands from CMB/Digital RTCC/SCADA etc. shall be executed. The remote-local selector switch shall be having at-least two spare contacts per position.

3.7.2.2.10 following minimum contacts shall be available in DM Box, which shall be wired to CMB for single phase unit. Further these contacts shall be wired to Digital RTCC panel:

a. ' INCOMPLETE STEP' which shall not operate for momentary loss of auxiliary power.
b. OLTC motor overload protection
c. Supply to DM Motor fail
d. OLTC INPROGRESS
e. Local / Remote Selector switch position
f. OLTC upper/lower limits reached

3.7.2.2.11 All relays, switches, fuses etc. shall be mounted in the OLTC local control cabinet and shall be clearly marked/labeled for the purpose of identification.

3.7.2.2.12 A permanently legible lubrication chart if required shall be fitted within the OLTC local control cabinet.

3.7.2.3 OLTC Control from Common Marshalling Box (CMB)

3.7.2.3.1 It shall be possible to monitor, control/operate, the OLTC of all the three 1- phase transformers of a transformer bank from Common Marshalling Box. The control and monitoring terminations of a spare transformer unit shall be brought to CMB. The necessary switching arrangement through male-female plug-in TB assembly shall be provided for replacing spare unit with any one of the faulty phase unit for monitoring & control from CMB.

3.7.2.3.2 'Independent-combined-remote selector switch, raise/lower switch and emergency stop Push Button shall be provided in the common marshalling box for OLTC control.

3.7.2.3.3 When the selector switch is in independent position, the OLTC control shall be possible from individual Local OLTC Control Cabinet (DM Box) only.

3.7.2.3.4 In '**combined position'**, raise-lower switch (provided in the CMB), shall be used to operate for bank of three single phase transformers from CMB.

3.7.2.3.5 In **'remote position'** control of OLTC shall be possible from Digital RTCC/SCADA etc.

3.7.2.3.6 From CMB, the operation of OLTC shall be for 3-phases of transformer units without producing phase displacement. Independent operation of each single phase transformer from CMB/Digital RTCC/SCADA will be prevented.

3.7.2.3.7 Following minimum **LED indications** shall be provided in CMB:

a. INCOMPLETE STEP
b. OLTC motor overload protection
c. Supply to DM Motor fail
d. OLTC IN PROGRESS
e. Local / Remote Selector switch positions of DM
f. OLTC upper/lower limits reached
g. 400V Main AC supply ON
h. 400V Standby AC supply ON

Following **contacts** shall be wired to TBs in CMB for further wiring to C & R Panels.

i. 400V Main AC supply Fail
j. 400V Standby AC supply Fail

Following **contacts** shall be wired to TBs in CMB for further wiring to digital RTCC Panel:

a. INCOMPLETE STEP
b. OLTC motor overload protection
c. Supply to DM Motorfail

d. OLTC INPROGRESS
e. Local / Remote Selector switch positions of DM
f. OLTC upper/lower limits reached
g. 'Independent-combined-remote' selector switch positions of CMB

Further, OLTC Tap position Digital indications for all three 1-PhTransformer units either separately or through selector switch shall be provided in CMB. The same shall also be wired to Digital RTCC Panel to display tap positions for all three 1-ph unit separately.

3.7.3 Digital RTCC Panel

3.7.3.1 The digital RTCC panel shall have Automatic Tap Changer control and monitoring relay with Automatic Voltage Regulating features (referred as **Digital RTCC relay**) to remotely control and monitor OLTC. The relay shall be offered from the manufacturer who has already supplied Digital RTCC relay, which is in operation for at-least 2 years for transformer OLTC application.

3.7.3.2 Digital RTCC relay shall be microprocessor based adopting the latest state of the art design & technology within-built large display for ease of programming and viewing. The unit supplied shall be field programmable so that in the event of change in transformer / location, it could be customized to site conditions without sending back to works. The programming shall be menu driven and easily configurable. If it is designed with draw out type modules, it should take care of shorting all CT inputs automatically while drawing out. The CT/VT ratio shall be field programmable and Relay shall display the actual HV Voltage and current considering suitable multiplying factors. The system shall be self-sufficient and shall not require any additional devices like parallel balancing module etc. All Digital RTCC Relays shall be of same make for smooth integration of these relays for parallel operations of all transformers in the substation.

3.7.3.3 The digital RTCC Panel shall be provided with digital RTCC relay having Raise/Lower push buttons, Manual/ Automatic mode selection features, Master / Follower/ Independent/ off mode selection features and emergency stop Push Button for control of OLTC. Touch screen option in the relay, instead of electrical push button/switch is also acceptable.

3.7.3.4 **In Manual Mode**: In this mode, power system voltage based automatic control from digital RTCC relay shall be blocked and commands shall be executed manually by raise/lower push buttons.

3.7.3.5 **In Auto Mode:** In Auto mode, digital RTCC relay shall automatically control OLTC taps based on power system voltage and voltage set points. An interlock shall be provided to cut off electrical control automatically upon recourse being taken to the manual control in emergency.

3.7.3.6 Master/Follower/Independent/Off mode

Master Position: If the selector switch is in master position, it shall be possible to control the OLTC units of other parallel operating transformers in the follower mode by operation from the master unit.

Follower Position: If the selector switch is in Follower position control of OLTC shall be possible only from panel where master mode is selected.

Independent Position: In independent position of selector switch, control of OLTC shall be possible only from the panel where independent mode is selected. Suitable interlock arrangement shall be provided to avoid unwanted/ in consistent operation of OLTC of the transformer

3.7.3.7 **Raise/Lower control:** The remote OLTC scheme offered shall have provision to raise or lower taps for the complete bank of three 1-phase transformers/3-Phase Transformers. Individual 1-phase OLTC operation shall not be possible from the remote control panel.

3.7.3.8 Digital RTCC relays shall communicate with SCADA using IEC 61850 protocols to monitor, parameterize & control the OLTC. Any software required for this purpose shall be supplied. The supplied software shall not have restriction in loading on multiple computers for downloading and analyzing the data. Software shall indicate the current overview of all measured parameters of the connected transformer in real time. The digital RTCC Relay shall have multiple selectable set point voltages and it shall be possible to select the set points from SCADA, with a facility to have the possibility of additional set points command from SCADA. Communication between the Digital RTCC relays to execute the commands for parallel operation shall be implemented using required communication protocol. IEC-61850 GOOSE messaging between Digital RTCC relays for OLTC parallel operation is not permitted. Suitable communication hardware shall be provided to communicate upto distance of 1km between digital RTCC relays. Scope shall also include communication cables between digital RTCC relays. Cables as required for parallel operation of OLTCs of all transformers (including existing transformers wherever required) from Digital RTCC relays shall be considered included in the scope of bidder.

3.7.3.9 The Digital RTCC relay shall have programmable Binary Inputs (minimum 7 Nos.) and Binary outputs (minimum 7 Nos.) for Employer's future use. It shall be possible to have additional module for Binary Input/output as well as Analogue input module depending upon requirement.

3.7.3.10 The relays shall ensure positive completion of lowering/raising of the OLTC tap, once the command is issued from the relay."Step-by-Step" operation shall be ensured so that only one tap change from each tap changing pulse shall be effected. If the command remains in the "operate" position, lock-out of the mechanism is to be ensured.

3.7.3.11 Following minimum indications/alarms shall be provided in Digital RTCC relay either through relay display panel or through relay LEDs:

a. INCOMPLETE STEP alarm
b. OLTC motor overload protection alarm
c. Supply to DM Motor fail alarm
d. OLTC IN PROGRESS alarm
e. Local/Remote Selector switch positions in DM Box
f. OLTC upper/lower limits reached alarm
g. OLTC Tap position indications for transformer units
h. 'Independent-combined-remote selector switch positions of CMB

3.7.3.12 In case of parallel operation or 1-PhaseTransformer unit banks OLTC out of step alarm shall be generated in the digital RTCC panel for discrepancy in the tap positions.

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 feeder as normal source and other as standby.

b) Upon failure of the normal source, the loads shall be automatically transferred after an adjustable time delay to standby sources.

c) Indication to be provided at cooler control cabinet 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 operate 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**.**

3.9 Constructional features of Cooler Control Cabinet/ Individual Marshalling Box/Common Marshalling Box and Digital RTCC Panel

3.9.1 Each transformer unit shall be provided with local OLTC Drive Mechanism Box, cooler control cabinet/individual marshalling box. Digital RTCC panel and common marshalling (for a bank of three 1-phase units) shall be provided.

3.9.2 The cooler control cabinet, Individual Marshalling Box, Common Marshalling Box, shall be made of stainless steel sheet of at least 1.6mm thick. Digital RTCC panel shall be CRCA sheet of minimum thickness of 2.5mm and shall be painted suitably as per **Annexure–E**.

3.9.3 The degree of protection shall be IP: 55 for outdoor and IP: 43 for indoor in accordance with IS: 13947/IEC: 60947.

3.9.4 All doors, removable covers and plates shall be gasketed all around with suitably profiled. All gasketed surfaces shall be smooth straight and reinforced if necessary to minimize distortion to make a tight seal. For Control cubicle / Marshalling Boxes etc. which are outdoor type, all the sealing gaskets shall be of EPDM rubber or any better approved quality, whereas for all indoor control cabinets /Digital RTCC panel, the sealing gaskets shall be of neoprene rubber or any better approved quality. The gaskets shall be tested in accordance with approved quality plan, IS: 1149 and IS: 3400.

3.9.5 Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh of brass. All the control cabinets shall be provided with suitable lifting arrangement. Thermostat controlled space heater and cubicle lighting with ON-OFF switch shall be provided in each panel.

3.9.6 The size of Common marshalling box shall not be less than 1600mm (front) X 650mm (depth) X 1800mm (height). All the cabinets except common marshalling box & Digital RTCC shall be tank mounted. All the separately mounted cabinets and panels shall be free standing floor mounted type and have domed or sloping roof for outdoor application.

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, nameledtion 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	*Typ
24.	Measurement of harmonic level in no load current	*Typ
25.	Measurement of acoustic noise level	*Typ
26.	Measurement of Zero seq. reactance	*Typ
27.	Measurement of power taken by fans and oil pumps	*Typ

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 OIP 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 Chapter2 – 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 despatch 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 silicagel in silicagel 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 Magnetising 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 energisation 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

(132/33 kV and 33/11, 3-Phase Power Transformer)

Cl. No.	Descriptio	Unit	TECHNICAL PARAMETERS	
1.1	Rated Capacity	MVA	24/27/30	10/13.3/16.66
1.2	Voltage ratio (HV/LV) Line to line	kV	132/33	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/ONAF1/ONAF2	
1.7	Type of Transformer		Constant Ohmic impedance type (Refer note 1)	
1.8	HV-LV Impedance at 75 Deg C			
i)	Principal tap	%	>11	>8
ii)	Tolerance on Impedance	%	As per IEC	
1.9	Service		Outdoor	
1.10	Duty		CONTINUOUS	
1.11	Overload Capacity		IEC 60076-7	IEC 76-1
1.12	Temperature rise over 50deg C Ambient Temp			
i)	Top oil measured by thermometer	deg C	50	35
ii)	Average winding measured by resistance method	Deg.C	55	40
1.13	Windings			
i)	System Fault level			
	HV	kA	31.5	
	LV	kA	25	
	Neutral	kA	-	
ii)	Lightning Impulse withstand Voltage			
	HV	kVp	650	170
	LV		170	95
	Neutral	kVp	95	
iii)	Switching Impulse withstand Voltage			
	HV	kVp	650	650
iv)	One Minute Power Frequency withstand Voltage			
	HV	kVrms	275	70
	LV	kVrms	75	28
v)	Neutral Grounding		Solidly grounded	
vi)	Insulation			
	HV		GRADED	UNIFORM

	LV		UNIFORM	UNIFORM
vii)	Tan delta of winding	%	<0.5%	
1.14	Vector Group (3 –ph) (unless specified differently elsewhere)		YNynO	Dyn11
1.15	Tap Changer		OLTC Vacuum type	
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/33kV HV	
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.	
1.16	Bushings			
i)	Rated voltage			
	HV	kV	145	36
	LV	kV	36	12
	Neutral	kV		
ii)	Rated current (Min.)			
	HV	A	400	400
	LV	A	1200	1200
iii)	Lightning Impulse withstand Voltage			
	HV	kVp	650	170
	LV	kVp	170	75
iv)	One Minute Power Frequency withstand Voltage			
	HV	kVrms	275	75
	LV	kVrms	75	28
	Neutral	kVrms	55/32	
v)	Minimum total creepage distances			
	HV	mm	3625	900
	LV	mm	900	300
	Neutral	mm	300	
vi)	Tan delta of bushing			
	HV	%	<0.4	
vii)	Max Partial discharge level at U_m			
	HV	pC	10	
1.17	Max Partial discharge level at 1.5Um/√3	pC	100	
1.18	Max Noise level at rated voltage and at principal tap on full load and all cooling active	dB	75	

Notes:

1. For parallel operation of transformers, 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 30 MVA, 132/33 kV 3-Ph Transformers)**

Description	Current Transformer Parameters(Transformer)			
	HV Side	HV Neutral Side	LV Side	LV Neutral Side
a) Ratio				
CORE 1	400/1	400/1	1200/1	1200/1
CORE 2	NA	NA	NA	NA
b) Minimum knee point voltage or burden and accuracy class				
CORE 1	5P20	5P20	5P20	5P20
CORE 2	0.2 Class 15 VA ISF≤5	-	0.2 Class 15 VA ISF≤5	-
c) Maximum CT secondary resistance (Ohm)				
CORE 1	1.5	1.5	1.5	1.5
CORE 2	-	-	-	-
d) Application				
CORE 1	Protection	Protection	Protection	Protection
CORE 2	NA	-	-	-
e) Maximum magnetization current (at knee point voltage)				
CORE 1	100 mA	100 mA	100 mA	100 mA
CORE 2	-	-	-	-

7.5.2 Technical Parameters of Current Transformers (for 10/16.66 MVA, 33/11 kV 3-Ph Transformers)

Description	Current Transformer Parameters(Transformer)			
	HV Side	HV Neutral Side	LV Side	LV Neutral Side
a) Ratio				
CORE 1	100/1	100/1	300/1	300/1
CORE 2	NA	NA	NA	NA
b) Minimum knee point voltage or burden and accuracy class				
CORE 1	5P20	5P20	5P20	5P20
CORE 2	0.2 Class 15 VA ISF≤5	-	0.2 Class 15 VA ISF≤5	-
c) Maximum CT secondary resistance (Ohm)				
CORE 1	1.5	1.5	1.5	1.5
CORE 2	-	-	-	-
d) Application				
CORE 1	Protection	Protection	Protection	Protection
CORE 2	NA	-	-	-
e) Maximum magnetization current (at knee point voltage)				
CORE 1	100 mA	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.

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.

8.1 TENDER EVALUATION AND THE GUARANTEED LOSSES

8.2 Capitalization of Transformer Losses

When evaluating the individual bid received from various Bidders, the transformer shall be evaluated for the cost of losses based on the following relation:

$$P_E = P_b + K_L * L_L + K_{NL} * L_{NL} + K_{CL} * L_{CL}$$

Where,

P_E = Evaluated price
P_b = Bid price
K_L = Value of load loss
K_{NL} = Value of no-load loss
L_L = Guaranteed load losses at rated Current and and at 75°C on max.MVA base
L_{NL} = Guaranteed no-load loss at Rated Voltage and Frequency on max. MVA Base.
K_{CL} = Value of Cooler loss
L_{CL} = Guaranteed Cooler losses for full load operation on max MVA base

The transformer losses will be capitalized as follows for evaluation purpose:

a) No load losses: US$ 4684 per kW

b) Load losses: US$ 1180 per kW

c) Cooler losses: US$ 393 per kW

8.3 Evaluation of Transformer Losses

If the bidders quote unrealistic and unachievable guaranteed transformer loss values (no-load or load losses), then the Employer may ask the bidder to submit technical justifications to substantiate such guaranteed losses. The technical justifications shall be in the form of type test reports performed on the similar type of power transformers. If the justifications are not satisfactory, the proposed transformers shall be rejected and the bid shall be considered non-responsive.

8.4 Guaranteed Values Not Reached

If the individual losses of a power transformer as measured during test exceeds the values guaranteed in the Bid, then for each kilowatt of losses in excess of the losses guaranteed, an amount at the rates of twice the rates of specified in clause 1.6.1 for no load losses and load losses shall be deducted from the Contract Price of the successful Bidder.

8.5 PERFORMANCE GUARANTEE

The performance figures quoted on Technical Data Sheet shall be guaranteed within the tolerances permitted by relevant standards listed under section of General Technical Specifications, and shall become a part of the successful Tenderer's Contract. In case of loss capitalization, no tolerance shall be permitted for the guaranteed value. The measured no-load and load losses (excluding fan loss) should not exceed the guaranteed value by over 15 % provided that the total losses do not exceed 10% as specified. In case the loss figures are not inside this tolerance, NEA has the right to reject the proposed transformer during factory test.

9.0 Oil Storage Tank

9.1 **General**

This specification is for oil storage tank. Oil Storage tank shall be supplied if specified in Bid Price schedule.

9.2 Standard

The oil storage tank shall be designed and fabricated as per relevant standards.

9.3 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.

9.3.1 The Bidder may further note that maximum height of any part of the complete assembly of the storage tank shall not exceed 4.0 metres above road top.

9.3.2 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.

9.3.3 The tank shall also fitted with manhole, outside & inside access ladder, silicagel 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/

9.3.4 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.

9.3.5 The painting of oil storage tank and its control panel shall be as per clause no 3.1.1.8.

9.3.6 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.

10.0 OIL SAMPLING BOTTLE

10.1 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.

10.2 Oil sampling bottles shall be made of stainless steel having a capacity of one litre.

10.3 Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

10.4 The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.

10.5 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 (in mm)	Permanent deflection of flat plate (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 silicagel in silicagel 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.
- Magnetising current test.
- Capacitance and Tan delta measurement of winding and bushing.
- DGA of oil just before commissioning and after 24 hours energisation at site.

• CHAPTER 9: POWER AND CONTROL CABLE

Table of contents

CHAPTER 9: POWER & CONTROL CABLES

1. POWER & CONTROL CABLES [FOR WORKING VOLTAGES UP TO AND INCLUDING 1100 V] CRITERIA FOR SELECTION OF POWER & CONTROL CABLES

1.1.1. Aluminium conductor XLPE insulated armoured cables shall be used for main power supply purpose from LT Aux. Transformers to control room, between distribution boards and for supply for colony lighting from control room.

1.1.2 Aluminium conductor PVC insulated armoured power cables shall be used for various other applications in switchyard area/control room except for control/protection purposes.

1.1.3 For all control/protection/instrumentation purposes PVC insulated armoured control cables of minimum 2.5 sq. mm. size with stranded Copper conductors shall be used.

1.1.4 Employer has standardised the sizes of power cables for various feeders. Bidders are to estimate the quantity of cables and quote accordingly. The minimum sizes of power cables to be used per feeder in different application shall be as follows:

S.No.	From	To	Cable size	Cable type
1.	Main Switch Board	LT Transformer	2-1C X 630 mm^2 per phase 1-1C X 630 mm^2 for neutral	XLPE
2.	Main Switch Board	AC Distribution Board	2-3½C X 300 mm^2	XLPE
3.	Main Switch Board	Oil Filtration Unit	1-3½C X 300 mm^2	XLPE
4.	Main Switch Board	Colony Lighting	1-3½C X 300 mm^2	XLPE
5.	Main Switch Board	HVW pump LCP	1-3½C X 300 mm^2	XLPE
6.	Main Switch Board	Main Lighting distribution board	2-3½C X 300 mm^2	XLPE
7.	AC Distribution Board	D.G. Set AMF Panel	2-3½C X 300 mm^2	XLPE
8.	AC Distribution Board	Emergency Lighting	1-3½C X 70 mm^2	PVC
		distribution board		
9.	AC Distribution Board	ICT MB	1-3½C X 70 mm^2	PVC
10.	AC Distribution Board	Bay MB	1-3½C X 70 mm^2	PVC
11.	Bay MB	AC Kiosk	1- 3 ½ x 70 mm^2	PVC
12.	AC Distribution Board	Battery Charger	1-3½C X 70 mm^2	PVC
13.	DCDB	Battery	2-1C X 150 mm^2	PVC
14.	DCDB	Battery Charger	2-1C X 150 mm^2	PVC

15.	DCDB	Protection/PLCC panel	1-4C X 16 mm^2	PVC
16.	Main Lighting DB	Lighting panels(Indoor)	1-3½C X 35 mm^2	PVC
17.	Main Lighting DB	Lighting panels (outdoor)	1-3½C X 70 mm^2	PVC
18.	Main Lighting DB	Receptacles (Indoor)	1-3½C X 35 mm^2	PVC
19.	Main Lighting DB	Receptacles (Outdoor)	1-3½C X 70 mm^2	PVC
20.	Lighting Panel	Sub lighting panels	1-4C X 16 mm^2	PVC
21.	Lighting Panel	Street Lighting Poles	1-4C X 16 mm^2	PVC
22.	Lighting Panel/ Sub lighting panels	Lighting Fixtures (Outdoor)	1-2C X 6 mm^2	PVC
23.	Bay MB	Equipments	1-4C X 16 mm^2 /1-4C X 6 mm^2 /1-2C X 6 mm^2	PVC

1.1.5 Bidder may offer sizes other than the sizes specified in clause 1.1.4. In such case and for other application where sizes of cables have not been indicated in the specification, sizing of power cables shall be done keeping in view continuous current, voltage drop & short-circuit consideration of the system. Relevant calculations shall be submitted by bidder during detailed engineering for purchaser's approval.

1.1.6 Cables shall be laid as per relevant IEC/International Standards.

1.1.7 While preparing cable schedules for control/protection purpose following shall be ensured:

1.1.7.1 Separate cables shall be used for AC & DC.

1.1.7.2 Separate cables shall be used for DC1 & DC2.

1.1.8 For different cores of CT & CVT separate cable shall be used

1.1.9 At least one (1) cores shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.

1.1.10 For control cabling, including CT/VT circuits, 2.5 sq.mm. Size copper cables shall be used per connection. However, if required from voltage drop/VA burden consideration additional cores shall be used. Further for potential circuits of energy meters separate connections by 2 cores of 2.5 sq.mm. Size shall be provided.

1.1.11 Technical data requirement sheets for cable sizes are being enclosed at **Annex-I.**

1.2. TECHNICAL REQUIREMENTS

1.2.1. General

1.2.1.1. The cables shall be suitable for laying in racks, ducts, trenches, conduits and underground buried installation with uncontrolled back fill and chances of flooding by water.

1.2.1.2. They shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions. The XLPE /PVC insulated L.T. power cables of sizes 240 sq. mm. and above shall withstand without damage a 3 phase fault current of at least 45 kA for at least 0.12 second, with an initial peak of 105 kA in one of the phases at rated conductor temperature (70 degC for PVC insulated cables and 90 degC for XLPE insulated cables). The armour for these power cables shall be capable of carrying 45 kA for at least 0.12 seconds without exceeding the maximum allowable temperature of PVC outer sheath.

1.2.1.3. The XLPE insulated cables shall be capable of withstanding a conductor temperature of 250°C during a short circuit without any damage. The PVC insulated cables shall be capable of withstanding a conductor temperature of 160°C during a short circuit.

1.2.1.4. The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All Aluminium used in the cables for conductors shall be of H2 grade. In case of single core cables armours shall be of H4 grade Aluminium.

1.2.1.5. The fillers and inner sheath shall be of non-hygroscopic, fire retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

1.2.1.6. Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.

1.2.1.7. Strip wire armouring method shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

1.2.1.8. The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

1.2.1.9. All the cables shall pass fire resistance test as per IEC: 60502 (Part-I)

1.2.1.10. The normal current rating of all PVC insulated cables shall be as per IEC: 60502.

1.2.1.11. Repaired cables shall not be accepted.

1.2.1.12. Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

1.2.2. XLPE Power Cables

1.2.2.1. The XLPE insulated cables shall be of FR type, C1 category conforming to IEC:60502 (Part-I) and its amendments read along with this specification. The conductor shall be stranded aluminium circular/sector shaped and compacted. In multicore cables, the core shall be identified by red, yellow, blue and black coloured strips or colouring of insulation. A distinct inner sheath shall be provided in all multicore cables. For XLPE cables, the inner sheath shall be of extruded PVC to type ST-2 of IEC: 60502. When armouring is specified for single core cables, the same shall consist of aluminium wires/strips. The outer sheath shall be extruded PVC to Type ST-2 of IEC: 60502 for all XLPE cables.

1.2.3. PVC Power Cables

1.2.3.1. The PVC (70°C) insulated power cables shall be of FR type, C1 category, conforming to IEC: 60502 (Part-I) and its amendments read alongwith this specification and shall be suitable for a steady conductor temperature of 70°C. The conductor shall be stranded aluminium. The Insulation shall be extruded PVC to type-A of IEC: 60502. A distinct inner sheath shall be provided in all multicore cables. For multicore armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC to Type ST-1 of IEC: 60502 for all cables.

1.2.4. **PVC Control Cables**

1.2.4.1. The PVC (70°C) insulated control cables shall be of FR type C1 category conforming to IEC: 60502 (Part-1) and its amendments, read alongwith this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC to type A of IEC: 60502. A distinct inner sheath shall be provided in all cables whether armoured or not. The over sheath shall be extruded PVC to type ST-1 of IEC: 60502 and shall be grey in colour.

1.2.4.2. Cores shall be identified as per IEC: 60502 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of cores shall be done by printing legible Hindu Arabic Numerals on all cores as per IEC: 60502 (Part-1).

2. HV POWER CABLES [FOR WORKING VOLTAGES FROM 3.3 kV AND INCLUDING 33 kV]

2.1. **HV POWER CABLE FOR AUXILIARY POWER SUPPLY**

The HV cable of 1Cx400mm^2 (Copper Conductor), 3Cx240mm^2 (Copper Conductor) & 3Cx400 mm^2 (Aluminium Conductor) of voltage class as specified for outgoing feeder from 132/33kV transformer to overhead pole, outgoing from 132/11kV transformer to indoor module & indoor module to overhead pole & connection between sub transmission line to 33kv incomer bay at 33kV substation respectively, insulated, armoured cable conforming to IEC: 60502 (Part-2). Terminating accessories shall conform to IEC 61442-1997/IEC60502-4 1998.

2.2. Bidder may offer sizes other than the sizes specified in clause 2.1. In such case sizing of power cables shall be done keeping in view continuous current, voltage drop & short-circuit consideration of the system. Relevant calculations shall be submitted by bidder during detailed engineering for purchaser's approval.

2.3. **Constructional Requirements**

Cable shall have compacted circular Aluminium conductor, Conductor screened with extruded semi conducting compound, XLPE insulated, insulation screened with extruded semi conducting compound, armoured with non-magnetic material, followed by extruded PVC outer sheath (Type ST-2), with FR properties.

2.4 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of the cable.

2.5 The cables shall have outer sheath of a material with an Oxygen Index of not less than 29 and a Temperature index of not less than 250°C.

2.6 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

3 CABLE DRUMS

3.1 Cables shall be supplied in returnable wooden or steel drums of heavy construction. Wooden drum shall be properly seasoned sound and free from defects. Wood preservative shall be applied to the entire drum.

3.2 Standard lengths for each size of power and control cables shall be 500/1000 meters. The cable length per drum shall be subject to a tolerance of plus or minus 5% of the standard drum length. The owner shall have the option of rejecting cable drums with shorter lengths. Maximum, One (1) number nonstandard lengths of cable size(s) may be supplied in drums for completion of project.

3.3 A layer of water proof paper shall be applied to the surface of the drums and over the outer most cable layer.

3.4 A clear space of at least 40 mm shall be left between the cables and the lagging.

3.5 Each drums shall carry the manufacturer's name, the purchaser's name, address and contract number and type, size and length of the cable, net and gross weight stencilled on both sides of drum. A tag containing the same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

3.6 Packing shall be sturdy and adequate to protect the cables, from any injury due to mishandling or other conditions encountered during transportation, handling and storage. Both cable ends shall be sealed with PVC/Rubber caps so as to eliminate ingress of water during transportation and erection.

4 TYPE TESTS

4.1 All cables shall conform to all type, routine and acceptance tests listed in the relevant IEC.

4.2 XLPE INSULATED POWER CABLES (For working voltages up to and including 11000V):-

4.2.1 Following type tests (on one size in a contract) as per IEC: 60502 (Part 1) including its amendments shall be carried out as a part of acceptance tests on XLPE insulated power cables for working voltages up to and including 1100 V:

a) Physical tests for insulation
   i) Hot set test
   ii) Shrinkage test

b) Physical tests for outer sheath
   i) Shrinkage test
   ii) Hot deformation
   iii) Heat shock test
   iv) Thermal stability

4.2.2 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Chapter 2: GTR for the following tests-

a) Water absorption (gravimetric) test.
b) Ageing in air oven
c) Loss of mass in air oven
d) Short time current test on power cables of sizes 240 sqmm and above on
   i) Conductors.
   ii) Armours.
e) Test for armouring wires/strips.
f) Oxygen and Temperature Index test.
g) Flammability test.

4.3 PVC INSULATED POWER & CONTROL CABLES (For working voltages up to and including 1100V)-

4.3.1 Following type tests (on one size in a contract) as per IEC: 60502 (Part 1) including its amendments shall be carried out as a part of acceptance tests on PVC insulated power & control cables for working voltages up to and including 1100 V:

a) Physical tests for insulation and outer sheath
   - i) Shrinkage test
   - ii) Hot deformation
   - iii) Heat shock test
   - iv) Thermal stability

a) High voltage test.

4.3.2 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Chapter 2: GTR for the following-

a) High voltage test.
b) Ageing in air oven.
c) Loss of mass in air oven.
d) Short time current test on power cables of sizes 240 sq.mm and above on
   i) Conductors.
   ii) Armours.
e) Test for armouring wires/strips.
f) Oxygen and Temperature Index test.
g) Flammability test.

4.4 XLPE INSULATED HV POWER CABLES(For working voltages from 3.3 kV and including 33 kV)-

4.4.1 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Chapter 2: GTR for XLPE insulated HV power cables (as per IEC: 60502 Part-2).

4.5 Terminating/jointing accessories as per IEC 60840:1999/ IEC62067

TECHNICAL SPECIFICATION FOR AIR CONDITIONING SYSTEM

TABLE OF CONTENTS

TECHNICAL SPECIFICATION FOR

AIR CONDITIONING SYSTEM

1 GENERAL

1.1 This specification covers supply, installation, testing and commissioning and handing over to POWERGRID of Air conditioning system for the control room building and switch-yard panel rooms.

1.2 Air conditioning units for control room building shall be set to maintain the inside DBT at 24 ^{o} C ± 2^{o}C and the air conditioning system for switch-yard panel rooms shall be set to maintain DBT inside switch-yard panel rooms below 24^{o}C.

1.3 Controllers shall be provided in Control room and Battery room for controlling and monitoring the AC units in these rooms as detailed in clause no.2.3.4.

1.4 Each switch-yard panel room shall be provided with temperature transducer to monitor the temperature of the panel room. The Temperature transducer shall have the following specification:

Sensor	:	Air temperature sensor (indoor use)
Output	:	4 to 20mA
Temperature range	:	-5^{o}C to 60^{o}C
Resolution	:	0.1^{o}C
Accuracy	:	0.5^{o}C or better.

2 AIR CONDITIONING SYSTEM FOR CONTROL ROOM BUILDING & relay room.

Air conditioning requirement of control room building shall be met using High wall type split AC units of 2TR.

2.1 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.

2.1.1 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.

2.1.2 Copper refrigerant piping complete with insulation between the indoor and outdoor units as required.

2.1.3 First charge of refrigerant and oil shall be supplied with the unit.

2.1.4 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.

2.1.5 Local start/stop facility for local starting/ stopping of all electrical equipment/ drives.

2.1.6 All instruments and local control panels alongwith controls and interlock arrangements and accessories as required for safe and trouble free operation of the units.

2.1.7 PVC drain piping from the indoor units upto the nearest drain point.

2.1.8 Supply and erection of Power and control cable and earthing.

2.1.9 MS Brackets for outdoor condensing units, condensers as required.

2.2 **Technical specifications.**

2.2.1 **High wall type split AC units**

2.2.1.1 The split AC units shall be complete with indoor evaporator unit, outdoor condensing units and cordless remote control units.

2.2.1.2 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.

2.2.1.3 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.

2.2.1.4 Cooling capacity of 2TR AC units shall not be less than 22000btu/hr. and shall have energy efficiency rating of 3star or above.

2.2.2 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.

2.3 The Split AC units shall be of Carrier, Voltas, Blue Star, Hitachi, Daikin, LG, National, O'General or Samsung make.

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 24oC 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^{o}C due to any emergency condition, the standby air- conditioner shall also start running to maintain the temperature less than 24^{o}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 high 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.

CHAPTER-11

A. TRANSMISSION LINE TOWERS

1. General

One (1) no of lattice tower is required, One for Dead End Tower, supporting two single circuit i.e. Bardaghat-Sardi Double Circuit 132kV Transmission line under construction, double circuit for Dead End Tower to 132kV Gantry at Dumkibas, double circuit, bear conductor in 132kV Transmission Line at Dumkibas substation.

Details of specification for 132kV Tower

The towers shall be self-supporting, hot dip galvanized, latticed steel type & designed to carry the line conductors with necessary insulators, shield wires and all fittings under all loading conditions. Outline diagram of double circuit towers are enclosed with the Specification. Please refer to drawing attached.

2. Design Spans

The design shall provide for basic, wind and weight spans. The term basic span shall mean the horizontal distance between centers of the adjacent towers on ground level. The term wind span shall mean half the sum of adjacent horizontal spans lengths supported on any one support. The term weight span shall mean the equivalent length of the weight of conductor supported at any one support at maximum temperature in still air.

3. Conductor and OPGW Clearances

For all supports the clearances from conductors, arc horns, jumper loops and all live metal to the structure or grounded steel work. Where uplift condition occurs at tension tower positions, details should be provided to show that the above requirements are not infringed. The length of angle structure cross-arm shall be such as to ensure that the distances between conductors from straight-line structures are maintained in plain normal conductors. For 132 kV towers carrying deviation angles up to 30° cross arms shall generally be so proportioned that live metal clearances of 1600 mm are maintained under all conditions without the use of jumper suspension insulators. Jumper suspension insulator strings must be used on tension structures with deviation angle of 30° or more. However, for tension structures with deviation angle below 30°, suspension insulator strings should be used on locations where sufficient clearance of the jumpers is not available with the structure without any additional cost to the Employer.

Sr. No	Type of insulator string	Swing in deg.	Min. live metal clearance in mm Altitude upto (+)1000m
1	Single suspension insulator string	Nil	1530
		15	1530
		30	1370
		45	1220
		60	1070
2	Jumper(without Pilot String)	Nil	1530
		10	1530
		20	1220
		30	1070

The minimum ground clearances from the bottom conductor shall not be less than for the following Altitudes at the maximum Sag conditions i.e. at max. temperature and still air:

- 7100mm upto Altitude (+)1000m,

However, to achieve the above clearance the height of tower has been increased in the following manner:

a) An allowance of 500 mm shall be provided to account for errors in stringing.

b) Conductor creep shall be compensated by over tensioning the conductor at temperature of 21^{0}C lower than the stringing temperature for ACSR Bear.

Further, the tension for the earth wires and power conductors shall be so co-ordinated that the sag of earth wire shall be at least 20% less than that of power conductors under all temperature loading conditions. The phase distance: the minimum distance between testing point at insulators shall set as per standard practice at IEC or any other standards. Allowance shall be made for increasing or decreasing the length and varying the arrangement of all terminal tower cross arms to enable span connections to be made in any desire phase sequence.

Where obstructions of other types are met requiring special clearance, the clearance shall be approved by the Employer. If any factors likely to cause infringement of clearance become apparent the Contractor shall inform the Employer immediately.

Clearance between phases: The distance between conductors belonging to different circuits shall be 1.20 times the distance belonging to the same circuit. However, the distance shall not be less than 3.0 m.

4. Extensions

The towers for ACSR Bear Conductor lines shall be designed for adding +3m, +6m, +9m body extensions for maintaining adequate ground clearance without reducing the specified factor of safety in any manner. All above extension provisions to normal towers shall be treated as part of normal tower only. In order to expedite the project and to reduce leveling, grading and protection works in undulating terrain leg extension of some towers may be required subjected to the approval of Employer. Payment for these leg extensions will be done on weight basis based on unit rate quoted by the bidder.

5. Tower Design

5.1 Design Requirement

Towers shall be self-supporting type of vertical configuration and are designated as tension towers, or special towers. The requirement of transposition and special towers shall be assessed after finalization of the detailed survey, profiles etc. The proposed Double circuit suspension towers shall be provided with single suspension string single conductor and jumper pilot string and double suspension string of EMS rating as given in relevant clause.

The minimum ground clearance and height of bottom conductor, wind spans & weight span, design data are as indicated Schedule A.2, Schedule A.3, & Schedule A.4.
In case of certain locations where actual spotting spans exceed the design spans, cross arms and certain members of towers are required to be modified / reinforced, the bidder shall submit the proposal to Employer for approval for reinforcement. The contractor shall also design a special tower for LILO of one circuit at another substation.

5.2 Base Width of the Towers

In view of the restricted ROW of 18m narrow based towers are conceived for this Transmission Line so as to minimize the total cost of towers, foundations, benching, rock cutting/ revetment works, The base width of narrow based towers shall be fixed on techno-economic considerations as well to expedite the execution of project. The recommended base widths for different Towers (i.e. Centre to centre distance between tower legs at the point of connection between legs & chimney for normal ±0m body extension shall be as follows:

Type of towers	**Upto Altitude (+)1000m**	
	Minimum Values (meter)	**Maximum Values (meter)**
DA	5.4	6.0
DB	6.2	7.0
DC	7.2	8.0
DD/DE	8.2	9.0

As substantial portion of Transmission Line traverses through hilly area, the maximum and minimum weight span under Normal Condition and Broken Wire Condition for Angle Towers shall be based as per CBIP Publication No 323 Tower Manual.

5.3 Sag Tension

The sag tension calculation for conductor and earth wire shall be made in accordance with the relevant provision of IS 5613 (Part-2/Sec-I) -1985 of the following load conditions. Appropriate drag co-efficient and gust response factors (Corresponding to Terrain Cat-II) shall be considered for accounting the wind pressure.

Ref. Cl.No. 10.3 of IS802	**Towers u (DA1, DB1, DC1, DD1/DE1)**			
Condition I (Every day Temperature + 100% Wind load)	Condition	Temperature	Wind Load	Ice Load
	0	32°	100% (full)	Nil
Condition II (Minimum Temperature + 36% Wind load)	Condition	Temperature	Wind Load	Ice Load
	0	5°	36% (full)	Nil

Condition III (Temperature + Wind load +Ice Load) Refer Cl No-6.1 ice loads CBIP Publication No-323 Tower Manual

In addition all the standard conditions for Sag Tension calculation as per IS 802 and CBIP Manual shall be considered as per good Industries practice.

5.4 Preliminary design

The preliminary design of the towers including suspension and tension tower design shall be prepared at the start of the project which shall be sound in engineering and economical in design. The preliminary design shall consist of all the necessary item/ components required to complete the tower to be erected. This preliminary design shall be presented to the Employer with the line diagram for approval. Necessary changes, as per Employer shall be incorporated to the design by the Contractor if necessary, without additional financial implication, and should not affect the period of completion of the project. The line diagram which is approved by the Employer shall be released for detailed design and for preparation of shop drawing. This approval in any way does not make the Contractor free from its obligation to the safety of the structure Tower Loadings.

5.5 Wind Load

The Transmission line is traversing in wind Zone: 4 as per IS 802 and the corresponding wind velocity is 47 m/s. This wind speed is applicable upto height of 10m at every day temperature of 32 deg C corresponding to 3 second peak gust wind. As this transmission line is traversing plain terrain, terrain roughness factor, K2 =1.08, corresponding to terrain Cat-I shall be adopted. However the Gust Response factors corresponding to Terrain –II for conductors, earthwire, Tower and Insulator shall be adopted for accounting the wind pressure.
The above base wind speeds shall be applicable for Double circuit towers. The corresponding Design Wind Pressure on towers, conductors and insulators shall be obtained from the relation Pd=0.6V2 as follows:

	Reliability Level	1 (50 yrs return period)
	Risk Co-efficient (k1)	1.00
	Terrain Roughness Co-efficient (K2) (but Gust factors corresponding to terrain category –II shall be considered for conductors/earthwire, Tower and Insulator for	1.08
	Design Wind Speed (VR_dR)	47 m /sec

5.6 Seismic Consideration
The design of towers and foundations shall be checked for seismic forces under no wind conditions and coefficient of seismic load as per IS: 1893 and check their criticality considering minimum seismic Load magnitude of 0.5g vis-à-vis wind load designs.

5.7 Lightning Consideration

To protect the line and towers against lightning, the angle of shield for 132kV double circuit towers shall be 30^0.

5.8 Selection of Type of Towers

Type of Tower	Deviation Limit		Typical Use
DA	0 deg – 2 deg	a)	To be used on straight runs and upto 2^0 line
DB	2 deg - 15 deg	a) b)	Small Angle tower with tension insulator string. To be used for line deviation from 0 to 15 degree To be used as transposition of transmission line.
DC	15deg - 30 deg	a)	Medium angle tower with tension insulator string. To be used for line deviation from 15 to 30 degree
DD & DE1/DE2	30 deg – 60 deg	a) b) c)	Large angle and Dead End Tower with Tension Insulator String. To be used for line deviation from 30 to 60 degree Complete Dead End Dead End with 0 deg to 15 deg deviation both on line and substation side (slack span)

6. Loads on Towers

Loads shall be computed for the following considerations as per IS: 802 (Part I/ Sec1): latest & CBIP publication No: 323, Manual on Transmission Lines and technical specification

i) Classification of Loads
- Climatic Loads under Normal Condition (Reliability)
- Failure Containment Loads (Security Requirements)
- Construction and Maintenance Loads (Safety Requirements)

ii) Computation of Loads

- Transverse Loads comprising Reliability requirements, security requirements and safety requirement
- Vertical Loads comprising Reliability requirements, security requirements and safety requirement
- Longitudinal Loads comprising Reliability requirements, security requirements and safety requirement

iii) Wind Load on Tower
The wind load on towers shall be worked out by dividing the tower into different panels duly considering appropriate drag coefficient and gust response factors.

iv) Wind Load on Conductor/Ground Wire

The wind load on conductors and ground wire corresponding to wind loads at 100% design wind pressure at every day temperature or 36% wind pressure at minimum temperature shall be worked out on each Line conductor and ground wire considering the average height of conductor/ground wire up to clamping point on tower less 2/3 of conductor/ground wire sag at minimum temp and Nil wind pressure.

v) Wind Load on Insulator Strings

Wind load on insulator Strings corresponding to wind loads at 100% design wind pressure at every day temperature or 36% wind pressure at minimum temperature shall be determined from the attachment point to the centre line of the conductor in case of suspension towers and up to the end of clamp in case of tension towers in the direction of the wind for design wind pressure. 100% of the area in case of polymer insulator shall be adopted for working out the projected area of insulator string.

6.1 Loading Conditions

- Reliability Conditions
  - Transverse Loads
  - Vertical Loads
  - Longitudinal Loads
- Security Conditions
  - Transverse Loads
  - Vertical Loads
  - Longitudinal Loads
  - Narrow front wind load (for Suspension Towers only DA1, DA2)
- Safety Conditions
  - Transverse Loads
  - Vertical Loads
  - Longitudinal Loads

6.2 Specific Details of Loading under Safety Conditions

- **Transverse Loads**

  i) Wind loads to be considered as Nil
  ii) Mechanical tension at 32°C and Nil wind on account of line deviation shall be considered under Normal and Broken Wire Conditions

- **Vertical Loads**

  i) Load of 150kg to be considered acting at each cross-arm as a provision for weight of lineman with tools
  ii) Load of 350kg to be considered acting at the tip of Cross-arms
  iii) Erection load of 1000kg at each lifting point located a distance of 600mm from tip of cross-arm
  iv) All bracing and redundant members of the towers which are horizontal or inclined up to 15˚ from horizontal shall be designed to with stand an ultimate vertical loads of 150kg considered acting at centre independent of all other loads
  v) Loads due to weight of conductors / ground wire based on design weight span, weight of insulator strings and accessories. For broken wire condition where the load due to due to weight of conductor/ ground wire shall be considered as 60% of weight span.
  vi) Self weight of tower structure upto point / level under consideration

- **Longitudinal Loads**

These loads shall be taken as under:

i) **For normal conditions** – These loads for dead end towers shall be considered as corresponding to mechanical tension of conductor / ground wire at everyday temperature and no wind.

ii) **For broken wire conditions**

a) **Suspension Towers** – Longitudinal load per conductor and ground wire shall be considered as 1000 kg and 500 kg respectively.

b) **Tension Towers** - Longitudinal load equal to twice the sagging tension (sagging tension shall be taken as 50 percent of tension at everyday temperature and no wind) for wires under stringing and 1.5 times the sagging tension for all intact wires (stringing completed).

6.3 Broken wire criteria

Broken wire conditions as applicable to double circuit towers during the design of towers:

- **Suspension Tower (0^0 - 2^0) (DA)**

Any two phases broken on the same side and same span or anyone phase and one ground wire broken on the same side and same span whichever combination is more stringent for a particular member.

- **Small (0^0 -15^0) and Medium angle tension towers (15^0 -- 30^0) (DB, DC)**

Any two phases broken on the same side and same span or anyone phase and one ground wire broken on the same side and same span whichever combination is more stringent for a particular member.

- **Large angle tension towers (30^0-60^0) and dead end towers (DD, DE)**

Any three phase broken on the same side and same span or any two phases and one ground wire broken on the same side and same span whichever combination is more stringent for a particular member.

6.4 Anti-cascading checks

All Tension towers shall be checked for anti-cascading/sectional considerations with all conductors and ground wire intact only on one side of the tower

- **Transverse Loads**

These loads shall be taken under NIL wind condition.

- **Vertical Loads**

These loads shall be the sum of weight of conductor/ground wire as per weight span of intact conductor/ground wire, weight of insulator strings and accessories.

- **Longitudinal Load**

These loads shall be pull of conductor/ground wire at everyday temperature and NIL wind applied simultaneously at all points on one side with zero degree line deviation

6.5 Tension Limits

Line Conductor/ground wire tension at everyday temperature and without external load, should not exceed the following percentage of the ultimate tensile strength of the conductor:

o Initial unloaded tension 35%

o The final unloaded tension of conductors at every day temperature for Transmission line shall not exceed 22% of UTS of conductor and 20% of UTS of ground wire

Provided that the ultimate tension under everyday temperature and 100% design wind pressure, or minimum temperature and 36% design wind pressure does not exceed 50% of the ultimate tensile strength of the conductor/ground wire.

6.6 Strength Factors Related to Quality

The reduction in strength due to dimensional tolerance of the structural sections and yield strength of steel used, the following strength factors shall be considered:

i. If steel with minimum guaranteed yield strength is used for fabrication of tower, the estimated loads shall be increased by a factor of 1.02.
ii. If steel with minimum guaranteed yield strength is not used for fabrication of tower, the estimated loads shall be increased by a factor of 1.05. In addition to the provision (i) above.

6.7 Details of Structural Steel

Details of structural steel			
a)	Steel Quality		IS: 2062, BS: 4360
1.	Minimum guaranteed yield stress (kg/cm^2)	MS HT	2600 3600
2.	Maximum allowable stress (kg/cm2) for tension members (on net area)	MS HT	2600 3600
3.	For compression member (on gross area)	MS HT	As per IS:802 As per IS:802
b)	Details of nuts & bolts		
1.	Shear stress on shank of class 5.6 bolts (kg/cm^2)		3160
2.	Bearing stress on shank of class 5.6bolts (kg/cm2)	MS HT	4440 ,6322
3.	Tension on net area of the thread (kg/mm^2) Class 5.6		2590

6.8 Slenderness Ratio L/R

The Slenderness ratio (L/R) {Ratio of maximum un-braced or unsupported length (L) to the least radius of gyration (R)} of a member shall not exceed:

a. For Compression Members

Leg members, ground wire peak and cross arm chord members: 120
Bracing and other member having calculated stress: 200
Redundant or Secondary members without calculated stress: 250

In determining the slenderness ratios for various members' suitable provisions shall be taken into consideration for various types of end connections, eccentricity of load transfer in the members' effective length as per the CBIP Manual guideline Annexure-12 and 13.

b. For Tension Members
All tension Members : 400

6.9 Miscellaneous Design Criteria

a) Redundant Members

Redundant members, if placed at an angle less than 15^0, are required to be checked to withstand bending also due to mid-point concentrated load of 150kg independent of other loads

b) Bolted Joint

In case where the bolt and structural member are of different materials, the lowest of the ultimate strength of bolt and structural member governs the breaking strength of the joint.

c) Framing

The angle between any two members common to a joint of a trussed frame shall preferably be greater than 20^0 and never less than 15^0 due to un-certainty of stress distribution between two closely spaced members.

d) Gusset Plates

Minimum thickness of gusset shall be 2mm more than the lattice it connects only in case when the lattice is directly connected on the gusset outside the leg member. In no case gusset shall be less than 5mm in thickness

e) Minimum Thickness of Members

Leg Members : 5mm
Other Members : 4mm

f) Minimum size of members ISA 45X45X4 mm

g) Minimum width of flanges

Minimum flange width for bolts of different diameters are given as under:

Bolt Dia (mm)	16	20	24
Flange Width (mm)	45	50	60
Thickness of Spring Washers (mm)	3.5	4.0	4.5

The Loading trees for Reliability, Security, Safety conditions of all towers shall be prepared and ensure the proposed tower geometry satisfying all essential electrical clearances before design of the tower.

The unsupported length of stub between chimney and the last bracing connection to the leg should also be checked for combined direct and bending stresses and an additional cleat of required suitable size be provided. The supporting calculations shall also be provided. The design of stub & foundation cleats shall be designed as per the CBIP manual & ASCE 10-97, ASCE-52.

The structural assembly drawing should be prepared according to IS 696 and IS 962. The drawing shall show the complete design dimensions, member length, slope factors or triangles, section sizes, bend lines, gauge lines, diameter, length and number of bolts, spacers, washers, sizes of gusset plates, position of holes etc., and relative location of various members.

Sufficient number of elevation, cross section and plan view should be presented to clearly indicate the details of joints and arrangement of members.

All members should be clearly shown and respective identification mark allotted to each member. The drawing should be drawn to scale large enough to convey the information adequately.
All connection should be detailed to minimize eccentricity of connections. Due consideration should be given to the additional stresses introduced in the member on account of eccentricity of connection.

Dimension of all members and on a member the distances such as hole – to – hole, length, gauge distance etc., should be given in full integers and not in decimals.

6.10 Construction of Tower Steel work

Manjan

All designs shall be such that no trouble shall arise in service from vibration or excessive deflection due to the use of too light a section. The height of standard towers (+/- 0 body & +/- 0 legs) from ground level to the bottom cross arm shall be 19m for DA and 17m for all other type towers. Bolt holes shall not be more than 1.5 mm larger in diameter than the corresponding bolt diameter. The distance from the center of bolt holes to the edge of any steel section shall not be less than 1.5 times the diameter of the bolt. All tower member joints or joints between prefabricated panels to be made at Site shall be secured with bolts, nuts and washers. As far as conveniently possible, bolt heads, rather than nuts, shall be on the outer or upper faces of support joints. Structure cross-arms shall be so arranged that they can be disconnected from the body without disturbing main structure body members.

The conductor landing points on cross-arms shall be so arranged that an additional hole for the attachment of conductor erection and maintenance tackle is provided adjacent to each hole for tension shackles. It shall be possible to apply full conductor tension and weight safely to these additional attachment points.

Mild steel when stored in the fabricators stockyard prior to fabrication and galvanizing shall be marked continuously throughout its length with a light blue water paint line. In addition the grade number of the steel shall be painted on and ringed around with paint.

Members that are capable of being fitted in more than one position on the structure shall all be of the grade of steel suitable for the most onerous loading conditions.

6.10.1 Anti-climbing device

At a height of at least 3m from floor or normal ground level (whichever is the higher) an adjustable anti-climbing frame shall be fitted to all faces of each tower.

The device for tower shall also prevent climbing access inside the structure body.

At each climbing leg a suitable gate shall be provided to allow access by the Employers maintenance staff.

6.10.2 Step-bolts

Two diagonally opposite legs of all structures shall be equipped with galvanized step bolts (M16 x160mm) confirming IS:10238 on the leg at intervals not exceeding 380mm commencing immediately above the anti-climb device and extending to within one meter of OPGW. Step-bolt design shall be to the approval of the Employer or the Employer's Representative. Holes for removable step-bolts below the anti-climbing device shall be provided at no more than 380mm centers on the legs to which the permanent step-bolts are fitted.

6.10.3 Workmanship

All work shall be in accordance with the best modern practice in the manufacture and fabrication of materials covered by this specification. The Contractor shall be responsible for the correct fitting of all parts, shall replace free of cost any defective material discovered during erection and pay all costs of field corrections for such replacement. All parts of the structure shall be neatly finished and free from kinks, twists or bends. All holes shall be made with sharp tools and shall be clean cut without torn or ragged edge. The fabrication shall be in strict accordance with the shop drawings prepared by the Contractor and approved by the Employer or the Employer's Representative.

Structural materials shall be straight and cleaned of all rust and dirt before laid out or worked in any manner. Shearing and cutting shall be performed carefully. Manually guided cutting torches shall not be used.

All bolt holes in steel members shall be punched, sub-punched, reamed or drilled before galvanizing. Holes shall be drilled instead of being punched if the thickness of the metal exceeds the diameter of the hole. All holes shall be clean-cut and without torn or ragged edges. All holes shall be cylindrical and perpendicular to the member.

The diameter of the finished bolt hole shall not be greater than the normal diameter of the bolt plus 1.5mm. Plugging, welding or slotting of mispunched, misreamed or misdrilled holes will not be permitted. The holes shall be located accurately so that when the members are in position the holes will be lined up before being bolted.

6.10.4 Member fabrication-galvanising

All galvanizing shall be carried out by the hot dip process and shall conform in all respects with BS 729.

All surface defects in the steel including cracks surface laminations, laps and folds shall be removed in accordance with BS 4360/IS 2629/ IS 209/IS2633. All drilling, cutting, welding, forming and final, fabrications of unit members and assemblies shall be completed before the structures are galvanised. The surface of the steelwork to be galvanised shall be free from welding slag, paint, oil, grease and similar contaminants.

The preparation for galvanising and the galvanising itself shall not distort or adversely affect the mechanical properties of the material.

For all parts other than steel wires the coating shall consist of at least 610 grams of zinc per square meter of surface and be not less than 0.086mm in thickness for steel members thickness equals to or more than 5mm.

At least 460 grams of zinc per square meter and 0.065mm for thickness of members less than 5mm. On removal from the galvanising bath the resultant coating shall be smooth continuous free from gross surface imperfections such as bare, spits, lumps, blisters and inclusions of flux, ash or dross. During off loading and erection of supports the use of nylon or braided slings shall be used. Galvanized steel work which is to be stored in the works or on site shall be stacked so as to provide adequate ventilation to all surfaces to avoid wet storage staining.

Small areas of the galvanized coating damaged in any way shall be restored in accordance with the requirements of item 1.7 of General technical specifications.

Tests on samples shall be carried out to BS 729/IS 4759/IS6745/IS14394.

6.10.5 Bolts and nuts

No bolt of diameter less than 16mm shall be used. No screwed threads shall form part of shearing plane between members.

When in position all bolts or screwed rods shall project through the corresponding nuts by at least one full thread but such projection shall not exceed 10mm.

Bolts shall be galvanized after thread cutting to the same specified coating weight as specified in BS 729/IS1367/IS1368/IS12427 /IS14394

Spring washers shall confirm to IS3063 and pack & plain washers confirm IS6821. Nuts and heads of all bolts shall be hexagonal.

All bolts, nuts and washers shall be hot dip galvanised and subsequently centrifuged (according to BS 729). Nuts shall be tapped after galvanising and the threads oiled to permit the nuts to be finger turned on the bolt for the full depth of the nut.

All bolts supplied for this contract will be provided with one nut and one spring washer of approved design. Taper washers and packers are to be fitted where necessary.

After fixing, bolt heads, washers and nuts shall receive two coats of zinc rich paint. Only one type of bolt for the whole project, either mild steel or high tension steel will be permitted in order to prevent inadvertent misuse. The Contractor shall state clearly which type of bolt his designs are based upon.

The Contractor will instruct his supplier to select two samples of each type of bolt and nut to be used on the Contract and send these samples to the Employer or the Employer's Representative for approval within one month of the date of issuing the order. The Employer or the Employer's Representative will then reject bolt consignments, which in his opinion fall in any respect below the standard of samples submitted and approved.

6.10.6 Aeronautical Sign on Steel Towers

The Contractor shall paint the steel towers in the vicinity of airports or aviation route in accordance with the following stipulations:

Painting of steel towers shall be applied on all surfaces of steel members after erection works have been completed. No painting shall be done in cold, damp, foggy or dusty atmospheres or started when the weather forecast indicates such conditions for the day. Prior to painting, the Contractor shall submit a painting plan including the quality of paint and the division of painting for the approval of the Employer.

The color of the paint shall be yellowish-red and white alternately in strips from the top of the tower. Painting shall be applied in four coats including prime coat. The primer paint shall be zinc dust-zinc oxide/ metal primer.

6.10.7 Bird Guards

To prevent birds perching immediately above the suspension insulator string of suspension and/ or tension towers and fouling the same with dropping, suitable bird guards shall be provided at cross arm tips of all suspension towers. The bird guard arrangement shall be such that it shall either prevent bird from perching in position where they are liable to cause the damages or ensure that if birds do perch, dropping will fall clear of the insulator string.

6.10.8 Payment for Line Tower

Payment for the contract item, "Line tower" including any required painting, will be made at the unit bid price per tower type bid. For supply, the tower is divided into Basic body and Body extension. For Erection the unit price shall include all cost incurred in transportation and erection of a complete tower. Therefore, in the Price Schedule, the unit bid price shall include full compensation for all the costs incurred in furnishing all materials, equipment, labors and all other operational related to tower design, fabrication delivery etc. as specified.

6.11 Tower Earthing

6.11.1 General

In addition to the mechanical OPGW termination requirement, all steel towers shall be fitted with separate earth bonds for OPGW continuity and the Contractor shall provide all necessary connecting facilities. All the four legs of the tower shall be connected to the earth through electrode as shown in attached Drawing.

The footing resistance shall be measured by the Contractor and approved by the Employer or the Employer's Representative for every tower prior to the stringing of the OPGW. The maximum footing resistance to the general mass of earth shall be 10 Ohms.

Steel towers need not be fitted with a separate earth bond and earthing continuity throughout the support will therefore depend upon surface contact between members.

All towers shall be provided with means for connecting an additional earthing device as required by the Employer or the Employer's Representative. Holes are to be provided in all supports near ground level to take bolts for earth lead connections.

All legs of every tower shall be equipped with galvanized steel wire and cast into the foundation concrete to be readily available for the connection of additional earth electrodes in the event of the initial footing resistance exceeding 10 ohms. Bidder's rates for the structures shall include for such additional works.

Galvanized steel rods shall be driven where necessary in sufficient number to ensure the combined structure footing and earth electrode resistance does not exceed 10 Ohms. Where it is necessary to drive more than one earth electrode at any support, the locations shall be to the approval of the Employer or the Employer's Representative. All earth electrodes shall be electrically bonded together using galvanized steel wire.

The tops of all electrodes shall be at least 500 mm below the surface of the normal reinstated ground level.

Connection of earth wires to the structure stub-angles shall be by bolting. Bidders shall submit details of their proposals in this regard.

6.11.2 Payment for Grounding Materials

Payment for grounding materials shall be made at the unit price bid. Therefore, in the Price Schedule, the unit bid price shall include full compensation for all the costs incurred in furnishing all materials, equipment, labors and other operational related to the scope of work of earthing as specified. Each set shall mean one complete set for each tower footing.

6.12 Danger, Phase and Number Plate

6.12.1 General Requirement

All structures shall be equipped with a suitable framework mounted immediately above the anti-climb device level, to accommodate a danger plate and support- number plate in a conspicuous position. One plate is to be supplied for every tower, except for phase identification plates, which shall be supplied for angle towers only.

All terminal structures shall be equipped with additional frameworks, mounted immediately above the anti-climb device level, to accommodate a set of three phase color plates.

All plates shall be affixed to the framework by means of galvanized bolts, nuts and lockouts. Washers should be of such material and so positioned that damage to the enamel will be prevented. The height for fixing these accessories shall not be more than 4.5m above the ground level. The corners of the number, danger & circuit plate shall be rounded off to remove sharp edges. All plates shall be manufactured from mild steel sheet with vitreous enameled finish. The letters figures and the conventional skull and bones of danger plates shall conform to IS:2551-1963 and shall be in a signal red on the front of the plate. A detail drawing for such plates shall be prepared by Contractor subject to the Employer's approval.

Line color-coded vitreous enamel identification plates should be fitted to the climbing legs of every structure in accordance with line color code scheme to be supplied to the successful Bidder. Each plate shall be approximately 70mm wide and shall be applied one immediately below the anti-climb device, one halfway up the towers and one immediately below the lowest crossarm.

6.12.2 Payment for Plates

Payment for danger, phase and number plates shall be made in per kg weight similar to lattice tower at the unit price bid.

6.13 Final Design and Design Drawing

The detailed design shall be prepared in line with the approved line diagram, which shall be submitted to the Employer required number of copies.

The tower accessories drawings like name plate, danger plate, phase plate, anti-climbing device, step bolt, D-shackle etc. shall also be prepared by the Contractor and shall be submitted to the Employer required number of copies along with the soft copies in CD. These drawings shall be prepared in A4 size sheet only.

Once the design is approved, the approved design drawing shall be submitted to Employer in four copies, along with one soft copy. The overall responsibility of fabricating tower for its correctness lies with the Bidder only, and should ensure that all the tower members can be fitted without any undue strain on them.

6.13.1 Shop drawing

The shop drawings shall be prepared based on the approved design drawing. Shop drawing should contain complete information necessary for fabrication of the component parts of the structure.

These drawings should clearly show the member size, length and marks, hole positions, gauge lines, bend lines, edge distances, amount of chipping and notching etc.

For gusset fabrication, separate individual item wise template can be made to facilitate gusset fabrication as well as inspection. In case of member to be bent, shop drawing should indicate the provision for variation in length. At the design/ drawing stage itself, drawing should indicate that the degree of bend given in any member such that neither flange width nor thickness shall vary beyond permissible limits.

Items requiring steep bending may be cut and welded as per approved welding procedure.

At the time of proto stage/ tower testing itself specific bend gauge and template to locate the holes after bending must be established for the items to be bent.

6.13.2 Bill of Material

Bill of material for of tower and extensions required should be prepared separately. This should indicate grade of steel (like high tensile steel , mild steel etc.), mark numbers, section sizes, member's lengths, their calculated weights, type & number of bolts, nuts and washer and their sizes, total quantities and structural drawing members.

Marking

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

A-BB-CC-DDD

A	=	NEA's code assigned to the Bidder –Alphabet
BB	=	Bidder's Mark-Numerical
CC	=	Tower type-Alphabet
DDD	=	Number mark to be assigned by Bidder-Numerical.
HT	=	High Tensile steel

6.13.3 Shop Erection/Proto type Tower Assembly

Steel work should be temporarily erected in horizontal or vertical so that accuracy of the member can be checked before testing the towers or commencing mass fabrication as applicable. The proto assembly is done on the basis of approved structural shop drawings of towers, all body extensions, stubs & templates for all types of towers.

6.14 Testing of Towers

6.14.1 General

Testing of tower generally serves as guide to good tower design and therefore shall not be considered as requisite proof test for all towers. The test shall be conducted on full scale prototype galvanized tower as per the approved loading schedules and rigging diagram. The members constituting the prototype shall be of same grade of steel as specified in the design and fabrication shall conform to the provision stipulated in IS 802 (Part – II). The tower shall be tested on rigid foundation. The test tower shall successfully withstand the ultimate loads specified for various conditions.

6.14.2 Leg Anchorage

The tower shall be erected vertically on rigid foundation with as much unbraced portion of the stub protruding above ground level as provided in the drawing.

6.14.3 Calibration of Measuring Instruments

All measuring instruments shall be calibrated in a systemic manner with the help of standard weights. The calibration shall, before commencing the test on each tower, be done upto the maximum anticipated load to be applied during testing. Calibration curves for the instrument to be used during testing shall be drawn by the testing authorities and the test loads shall be suitably corrected with the help of these curves.

Calibration of load cells shall be done with Universal Testing Machine (UTM) or by using standard weights. The UTM in turn shall be calibrated once in every six months or periodically as per advice of the supplier of UTM.

6.14.4 Types of Tests

- o Bolt-Slip Test
- o Load Tests

  Reliability Condition (Normal Condition)
  Security and Safety Conditions as well as Anti-Cascade Conditions
  Broken Wire Condition
- o Destruction Test including Material test after Destruction Test

6.14.5 Method of Load Application

Load shall be applied according to approved rigging diagram through normal wire attachments, angles, or bent [plates. U bolt/ D shackle or swinging brackets (hangers) may be used in the test tower if desired by the Employer, provided that satisfactory and safe rigging is attained.
The various type of loads, transverse, vertical and longitudinal shall be applied in such a way that there is no impact loading on the tower due to jerk from the winches.
Loading cases (values, direction and points of application of loads) shall be determined by the Bidder and get approved form the Employer before applying to the test towers.

6.14.6 Loads and Deflection Measurement

All loads shall be measured through a suitable arrangement of strain devices or by using weights. Positioning of strain devices shall be such that the effect of pulley friction is eliminated. In case the pulley friction cannot be avoided the same shall be measured by means of standard weight and accounted for in the test loads.
Tower deflection under loads shall be measured by suitable procedure at the top cross arm level on the front side of the transverse and longitudinal faces or front and rear side of the transverse faces. Deflection reading shall be recorded for the 'before load', ' load on' and 'load off' conditions.

6.14.7 Testing Procedure

Bolt slip test – In bolt slip test, the test loads upto 50% of Ultimate Normal Condition (Reliability Condition) Loads are gradually applied and kept constant for 1 minute at these loads and then the loads are released gradually.
The initial and final reading on the scale before application and after the release of loads respectively shall be taken with the help of theodolite. The difference between these readings gives the value of the bolt slip.
Normal load/ broken wire load tests – All loads shall be applied gradually upto the ultimate design loads in the following steps and shall be released in the similar manner:

25%
50%
75%
90%
95%
100%

6.14.8 Observation Periods

Under normal and broken wire load tests, the tower shall be kept under observation for sign of failure for one minute (excluding the time for adjustment of loads) for all intermediate steps of loading up to and including 95 % of ultimate design loads.
For normal as well as broken wire tests, the tower shall be kept under observation for five minutes after it is loaded up to 100 percent ultimate loads.
While the loading operations are in progress, the tower shall be constantly watched, and is it shows any tendency of failure anywhere, the loading shall be immediately stopped, released and then the entire tower shall be inspected. The reloading shall be started only after the corrective measures are taken.

6.14.9 Recording

The deflection of the tower shall be recorded at each intermediate and final stage of normal loads/ broken wire load test by means of a theodolite and graduated scale.

6.14.10 Destruction Test

If the Employer desired so, destruction test for the tower shall be carried out.
Destruction test shall be carried out under normal condition or broken wire condition as agreed between the Employer and the Bidder.
All the provision of the specification and IS 802 for normal broken wire conditions shall be applicable to destruction tests of Double circuit towers during the design of towers.

6.15 Material Quality Control

Various grade of steel used in tower, details of sections, bolts and nuts and other accessories need a detailed scrutiny and quality control procedure before being processed for fabrication, assembly etc. All structural material including nuts and bolts shall be in compliance with their respective Indian Standards.

Chemical composition and mechanical properties of various grade of steel used shall be clearly mentioned and those shall be in accordance with relevant IS or international standards.

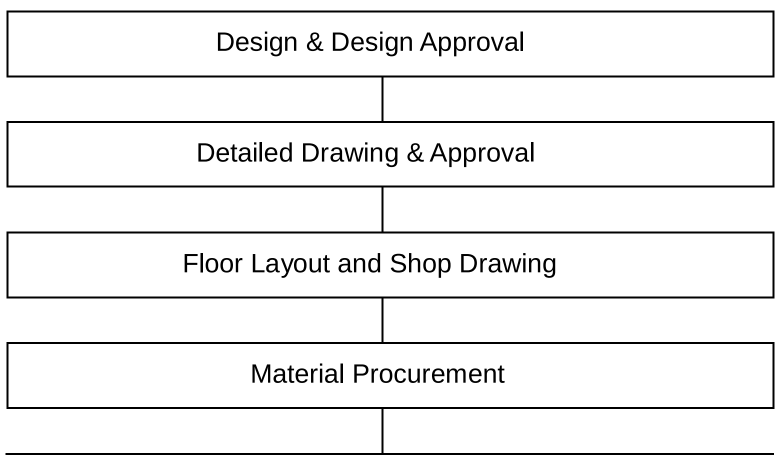
Steel Sections of tested quality in conformity with IS: 2062 (Designated Yield Strength. 250 MPa) and/ or IS: 8500 grade 490 (Designated Yield Strength 350 MPa) are to be used in towers, extensions, stubs and stub setting templates. The Contractor can use other equivalent grade of structural steel angle sections and plates conforming to latest International Standards. However, use of steel grade having designated yield strength more than that of EN 10025 grade S355 JR/JO (designated yield strength 355 MPa) is not permitted, unless otherwise indicated in this specification.

For designing of towers, preferably rationalized steel sections shall be used. During execution of the project, if any particular section is not available, the same shall be substituted by higher section. Any cost on account ofthe same shall be borne by the Bidder. However, design approval for such substitution shall be obtained from the Employer before any substitution and records of such substitutions shall be maintained by the Bidder.

At the time of procurement of steel other than that conforming to IS 2062, green colour on the edge of HT material on both sides is applied so that there is no mix up of MS and HT steel in stockyard as well as in shop. A distinct green colour patch is maintained throughout and on shop sketch also, HT marking is added for identifying high tensile steel item.

6.16 Process Flow Chart for Fabrication of Towers

In general following flow chart shall be followed for design, assembly, testing and supply of towers:



Proto Manufacture

Assembly of Tower

Proto Test and Approval

Mass Fabrication

Marking

Galvanising

Bundling

Dispatch

6.17 Packing

Angle section shall be wire bundled. Cleat angles, gusset plates, brackets, fillet plate, hanger and similar loose pieces shall be tied and bolted together in multiples or securely wired through holes. Bolts, nuts washers and other attachments shall be packed in double gunny bags accurately tagged in accordance with the contents. The packing shall be properly done to avoid losses & damages during transit. Each bundle or package shall be appropriately marked.

6.18 Standards

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

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

Sl. No.	Indian Standards (IS) Standards / Guides	Title	Internationally recognized
1.	IS: 209-1992	Specification for Zinc	ISO/R/752 ASTM B6
2.	IS: 278-1991	Galvanized Steel Barbed wire	ASTM A131
3.	IS: 800-2007	Code of Practice for General Building Construction in Steel	CSA 6.1
4. (a)	IS: 802(Part1) Sec 1-1995	Code of Practice for General	ASCE 52
		Building Construction in Steel Sec 2-1992 in Overhead Transmission Line Towers: Materials, loads and Permissible Stresses	IEC 826 BS 8100
		Section 1 Materials and loads	
		Section 2 Permissible stresses.	
4. (b)	IS: 802-1990 (Part 2)	Code of practice for use of structural steel in over-head Transmission Line : Fabrication, Galvanizing, Inspection and Packing	
4. (c)	IS: 802-1990 (Part 3)	Code of practice for use of Structural Steel in over-load Transmission Line Towers Testing	ASCE 52 IEC 652
5.	IS: 808-1991	Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections.	
6.	IS: 875-1992	Code of Practice for Design Loads (other than Earthquakes) for Buildings and Structures.	
7.	IS: 1363-1990	IS: 1363-1990 Hexagon Nuts(size range M5 to M36)	
8.	IS: 1367-1992	Technical Supply Conditions for Threaded Steel/ Fasteners	
9.	IS: 1477-1990	Code of practice for Painting of Ferrous Metals in Buildings:	
		Part-I Pre-treatment	
		Part-II Painting	

Sl. No.	Indian Standards (IS) Standards / Guides	Title	Internationally recognized

10.	IS: 1573-1991	Electro-Plated Coatings of zinc on iron and Steel	
11.	IS: 1852-1993	Rolling and Cutting Tolerances of Hot Rolled Steel Products	
12.	IS-1893-1991	Criteria for Earthquake Resistant Design of Structures	IEEE 693
13.	IS: 2016-1992	Plain Washers ISO/R887	ANSIB18-22.1
14.	IS: 2062-1992	Steel for general structural purposes	
15.	IS: 2074-1992	Ready Mixed Paint. Air Drying, Red Oxide, Zinc Chrome, Priming Specification.	
16.	IS: 2551-1990	Danger Notice Plates	
17.	IS: 2629-1990	Recommended Practice for Hot Dip Galvanizing of iron and steel.	
18.	IS: 2633-1992	Method of Testing Uniformity of Coating of Zinc Coated Articles	ASTM A123 CSA G164
19.	IS: 3043-1991	Code of Practice for Earthing	
20.	IS: 3063-1994	Single coil Rectangular section Spring Washers for Bolts, Nuts Screws	DIN-127
21.	IS: 3757-1992	High Strength Structural Bolts	
22.	IS: 4759-1990	Specification for Hot zinc coatings on structural steel and other Allied products	
23.	IS: 5369-1991	General Requirements for Plain Washers	
24.	IS: 5613-1993	Code of Practice for Design installation and Maintenanceof Overhead Power Lines	
		Section 1 Design Part 2,	
		Section 2 Installation and Maintenance	
25.	IS: 6610-1991	Specification for Heavy Washers for Steel structures.	

Sl. No.	Indian Standards (IS) Standards / Guides	Title	Internationally recognized
26.	IS: 6623-1992	High Strength Structural Nuts	
27.	IS: 6639-1990	Hexagon Bolts for Steel Structure.	ASTM A394 CSA B334
28.	IS: 6745-1990	Method for Determination of weight of Zinc coated iron and Steel Articles.	ASTM A90
29.	IS: 8500-1992	Specification for Weldable Structural Steel (Medium & High Strength Qualities)	
30.	IS: 10238-1989	Step Bolts for Steel Structures	
31.	IS: 12427-1988	Bolts for Transmission Line Towers	
32.	IS:4091-1979	Code of practice for design and construction of foundation for transmission line between tower & poles.	
33.	IS:5358	Specification for hot dip galvanized coating and fastners	
34.	IS: 7215-1992	Specification for tolerance for fabrication of steel structures	

7. TOWER TECHNICAL SCHEDULE

1 Schedule A.1

System and Line Data

ITEM 1.	**DESCRIPTION System & Tower Data**	**UNIT** For 132kv Line	
1.1	System Nominal Voltage	kV	132
1.2	System Maximum Voltage	kV	145
1.3	System Nominal frequency	Hz	50
1.4	Special Dead End Tower	Nos	1
1.4	Line Conductor		ACSR - BEAR
1.4	Ground Wire		OPGW
2	**System & Tower Data**	For 33kv	sub transmission Line
2.1	System Nominal Voltage	kV	33
2.2	System Maximum Voltage	kV	36
2.3	System Nominal frequency	Hz	50
2.4	Special Dead End Tower	Nos	2
2.4	Line Conductor		ACSR - wolf

2 Schedule A.2

Design Data

ITEM 1.	**DESCRIPTION Temperature**	**UNIT**	**DATA**
1.1	Maximum ambient temperature	^0C	32
1.2	Minimum ambient temperature	^0C	0
1.3	Maximum temperature of conductor	^0C	85
1.4	Everyday temperature of conductor	^0C	32

Wind Load

ITEM	**DESCRIPTION**	**UNIT**	**DATA**
1.	**Temperature**		
1.1	Design Wind Speed (Vd)	m/s	47 (Wind Zone:4 as per IS:802)
1.2	Reliability Level		1 (50 yrs

		return period)
1.3	Risk Co-efficient (k1)	1
1.4	Terrain Roughness Co-efficient (K2)	1.08
But Gust factors corresponding to terrain category –II shall be considered for conductors/earthwire, Tower and Insulator for arriving the wind load.		
The corresponding Design Wind Pressure on towers, conductors and insulators shall be obtained from the relation $Pd=0.6V^2$.		

3 Schedule A.3

Minimum clearances

The followings are the minimum clearances between live conductors and other objects, which correspond to the maximum conductor sag conditions at different altitude zones.

ITEM	DESCRIPTION	MINIMUM CLEARANCES (IN METER) IN NORMAL CONDITION Altitude ≤ 1,000m
1	System Voltage, Kv	**132**
1.1	Normal ground for pedestrians only	7.1
2	System Voltage	
2.1	Ground clearance for River and other areas	6.5

For other objects not listed in the Schedule the requirements for minimum clearances shall comply also with NESC (NATIONAL ELECTRIC SAFETY CODE).

Approximately 0.5m shall be added to the clearance values above to allow for survey and drawings errors.

Crossing of houses, huts and other objects with soft roofing is not allowed.

4 Schedule A.4

TOWER TYPES

Type of Tower	Deviation limit	Typical use
DA	a) 0 deg.-2 deg.	To be used as tangent tower.
DB	a) 2 deg.-15 deg.	a.1) Tension towers with tension insulators string.
		a.2) Tension towers for uplift forces corresponding to normal and broken wire weight spans.
		a.3) Also to be designed for anti-cascading condition.
	b) 0 deg.	b.1) To be used as SectionTower
DC	a) 15 deg.-30 deg.	a.1) Tension towers with tension insulators string.
		a.2) Tension towers for uplift forces corresponding to normal and broken wire weight spans..
		a.3) Also to be designed for anti-cascading condition.
DD	a) 30 deg.-60 deg.	a.1) Tension towers with tension insulators string.
		a.2) Tension towers for uplift forces corresponding to normal and broken wire weight spans.
		a.3) Dead end with 0 deg. To 15 deg. deviation both on line and substation side (slack span).
SDD	b) 60 deg.-90 deg.	a.1) Tension towers with tension insulators string.
		a.2) Tension towers for uplift forces corresponding to normal and broken wire weight spans.
		a.3) Dead end with 0 deg. To 15 deg. deviation both on line and substation side (slack span).

2.	DESIGN SPANS			WEIGHT SPAN (m)			
ITEM	TOWER TYPE DOUBLE CIRCUIT	BASIC SPAN (m)	WIND SPAN (m)	Normal Condition (Maximum)	Normal Condition (Minimum)	Broken Wire Condition (Maximum)	Broke Wire Condition (Minimum)
2.1	DA	350	350	488	208	192	104
2.2	DAL	700	900	960	-960	576	-576
2.3	DB	350	350	960	-960	576	-576
2.4	DC	350	350	960	-960	576	-576
2.5	SDD/DDE	350	350	960	-960	576	-576

5 Schedule A.5

FACTOR OF SAFETY

ITEM	DESCRIPTION	MINIMUM FACTOR OF SAFETY
1.	Tower Foundations	
1.1	All types of suspension(DA) and small angle(DB) towers	1.1
1.2	All types of other tension towers (DC, DD, DE)	1.2
2.	Conductors and Insulators	
2.1	Conductors based on ultimate tensile strength	2.5
2.2	Conductors based on ultimate tensile strength at still air every –day temperatures	4.5
2.3	Compete insulator strings and fittings on minimum breaking load of insulator	3.3
2.4	Dead end compression clamps and compression splices based on conductor ultimate tensile strength	0.95
3.	Ground Wires	
3.1	Ground wire based on earth wire ultimate tensile strength	2.5
3.2	Ground wire at still air everyday temperature based on earth wire ultimate tensile strength	5.0
3.3	Complete tension assembly at ground wire maximum working tension	4.0
3.4	Complete suspension assembly at maximum vertical	4.0

6 Schedule A.6

TOWER PARTICULARS

ITEM	DESCRIPTION	UNIT	MINIMUM VALUES
1.	Unit Stresses		
	The quality of steel used for support members and bolts		
1.1	Structural Mild Steel:		
1.1.1	Structural Members		
	i. Tension based on net sectional area	kg/cm^2	2600
	ii. Axial compression based on gross sectional area	kg/cm^2	As per IS:802
1.1.2	Connection bolts		
	i. Shear on gross area (Class 5.6)	kg/cm^2	3160
	ii. Bearing (on Mild Steel) (Class 5.6)	kg/cm^2	4440
	iii. Tension on net area of threaded portion (Class 5.6)	kg/cm^2	2590
2	Slenderness Ratios (L/R)		
	The slenderness ratio of unsupported length of steel compression members to their least radius of gyration.		
2.1	Main members	NA	120
2.2	Braces	NA	200
2.3	Redundant members	NA	250
2.4	Members loaded in tension only	NA	400

7 Schedule A.7

TOWER MEMBERS PARTICULARS

The minimum thickness and diameter of material used in members and bolts shall be as follows:

ITEM	DESCRIPTION	UNIT	MAXIMUM VALUES
1.	Calculated members	mm	45x45x4
2.	Redundant members	mm	45x45x4
3.	Thickness of legs, members in crossarms and in ground wire peaks	mm	6
4.	Diameter of bolts for member carrying stress	mm	16
5.	Diameter of bolts for redundant members without calculated stress	mm	16
6.	Gusset plates	mm	6
7.	Stub angles	mm	8

B. CIVIL WORKS FOR TOWER FOUNDATION

1. General

The Contractor shall furnish all materials, equipment and labour and perform all operations required for the design and construction of all of the concrete foundations as shown on the drawings and other relevant civil works, as specified herein and as evidently necessary to complete the work. Before start of design of foundation, successful bidder shall carry out geotechnical investigation during detailed/check survey of Transmission Line route primarily consists of laying trial bore- holes (normally up to10 meter and 30 meter below natural ground level) at the required tower locations or as directed by the Employer to have a fair idea of soil type/nature and subsoil water position. If the soil characteristics are changing rapidly or soil up to 10.0 meter is very weak, the depth of bore-hole be increased beyond 10.0 meters so as to know the soil properties/type below the foundation. The bore log data containing information such as position of sub-soil water table, soil strata, the crop pattern in the agricultural fields where the foundation is to be laid and the suitability for founding the required foundation, shall be submitted to the Employer for according approval for "Classification of foundation" at each location.

2. Foundation Design

2.1 General

The foundation for tower structure plays an important role in the safety and satisfactory performance of the structure as it transmits the load from the structure to the soil. Therefore, the foundation shall be so designed to carry the entire load as required, with sufficient factor of safety as recommended by the Code of practices.

The foundation in various types of soils shall be designed to suit the soil conditions of particular type, from the recommendation of the geotechnical investigation report, which has to be approved by the Employer.

Several types of foundations are used for different type of transmission towers and different types of soil. The foundation should be strong and stable, and able to take care of all the loads like dead load, live load, wind loads, seismic load, erection loads etc., causing vertical thrust, uplift as well as horizontal reaction.

The quantity of foundations in every type given in the Price Schedule is provisional only and may vary as per the result of the detail soil test.

Foundations should be designed for a working life of 50 years and Bidders should comply in full with the requirements of these specifications in establishing his design. In all locations, all steelwork, whether part of the tower or part of the stub-angle foundations shall be completely encased in concrete to ensure a cover of 100mm from any part of the stub leg or tower from a point 300 mm above ground down to the base of the main foundation block. All Stubs shall have cleats designed to carry the entire stub load.

The Contractor shall design at least one foundation for each of the foundation types specified on the bid drawings for all types of towers used in the line to produce an economical family drawings and calculation for the approval of the Employer or Employer's representative before commencement of construction. Upon completion of detail soil test, the Contractor shall select the most economical foundation subject to the approval of the Employer or Employer's representative. The general foundation design parameters are given in Schedule A. 13 and Conceptual Drawing is given in Dwg. section.

2.2 Submittal

The Contractor shall submit for each type of foundation one set of design calculations, detail drawings and reinforcing steel and concrete schedules to the Employer or Employer's representative for review and comment before construction commences. Review of the foundation designs by the Employer or Employer's representative in no way relieves the Contractor from his responsibility for an adequate foundation design, even though this specification sets forth the basic foundation design criteria. Upon receiving the Employer's or Employer's representative's comments, the Contractor shall submit to the Employer required number of sets, electronic copy and prints of drawings of all foundation details, including reinforcing steel schedules on drawing sheet sizes, form, heading, etc., as required by the Employer for record.

2.3 Structural Design of Foundation

It comprises the design of chimney and the design of base slab / pyramid / block. Structure design of chimney shall be suitable for maximum bending moments due to side thrust in transverse and longitudinal directions combined with uplift (tension), down thrust (compression). The combined uplift and bending shall determine the requirement of longitudinal reinforcement in the chimney. The stub angle shall be embedded in the chimney to its full depth and anchored to the bottom slab / pyramid. The chimney shall be designed considering the passive resistance of soil leaving 500mm from ground level.

Design of foundation based on stub embedded in the chimney for required development length alone and the same is not taken to bottom of the foundation, is not permitted.

a) Structural Design of Base Slab

The base slab in RCC foundation may be single stepped or uniform. The design of concrete foundation shall be done as per Limit – state method of design given in IS: 456.

b) Criteria for Structural Design of Foundation

(a) Isolated identical footings shall be provided for each leg of the tower.

(b) All foundations shall be designed so as to satisfy and meet the following requirements:

i) The chimney of the foundation shall at least be 400 mm square providing a minimum clear concrete cover of not less than 100 mm over any part of the stub angle in case of dry foundations and at least 450 mm square with minimum clear concrete cover of not less than 150 mm over any part of the stub angle in case wet, fully submerged foundations.

ii) The chimney top shall extend 500 mm (Minimum) above ground level and coping shall be up to 50 mm below the joint between the bottom bracing and the leg members.

iii) In all foundations, a lean concrete sub-base having a thickness of 100 mm and of size equal the concrete pyramid base/RCC shall be provided under structural concrete. The lean concrete shall be of grade M-10 (1:3:6) conforming to IS: 456-2000. The lean concrete sub-base provided under the footings shall not be considered in the structural calculations.

iv) The embedded end of the stub angle shall have a 150 mm thick clear concrete cover up to the top of the lean concrete sub-base in the case of dry foundations and a 200 mm thick clear concrete cover in the case of wet, partially submerged and fully submerged foundations.

v) The depth of foundation below ground level shall not be more than 3.0m.

vi) The centroidal axis of the stub shall coincide with axis of the chimney and pass through the Centre of the footing base. The design of the foundation shall take into account the additional forces resulting from eccentricity introduced due to non- compliance of above requirements.

vii) Wherever reinforcement is provided in foundation, the clear concrete cover to reinforcement shall not be less than 50 mm.

viii) The slab type isolated RCC foundations shall also satisfy and meet the following requirements:

- The structural design of foundations shall be strictly in accordance with IS: 456-2000 and other relevant IS codes.
- The design of RCC foundations shall be carried out by Limit state method in accordance with IS:456-2000.
- The minimum thickness of footing slab at chimney perimeter shall not be less than 300 mm.

- The minimum thickness of footing slab at the edges shall not be less than 150 mm as specified in IS:456-2000.
- In the design of the footing slabs, actual soil pressure under the footing shall be considered to calculate the maximum moments and shears at various sections. The critical sections for moments and shears shall be as specified in IS: 456-2000.

2.4 Design loads.

The reinforcement in the footings shall be accordingly calculated and provided. The loads used to design the foundations shall be actual loads applied to the foundations by the towers. The foundations shall be designed in such a manner that the factors of safety shall not be less than the following requirements:

2.5 Types of loads on foundations

The foundation may be subjected to three types of forces (ultimate loads):

- o Compression or downward thrust
- o Tension or uplift, and
- o Lateral force or side thrust in both transverse and longitudinal directions.

The magnitudes of each of type of load depend on the type of tower and configuration of the transmission lines.

Partial Factors of safety for foundation design

a) Towers upto an angle of 15 deg deviation
b) Towers above an angle of 15 deg deviation

1.1

Weight of concrete (kg/m^3)		Dry	Wet, PS and FS
1.	Plain (M10)	2240	1240
2.	RCC (M15)	2400	1400
3.	RCC (M20)	2400	1400

S.N	Type of Soil	Angle of Earth Frustum. (deg)	Unit weight of soil (kg/ m3)	Limit Bearing Capacity (kg/cm2)
1	Normal Dry Soil			
	Without Under-cut	30	1440	25,000
2.	wet soil due to presence of sub soil water / surface water	15	940	12,500
3.	Black Cotton soil			
	(a) in dry portion	0	1440	12,500
	(b) in wet portion	0	940	12,500
4.	Sandy soil			

	(a) with clay content 0-5%	10	1440	25,000
	(b) with clay content 5-10%	20	1440	25,000
5.	Fissured Rock / Soft Rock (b) In wet portion	10	940	62,500
6.	Hard Rock	-	-	1,25,000

Unless specified otherwise, design and details shall comply with the latest published editions of BS/IS 6403, IS456, IS 1786, CBIP Tower manual or with other standard specifications provided they are of equal or higher standard where such standard exists with accepted national or international good practice. Support foundation designs as detailed in the specification which in the opinion of the Employer or Employer's representative do not demonstrate an acceptable type of foundation for the type of soil condition so described will be rejected.

2.6 Foundation type

In some section of the proposed transmission line, water level of terrain is high. In such cases the foundation is to be designed for fully submerged condition. If required by the Employer, the Contractor shall construct embankments for tower sites where footings are located in standing water of sloughs, pot holes and marshes. No separate payments shall be made for such embankments. Reinforced cement concrete footing shall be used for all types of normal towers / extension towers in conformity with the present day practices followed in the country and the specifications laid herein. All the four footings of the tower and their extensions, if any shall be similar irrespective of down thrust and uplift.

Foundation includes supply of materials such as cement, fine and coarse aggregates, water, reinforcement steel and binding wire etc. Rates quoted for foundations shall include all items of work relating to supply and installation of foundations such as form work, excavation and back filing with good soil, compaction, stub setting, shoring & timbering etc. where ever required, placing of reinforcement in position, concreting and all other works related for completion of foundation.

2.7 Classification of Foundations

General Classification of Foundations

The foundation classification shall depend upon the type of soil, subsoil water level and the presence of surface water which have been classified as follows:

a) Dry Soil Foundation

To be used for locations

- o where normal dry cohesive soil is met.
- o where cohesion less pure sand or negligible cohesion sand mixed with soil are met in dry condition and The water table is below foundation base

b) Wet Soil Foundation

To be used for locations:

- o Where subsoil water table is met at 1.5 m. or more below the ground level.
- o Which are in surface water for long periods with water penetration not exceeding one meter below the ground level e.g. the paddy field.
- o When the top layer of soil upto 1.5 m is black cotton/loose silty sandy soil and there after it is normal dry cohesive soil.

c) Fully Submerged Foundation

To be used at locations

- o where sub - soil water table is met at less than 0.75 m below the ground level and the soil is normal and cohesive.

- o To be used at locations where soil is cohesive having inorganic clay exceeding 15%, not necessarily black in colour, which shrinks when dry and swells when wet, resulting in differential movement. For designing foundations, for such locations, the soil is to be considered submerged in nature.

- o Fully submerged top layer consists of partly black cotton/ loose silty sandy soil followed by ordinary fine grained soil strata.

d) Wet Fissured Rock Foundation

In places, where soft rock, the decomposed or fissured rock, hard gravel, kankar, limestone, laterite or any other hard soil strata , which can be excavated using normal tools without blasting and the water table is met at 1.5 meter or more below ground level.
In case the undercut type foundation is to be used for fissured rock locations.The additional strength obtainable from under cut provision will not be considered in the design of foundation.

e) Hard Rock Foundation

The locations where chiseling, drilling and blasting is required for excavation, hard rock type foundations are to be used. For these locations, rock anchoring by providing anchor bars embedded into the grouted anchor holes to resist uplift forces. For design purpose, rock level shall be considered at ground level and no over burden soil weight shall be considered for resisting the uplift. In case of weathered rock / out crop rock, the first half meter rock from the surface will not be considered for design purpose.
In addition to the above, depending on the site conditions other types of foundations shall also be provided by the Bidder, suitable for intermediate conditions under the above classifications to affect more economy.

2.8 Footings

2.8.1 Concrete spread footing

The foundation shall be designed to carry maximum shear loads below ground level, that is, the stub legs are not to be considered as reinforcement. Allowance shall be made for the loss of uplift resistance due to overlap of frusta where applicable. Uplift foundations shall be cast against undisturbed soil for a minimum height of 250mm and 50mm lean concrete.
For the purpose of bidding the Bidder shall design each type of foundation with the value of soil bearing capacity as stated in Foundation Application Schedule.
These are only reference values and are taken from similar type of soil location from nearby site. After award of contract the Contractor shall carry out detail soil test of support site and shall design each type of support foundation accordingly. No extra payment will be made for change in the quantity of concrete/rebar and other associated works due to change in design parameters.

2.8.2 Pile Foundation

This type of foundation is usually adopted when soil is very weak and has very poor bearing capacity or foundation has to be located in filled up soil or tower are to be erected in the land which is prone to flash flood. Piles are long and slender members which transfer load to the deeper soil or rock of high bearing capacity avoiding the shallow soil of low bearing capacity.
The piles should be cast in place fast setting concrete which should have 28 day cubical compressive strength of 210 kg/sq.cm.
The pile should be designed for the pile diameter of 900mm. Piles in a footing should be firmly connected by horizontal tie beam of minimum 900x900mm sizes with adequate reinforcement which should be 1.5m above the existing ground level. All arrangement for anchor plate (or any

other arrangement) with anchor bolts etc whichever is appropriate for the connection of the tower legs to the foundation shall be in the scope of the pile foundation.

2.8.3 Spread foundation in hard rock

The rock which cannot be excavated using normal tools and require chiseling, drilling and blasting are classified as hard rock. These include hard sand stone, quartzite, granite, basalt, marble etc. The foundation in hard rock shall be designed to carry maximum shear loads below ground level, that is, the stub legs are not to be considered as reinforcement. Allowance shall be made for the loss of uplift resistance due to overlap of frusta where applicable. The footing should be safe against overturning. In case if it is unsafe against overturning, appropriate measures (e.g. counter weight) should be provided.

2.9 Stub Angle Anchor

2.9.1 Stub Angle

Tower Stub angles shall be of galvanized steel and shall have cross-sectional area of not less than the structure leg member to which it will be attached. The stub angle shall not be included in the calculation of the steel reinforcement requirements against bending and tension forces in concrete foundation design.
Only those holes in the stub which have been previously punched and galvanized at the manufactures works will be used for the attachment of cleats. Site drilling will not be permitted.

2.9.2S tub setting template

Stub setting templates, to approval of Employer or Employer's representative, shall be provided by the Contractor. They shall be of such design and construction as to resist distortion and damage and withstand repetitive use. They shall be manufactured from mild steel angle or channel or a combination of both, of approved and adequate cross- section, and shall be equipped with central alignment notches or holes corner braces, riser braces, and stub-angles in respect of the following requirements:

- Route longitudinal center line
- Structure lateral central line
- Stub elevations (with reference to datum)
- Stub leveling
- Stub rake
- Stub hip bevels
- Stub angle spacing

No concreting shall be commenced before the stub setting is approved by the Employer or Employer's representative. After the completion of Works all the template sets shall be handed over to Employer. No extra payment for the design, manufacturing and delivery for the templates shall be claimed by the Contractor.

3 Excavation and Backfilling

3.1 Scope

This specification covers the general requirements of earthwork in excavation in different materials, filling back around foundations, conveyance and disposal of surplus spoils or stacking them properly as shown on the drawings and as directed by the Employer or Employer's representative and all operations covered within the intent and purpose of this specification.

3.2 General

a. The Contractor shall furnish all tools, plants, instruments, qualified supervisory personnel, labor, materials, any temporary works, consumable, and everything necessary, whether or not such items are specifically stated herein, for completion of the job in accordance with specification requirements.

b. The Contractor shall carry out the check survey of the site before excavation and set properly all lines and establish levels for foundations.

c. The excavation shall be done to correct lines and levels. This shall also include, where required, proper shoring to maintain excavations and also the furnishing, erecting and maintaining of substantial barricades on ground excavated areas and warning lamps at night for ensuring safety.

d. The item also includes for dumping of excavated materials in regular heaps, bunds, riprap with regular slopes as directed by the Employer or Employer's representative, within the lead specified and leveling the same so as to provide natural drainage. Rock/Soil excavated shall be stacked properly as directed by the Employer or Employer's representative. As a rule, all softer material shall be laid along the center of the heaps, the harder and more weather resisting materials forming the casing on the sides and the top. Rock shall be stacked separately.

e. Clearing

The area to be excavated/filled shall be cleared of trees, plants, logs, stumps, bush, vegetation, rubbish, slush etc. and other objectionable matter. If any roots or stumps of trees are met during excavation, they shall also be removed. The materials so removed shall be burnt or disposed off as directed by the Employer. Where earthfill is intended, the area shall be stripped of all loose/soft patches, topsoil containing objectionable matter/materials before filling commences.

f. Precious object, relics, objects of archeological importance

All gold, silver, oil, mineral, archeological and other findings of importance, trees cut or other materials of any description and all precious stones, coins, treasures, relics, antiquities and other similar things which may be found in or upon the site shall be the property of the Employer and Contractor shall duly preserve the same to the satisfaction of the Employer and from time to time deliver the same to such person or persons as the Employer may from time to time authorize or appoint to receive the found goods.

g. The Contractor shall excavate earth, rock, stumps and all other materials encountered as required for construction of each foundation. The Contractor shall place all suitable excavated material in backfill or in graded embankment in the immediate area at structures. Materials found to be unsuitable for foundation backfill or grading shall be wasted and disposed at Contractor's own cost.

h. The Contractor shall excavate each foundation hole to the nominal excavation depth for the applicable foundation type except in case where the material being excavated is not capable of supporting 0.5 kg/sq.cm.

i. At the nominal excavation depth, the foundation shall be carefully graded to a level plane and all loose or disturbed material shall be removed. The foundation excavation shall then be examined by the Contractor and a final determination will be made on the foundation type to be used.

j. Excavations shall be maintained in a clean, safe and sound condition until completion of the foundation construction and shall be diked to prevent flooding by surface runoff. Suitable pumping equipment shall be provided and used to dewater excavations so that all installation work and backfilling is performed in the dry state. Any previously prepared foundation bearing surface that is softened by water runoff or otherwise contaminated before placement of the structure foundation shall be excavated and replaced at the Contractor's expense.

k. Those excavations where the base is unstable, lies below groundwater level, or has been over excavated, the Contractor shall furnish and place a layer of crushed stone, or selected backfill, or borrow to stabilize the base for placement of foundation materials. No extra payment shall be done for over-excavation and backfilled crushed stone layer.

l. Topsoil and excavated material that is suitable for backfill around the foundations shall be stockpiled separately for use in backfill. Material that is unsuitable for backfill shall be disposed of. The stockpiles shall be sloped to drain and shall be protected from rainfall or other elements, which render the material unsuitable for backfill.

m. Backfill shall be placed in not greater than 20cm lifts before compaction. Each lift shall b thoroughly compacted before the following lift is placed. Pneumatic or equivalent tampers shall be used on cohesive materials; vibratory compactors shall be used on non-cohesive materials. Compaction shall achieve a density at least equal to that of the surrounding undisturbed earth. Large stones or rock fragments may be used in the backfill provided they do not interfere with proper compaction. Particles larger than 25 cm shall be placed not nearer than 0.5 m of the structure and at least 1.0m below ground surface.

n. Rock particles larger than 10 cm shall not be in contact with the concrete.

o. Following completion of 75 percent of the compacted backfill portion, the remaining backfill and topsoil shall be placed and the topsoil mounded 30 cm above the ground surface and sloped to drain. Compaction of this material will not be required. Before final acceptance of the Works, the Contractor shall refill any locations that settle below the surface of the surrounding ground.

p. Earth is defined as material which shall include all kinds of soil containing gravel, sand, silt, moorum or shingle, gravel, clay, loam, peat, ash, etc. which can generally be excavated with the aid of shovels and pick axes. This shall also include embedded rock boulders not longer than one meter in any direction and not more than 200 mm in any of the other two directions.

q. Rock is defined as material which shall include rock, boulders, shale, chalk, slate, hard mica, schist, laterite and all other materials which in the opinion of the Employer is rock and can be removed with picks, hammer, wedges, crowbars, pneumatic breaking equipment and blasting. This category shall also include excavation in macadam and tarred roads and pavements.

r. Rock excavation may be made by drilling, barring, wedging, or compressed-air tools. No blasting will be permitted. The Contractor shall furnish all material and equipment to perform all work required for excavation of rock.

For selection of rock type foundation for any tower location, the characteristics of rock shall be thoroughly investigated by the Contractor. Disintegrated rock or other types of rock such as soluble limestone, soft shale, slate, hard pan and organic rocks may not be suitable for construction of rock foundation.

s. All loose boulders, semidetached rocks (along with earthy mounds) not directly in the excavation area but so close to the area to be excavated as to be liable, in the opinion of the Employer, to fall or endanger the workman, equipment or the Works, shall be stripped off and removed away from the area of the works. Any material not requiring removal as contemplated in the work, but which in the opinion of the Employer is likely to become loose or unstable later, shall also be promptly and satisfactorily removed as directed by the Employer.

t. Payment: No separate or direct payment will be made to the Contractor for preparation of site, excavation, and backfill and rock excavation of tower foundation. All costs of soil and rock excavation incurred in connection therewith shall be included in the unit bid prices for the construction of the various foundation types.

However, payment for the excavation and backfilling for foundation protection such as stone masonry work, removing unsafe boulders and earthwork near the foundation site, construction of embankment and stripping ground to obtain ground clearance between earth and conductor will be made at unit price bid specified in the Price Schedule. Therefore in the Price Schedule the unit bid price shall include full compensation for all costs incurred in furnishing all materials and labor and other operation costs.

4 Dewatering

4.1 Scope

This specification covers the general requirements of dewatering during excavations in general.

a. All excavations shall be kept free of water. Grading in the vicinity of excavations shall be controlled to prevent surface water running into excavated areas.

   The Contractor shall remove by pumping or other means approved by the Employer or Employer's representative any water inclusive of rainwater and subsoil water accumulated in excavation and keep all excavations/trenches free of water required for further work. Method of pumping shall be approved by the Employer or Employer's representative; but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or blowing-in due to differential head of water during pumping. Pumping arrangements shall be adequate to ensure no delays in construction.

b. When there is a continuous inflow of water and quantum of water to be handled is considered in the opinion of the Employer as large, well- point system- single stage or multistage shall be adopted. The Contractor shall submit to the Employer his scheme of well-point system including the stages, the spacing number and diameter of well points, headers, etc., and the number, capacity and location of pumps for approval.

c. Payment: No separate or direct payment will be made to the Contractor for dewatering of tower foundation and any other foundation works. All costs incurred in connection therewith shall be included in the unit bid prices for the construction of the various foundations and other civil works.

5 Timber Shoring

5.1 Scope

This specification covers the general requirements of timber shoring for open excavations for structure foundation.

a. Close timbering shall be done by completely covering the sides of the pits generally with short, upright members called polling boards. These shall be of minimum 25 cm x 4-cm sections or as directed by the Employer or Employer's representative.

   The boards shall generally be placed in position vertically side by side without any gap on each side of the excavation and shall be secured by horizontal walling of strong wood at maximum 1.2 meters spacing, strutted with bellies or as directed by the Employer or Employer's representative. The length of the bellies struts shall depend on the excavation and supported by vertical walling, which in turn shall be suitably strutted. The lowest boards supporting the sides of the trench or pit shall remain exposed, so as to render the earth liable to slip out.

b. Timber shoring shall be 'close' or 'open' type, depending on the nature of soil and the depth of pit. The type of timbering shall be as approved by the Employer. It shall be the responsibility of Contractor to take all necessary steps to prevent the sides of excavations, pits, etc., from collapsing.

c. Timber shoring may be required to keep the sides of excavations vertical to ensure safety of adjoining structures or to limit the slope of excavations, or due to space restrictions or for other reasons. Such shoring shall be carried out, except in an emergency, only under instruction from the Employer.

d. Payment: No separate payment will be made to the Contractor for timber shoring. All costs incurred in connection therewith shall be included in the unit bid prices for the construction of the various foundation types and other civil works.

6 Select Borrow

a. Where the material excavated for the foundation is unsuitable for backfill or is required for construction of embankment, the Contractor shall provide and compact select borrow. Excavated material shall be disposed at the Contractor's own expense.

b. Material for select borrow shall be well-graded bank-run gravel, relatively free from clay, loam or vegetation matter and with no stones over 10 cm in maximum dimensions, or materials of equivalent strength and characteristics. Representative sample from proposed borrow sources shall be submitted to the Employer for approval of the borrow source. Approval of borrow source shall not mean automatic approval of all materials obtained from that source.

c. The Contractor shall, at his option, use areas approved by the Employer or Employer's representative for production of select borrow or at his own expense, make arrangements for obtaining select borrow at other sources.

d. The select borrow shall be placed and compacted as specified for the backfill in Article 3.3 Excavation and Backfilling.

e. Payment: No separate payment will be made to the Contractor for select borrow required for back filling tower foundation. Hence, all costs incurred in connection therewith shall be included in the unit bid prices for the construction of the various foundation types and other civil works.

7 Foundation Construction

7.1 General requirement

All materials and labor required for the construction of foundations shall be furnished by the Contractor.

a. The Contractor will be required to remove and replace at his expense any materials incorporated in the work that do not conform to these specifications.

b. The Contractor shall furnish without any extra cost all materials the Employer require for testing. The cost of the tests shall be borne by the Contractor.

c. The final selection of the type of foundation footing to be actually constructed for each particular structure will be done by the Contractor after the results of the sub soil tests and shall be subject to the approval of the Employer.

7.2 Measurement for Foundation Payment

Measurement for payment for the Contract item, Foundations, shall be on the basis of the actual Excavation, backfilling, reinforcement and concrete item only. Other item should be included in above item of work.

7.2.1 Reference to standard specifications

Standards referred to in these specifications are as follows:

a) ASTM referred to the latest edition of publications of American Society for the Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

b) ACI refers to the latest edition of publications of American Concrete Institute, P.O. Box 19150, Redford Station, and Detroit, Michigan 48219.

c) BIS referrers to the latest, Bureau of Indian Standard ManakBhawan, 9. Bahadur Shah ZafarMarg, New Delhi India.

7.2.2 Measurement Standards

Measurement standards referred to in these specifications are as follows:

a. Gallons - Wherever used in these specifications, gallons shall be understood to be U.S.gallons.

b. Bag - Wherever used in these specifications, bag will be understood to mean 50-kg bag of Portland cement. Concrete shall be composed of cement, sand, coarse aggregate, water and admixtures, if required, all well mixed and brought to the proper consistency.

7.2.3 Concrete

The Contractor shall design and test concrete mixes, which have 28-day cubicle compressive strength of M25.

a. At least one month prior to the placement of any concrete, the Contractor shall make a set of test concrete compressive strength test cubes for each design mix under field conditions. The test cubes shall be made and tested in accordance with the applicable standards.

b. The concrete mix shall be of such proportions as to produce a plastic and workable mix which will not separate during the placing and will finish well without using excessive quantities of mixing water. Addition of water to compensate for stiffening of concrete before placing will not be permitted. Uniformity in concrete consistency from batch to batch will be required.

c. After the test results are known for the field condition test cubes, the Contractor shall submit these result to the Employer or Employer's representative and the Employer or Employer's representative will notify the Contractor of the approval of test results and the acceptable design mixes.

d. When placing concrete in hot weather, the recommendations of the American Concrete Institute's publication "Recommended Practice for Hot Weather Concreting"(ACI 605) or equivalent shall be followed insofar as the Employer or Employer's representative may direct.

   The use of set accelerators will be at the Employer's or Employer's representative's discretion. For concrete placed during extremely hot weather, the aggregate shall be cooled by frequent water spraying in such a manner as to utilize the cooling effect of evaporation. Concrete with a temperature of 35 degree centigrade or higher before placement will be rejected and shall be wasted at the Contractor's expense.

e. Submerge concrete

   Concrete to be placed under water shall be deposited by tremie, and only after it has been determined by the Employer or Employer's representative that placing of concrete in an unwatered excavation cannot be practically accomplished by any other means. The tremie will not be allowed to drop below the level of water outside. Under no circumstances will concrete be allowed to drop through water within the tremie.
   The tremie shall be watertight and sufficiently large to permit a free flow of concrete. The bottom of the tremie shall be as near to the surface against which the concrete is to be placed as practicable and the tremie shall not be raised until seal has been established by the concrete sufficiently to prevent the entry of water of the tremie. The discharge of the tremie shall be kept submerged in concrete at sufficient depth so as to maintain an adequate seal during underwater placement. Placing of concrete shall proceed without interruption until underwater placing in the foundation has been accomplished. As placing of concrete under water progresses, the Contractor shall remove water displaced by the concrete when the top

of the concrete being placed by tremie reaches the elevation of the water table level; no further placement by tremie shall be performed.

f. The concrete used as lean concrete or base concrete shall be as mentioned on respective drawings.Theaggregatesizeshallbe40mmnominal.Base concrete shall be well compacted. The top surface of base concrete shall be leveled before placing the reinforcement.

g. During excavation, if excavation exceeds the required depth or if any loose pocket of earth is met below the base of footing, then the loose earth shall be removed or excavation depth be increased till normal hard soil is met as per satisfaction of the Employer. This extra depth shall be filled with lean concrete. No extra shall be paid on account of this extra excavation and lean concrete.

h. The cement concrete used for foundation shall be of grade M-20 (1:1.5:3) nominal Mix conforming to IS 456 using 20mm size coarse aggregate shall be adopted.

i. The Water Cement ratio shall be minimum 0.50 and maximum 0.55.

j. For volumetric use of ingredients for concrete mix, the contractor along with the Mix Design shall intimate the size of measuring boxes along with the Mix design.

k. The nominal of Mix Design shall not absolve the contractor from the responsibility of achieving the required strength, workability etc. during actual execution. In case of failure of concrete samples, the work done is liable to be rejected. In such case the contractor shall recast the foundation at the same location by dismantling the rejected foundation or ata nearby location as directed by the Employer. In case of honey combing, the contractor shall do the pressure grouting as directed and to the full satisfaction of th e Employer. The construction of new foundation in place of rejected one and pressure grouting if done shall be without any extra payment.

l. The water used for mixing concrete and for curing purpose shall be fresh, clean and free from oils, acids and alkalis, organic materials or other deleterious substance. Potable water is generally preferred. Saltish or brackish water shall not be used. Water used shall conform to clause 5.4 of IS 456.

7.2.4 Cement and Aggregates

In locations where conditions do not require high sulphate resistance, cement shall conform to the requirements of ASTM C150 Type T or equivalent (IS263, IS8112,IS12269)

a) In locations where, in the opinion of the Employer or Employer's representative, the conditions require the use of high sulphate resistance cement, cement conforming to the requirements of ASTM C150 Type V or equivalent shall be used. No extra payment will be made to the Contractor for the use of high sulphate resistance cement.

b) The aggregates shall consist of clean, natural material or, subject to the approval of the Employer or Employer's representative, manufactured aggregates may be used.

c) Aggregates shall be separated into sand and coarse aggregate before being used. The Employer or Employer's representative will permit no pit or crusher run materials without prior approval.

d) Natural fine aggregate or sand shall be graded within the following limits and the fineness module be between 2.5 and 2.8 as per IS 383:

Sieve size Laboratory (U.S Std. Sieve)		Amounts Finer than Each weight Percent
3/8	(9.5mm)	100
4	-4.75	95 to 100

8	(2.36mm)	80 to 100
16	(1.18mm)	50 to 85
30	(600 micron)	25 to 60
50	(300 micron)	10 to 30
100	(150 micron)	2 to 10

Natural coarse aggregate shall be graded within the following limits, depending upon the clear spacing between reinforcing bars.

U.S. Standard Sieve		Nominal 1-1/2"	Nominal 3/4"
2"	(50.8mm)	100	
1-1/2"	(25-38mm)	95-100	
1"	(25mm)	70-95	100
3/4"	(19mm)	35-70	90-100
3/8"	(9.5mm)	10-30	20-55
No.4	(4.75mm)	0-5	0-10
No.8	(2.36mm)		

7.2.5 Slump

All concrete used shall have a slump of maximum 120mm and minimum 75mm at the time of placing. The water cement ratio shall be determined by consideration of the specified strength, the water reducing admixtures, the slump required for proper placement, air entraining requirements the available and maximum allowable aggregate size and its specific gravity, and the amount of water carried on the aggregates.
The slumps and maximum sizes of aggregate as well as, the computation of trail mixes shall be as described in the America concrete Institute Recommended Practice for Selected Proportions for concrete (ACI 613).

7.2.6 Storage of material

Cement and aggregates shall be stored at the Site of the work in such manner as to prevent deterioration or intrusion of foreign matter in Contractor’s own cost. Special care shall be taken in storing cement to keep it thoroughly dry at all times.

a) Cement that has been caked in storage is still usable only if, when pressed between the thumb and fingers, it powders readily. Otherwise, its use will not be permitted.

b) When reinforcing steel is delivered to the job in advance of the Contractor's requirements, the Contractor shall provide suitable protection in order to prevent excessive rust developing on the reinforcing steel as it will be Contractor's responsibility to remove the excessive rust.

7.2.7 Concrete mixing and placing

Before any concrete mixing is begun, all equipment for mixing, transporting and debris shall be cleaned of all dirt and debris. All dirt and debris shall also be removed from the places to be occupied by the concrete.

a. All mechanical equipment shall be checked before starting a concrete pour to ascertain whether or not it is in good operating condition and if not shall be tuned-up, or repaired, or replaced to the satisfaction of the Employer or Employer's representative. Also the stock of construction material (cement, aggregate and sand) shall be checked before starting the concreting work to ascertain whether or not it is in sufficient quantity for one foundation work.

b. When a foundation location is ready for concrete placement, the Employer shall be notified at least 24 hours prior to concreting so that he may inspect to assure that the excavation is free of water, mud and debris; that the bottom surface of the excavation is well leveled and compacted; and where required, a crushed stone sub-base has been placed; that the reinforcing steel is properly secured in place; and that the formwork is properly braced.

c. Rock surfaces shall be as flat as possible and projecting ridges shall be leveled off before the concrete is placed or spaces between the ridges shall have been previously filled with concrete to form a horizontal surface.

d. The Contractor shall see that all material that is to be embedded in the concrete has been placed before the concrete is placed. The Contractor shall be responsible for the accurate location of all embedded materials. Any work inaccurately or improperly set shall be relocated and reset at the Contractor's expense.

e. All batching components of the concrete shall be accurately measured. Measuring on a weight basis is preferred, however, measuring on a volume basis will be allowed as long as careful controls are maintained. Weight measurements shall be made using standard batching equipment for large quantities and wheelbarrow scales for small quantities. Volume measurements shall be made in batching boxes. The batching boxes shall be as large as is practical.

f. The batch mixer shall be rotated at a speed recommended by the manufacturer and mixing shall be continued for at least one and one-half (1-1/2) minutes after all materials are in the mixer, unless the size of the batch is over 1.2 cu.m., when additional mixing time shall be required as advised by the Employer. A mechanically-operated batch mixer shall be used for mixing unless otherwise approved by the Employer.

g. The tempering of concrete which has partially hardened, that is, remixing with or without additional cement, aggregate or water, will not be permitted.

h. Concrete shall be conveyed from the mixer to the place of final deposit within 30 minutes by methods which will prevent the segregation or loss of the materials. After 30 minutes of mixing the concrete shall be rejected and replaced by fresh concrete without any extra cost to the Employer.

i. Equipment for chuting, pumping and pneumatically conveying concrete shall be of such size and design as to ensure a practically continuous flow of concrete at the delivery end without separation of the materials. The chutes shall never be on a slope that is steeper than two vertical to three horizontal. Conveying equipment shall not have any aluminum parts that come in contact with the concrete.

j. When the concrete is to be placed on hard rock or other concrete, after the existing surface has been properly cleaned and otherwise prepared, the existing surface is to be wetted until it is saturated. The first batch of concrete placed shall be a grout obtained by omitting the coarse aggregate from the mix and reducing the water as required. The grout shall be evenly spread on the water-saturated surface and then the concrete shall be deposited continuously and as rapidly as practicable.

k. The concreting shall be carried on at such a rate that the concrete is at all-time plastic and flows readily into the spaces between the bars and so that each successive layer properly bonds with its predecessor. Successive layers shall be placed within 15 minutes of the preceding layer.

l. When placing foundations with drops over 2 meters, hoppers and trunks must be provided of a size to allow for proper placing. Not less than four hoppers of any size shall be available and used, if requested, and a sufficient number of sections of trunk shall be furnished to reach within 500 mm of the bottom of the foundation.

m. The concrete shall be compacted during and after depositing by vibration. The concrete shall be thoroughly worked around embedded materials.

n. All concrete must be consolidated by means of internal vibration except where the Employer has given written permission to use some other method of consolidation. The type and make of vibrator must have a speed of at least 6,000 vibrations per minute (VPM) when the machine is being supplied at its rated voltage, air pressure, etc. The Contractor shall at his own expense, furnish sufficient transformers, compressors, etc. of approved type to operate all vibrators at the voltage, pressure, etc., specified by the manufacturer.

o. The Contractor shall always have at least two vibrators in operating condition at the location of the concrete placement.

The Contractor shall make one set of concrete compressive strength test cubes for each structure or as directed by the Employer or Employer's representative. There shall be three cubes to a set and the cubes shall be made in accordance with ASTM C31. Only one cube shall be made from any one batch containing less the 1/2 cubic meters of concrete. The Contractor shall also make one set of concrete compressing strength test cube for each new batch of cement purchased two week before using that cement. After the cubes have aged at least 24 hours in the field, the Contractor shall deliver them to a location designated by the Employer where they will be tested in accordance with ASTM C39/IS 516. If two of the cubes tested at 28-day tests indicate a compressive strength of 250kg/sq.cm or more, the remaining cubes shall be discarded. If the 28-day compressive strength indicates a compressive strength of less than 250kg/sq.cm., the Employer or Employer's representative will determine what remedial measures are necessary and the Contractor shall perform the remedial measures at his own expense. The remedial measures may include, but are not limited to, the replacement of the entire foundation.

7.2.8 Concrete formwork

Forms shall be used, wherever necessary, to confine the concrete for structures and shape it to the required lines, or to insure against contamination of the concrete by materials caving or sloughing from adjacent surfaces left by excavation.

a. Forms shall have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete, and shall be maintained rigidly in position. Forms shall be sufficiently tight to prevent loss of mortar from the concrete. Molding strips shall be placed in the corners of forms so as to produce chamfered edges on permanently exposed concrete surfaces. All exposed surfaces may be formed with any material of adequate strength and tightness to hold the wet concrete in proper position and prevent the loss of mortar.

b. If plywood or steel forms are not readily available, the Contractor with Employer's special recommendation may substitute wood planking provided exposed surfaces are rubbed to remove ridges on exposed surfaces.

c. The Contractor shall provide templates, which firmly hold the stub angles within 10 mm of the horizontal side setting dimensions and within 5 mm of the required elevation during the placing of the concrete. Details of the templates shall be submitted to the Employer or Employer's representative at least one month before the commencement of any foundation construction. The bottom portion of the structure may be used for this purpose providing that adequate cribbing and bracing are supplied for support.

d. Before concrete is placed, the surfaces of all forms shall be oiled with a form oil that effectively prevents sticking and will not stain the concrete surfaces. For wood forms, form oil shall consist of straight, refined, pale paraffin mineral oil. For steel forms, form oil shall consist of refined mineral oil compound.

e. Forms shall be removed only when the strength of the concrete is such that form removal will not result in cracking, spelling, or breaking of edges of surfaces, or other damage to the concrete. Usually formwork shall be removed after 48 hours from concreting times. Any concrete damaged by form removal or otherwise shall be repaired immediately without any extra cost to the Employer.

7.2.9 Concrete finishing and curing

a. The exposed top surfaces of all concrete foundation piers shall be slightly sloped to prevent the accumulation of water.

b. Immediately after the removal of forms, the holes left by form tie rod fasteners shall be filled with mortar and all damaged or defective concrete shall be repaired or removed and replaced to the satisfaction of the Employer or Employer's representative. Improperly consolidated concrete shall be removed by chipping, and the chipped openings or recesses shall be of such depth and shape as required by the Employer or Employer's representative to insure that the patching material placed in the openings or recesses will be thoroughly keyed and bonded to the concrete. "Dry pack" mortar shall be used for filling relatively deep required for the replacement of defective concrete where surface dimensions of the chipped openings or recesses are relatively large. The depth of chipped recesses for concrete patches shall extend at least 25 mm beyond the nearest reinforcing steel.

c. To ensure proper curing, all concrete shall be kept moist for a period of at least 10 days. Burlap or an equivalent material or a curing compound shall be applied over exposed concrete surfaces. The burlap shall be kept moist at all times. If the foundation is backfilled before the one-week curing time has elapsed, the burlap protection shall remain on the exposed projection.

7.2.10 Membrane curing compound

Membrane curing compound shall be applied uniformly by spray, leaving no pinholes or gaps, at a rate not to exceed 4.91 square meter per liter. The curing compound shall be applied after finishing operations are completed and surface moisture has disappeared. If forms are removed prior to 7 days after placing the concrete, the uncovered surfaces shall be coated with the curing compound as specified herein.

a. Foundation shall not be backfilled before they have been inspected to see that they are free from surface defects and voids, or that the defects and voids have been properly repaired.

b. The foundations shall not be subjected to any loads in addition to those existing at the time of the placing of the foundation concrete until the curing period has elapsed.

7.2.11 Payment

Works involve for construction of foundation shall be made as per bid price schedule. No extra payment will be made. All works except bid price is included corresponding item in bid price schedule.

7.2.12 TMT steel Reinforcing Bar

All TMT steel-reinforcing bars shall conform to the requirements of Grade fe-500 and shall be fabricated in accordance with the "Manual of Standard Practice" of the Concrete Reinforcing Steel Institute.

a. Mill scale, rust, oil and mud shall be removed from reinforcing steel by firm rubbing with burlap or equivalent treatment before the reinforcing steel is placed.

b. The minimum center-to-center distance between parallel bars shall be two and one-half (2-1/2) times the diameter of the bars. In no case shall the clear spacing between bars be less than 25 mm nor less than one and one-third (1-1/3) times the maximum size of coarse aggregate.

c. All TMT steel-reinforcing bars shall have a protective concrete cover of not less than:

- 50 mm - on the bottoms of footings and on any surface of concrete that will be exposed to salt water.

- 50 mm - concrete exposed to weather or ground.

d. TMT steel reinforcing bar shall be accurately located and shall be secured in position by the use of annealed iron wire of no less than No.16 gauge, and shall be supported in a manner that will keep the reinforcement away from the exposed concrete surfaces. Concrete blocks shall be used to support the reinforcing steel in the foundation mat; broken stones or wooden blocks shall not be used for supporting the reinforcing steel.

7.2.13 Payment

Payment of reinforcement bars of tower foundation will be made to the Contractor shall be per MT. Payment shall be made for the number of Metric Ton measured as provided at the unit price specified in the schedule. The unit price shall include all labor, tools and equipment, materials including furnishing, transporting, bending and placing the materials, necessary for the performance and completion of the work.

8 Foundation Protection Works

8.1 M15 Concrete Nominal Mix 1:2:4 for top seal cover: P.C.C.

Top of the gabion wall and stone masonry wall shall be sealed with M15 concrete cover. The thickness of the cover shall be minimum 75mm or as directed by Employer's representative.

Payment:

Measurement for payment of "M15 Concrete Nominal Mix 1:2:4 for top seal cover" works shall be made on the basis of actual placed volume of Concrete in cubic meters. Payment shall be made for the number of cubic meters measured as provided at the unit price specified in the schedule. The unit price shall include all labour, equipment, materials and all other cost necessary for the performance and completion of the works.

8.2 Slope Cutting and revetment works:

This section covers the cutting of slopes where sufficient electrical ground clearance of the line is not available. After slope cutting, revetment wall shall be constructed as directed by Engineer. Back filling of the revetment wall shall be done with leveling.

CHAPTER12: 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, etc and be of uniform toughness over its entire surface. All exposed glass surfaces shall be smooth.

1.1.1.3 When operating at normal rated voltage there shall be no electric discharge between conductor and insulator which would cause corrosion or injury to conductors or insulators by the formation of substances due to chemical 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.

d) 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.

e) 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.

f) 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.

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 wet flashover voltage	1.3 times the actual

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	$\pm$ 1050	$\pm$ 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 (11 KV)**

a) Power frequency withstand voltage of the complete string with Corona Control ring (wet) - kV rms : 28

b) Lightning impulse withstand : Voltage of string with corona control rings (dry) – kVp ±75

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) : 300

1.4.2.1 **INSULATOR STRING (33 KV)**

a) Power frequency withstand voltage of the complete string with Corona Control ring (wet) - kV rms : 70

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

1.5 **COMPOSITE LONG ROD INSULATOR**

As an alternative to disc insulator/long rod porcelain, Bidder can also offer composite long rod insulators with suitable hardware.

1.5.1 **Details of Composite Long Rod Insulators**

1.5.1.1 Contractor shall offer such composite insulators which have proven use under foggy/ humid operational conditions in polluted industrial environment combined with smoke and dust particles. The Bidder shall furnish evidence in the form of certification from the power utilities that the similar type of product supplied to them had been performing satisfactory. The Bidder shall also submit certified test report for an accelerated ageing test of 5000 hours such as that described in Appendix-C of IEC-61109 or test at multiple stresses of 5000 hrs as described in annexure –B of IEC-62217.

1.5.1.2 Insulators shall have sheds of the "open aerodynamic profile without any under ribs" with good self-cleaning properties. Insulator shed profile, spacing projection etc. shall be strictly in accordance with the recommendation of IEC-60815.

1.5.2 Ball and socket shall be 20 mm designation for 120 kN & 24 mm designation for 210 kN Insulators in accordance with the standard dimensions stated in IEC:60120. Insulators shall be interchangeable and shall be suitable for forming either suspension or tension strings. Each insulator shall have rated strength markings on each composite insulator rod unit. no negative tolerance shall be applicable to creepage distance of composite insulators

1.5.3 All ferrous parts shall be hot dip galvanized to give a minimum average coating of zinc equivalent to 610 gm/sq.m. and shall be in accordance with the latest edition of equivalent International standard. The zinc used for galvanizing shall be of purity of 99.95%. The zinc coating shall be uniform, adherent, smooth, reasonably bright continuous and free from imperfections such as flux, ash rust stains, bulky white deposits and blisters. The galvanized metal parts shall be guaranteed to withstand at least six successive dips each lasting for one (1) minute duration under the standard preece test. The galvanizing shall be carried out only after any machining.

1.5.4 **Materials**

1.5.4.1 **Core**

It shall be a glass-fiber reinforced (FRP rod) epoxy resin rod of high strength. The rod shall be resistant to hydrolysis. Glass fibers and resin shall be optimized. The rod shall be electrical grade corrosion resistant (ECR), boron free glass and shall exhibit both high electrical integrity and high resistance to acid corrosion.

1.5.4.**2** **Housing & Weather sheds**

The FRP rod shall be covered by a sheath of a silicone rubber compound of a thickness of minimum 3mm. The housing & weather sheds 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 weather sheds of the insulators shall be of alternate shed profile. The weather sheds 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 weather shed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

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

Harijan

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 CARDINAL conductor shall be as per the standard guaranteed technical particulars enclosed in Annexure-A are tabulated below:

ACSR CARDINAL CONDUCTOR:

Sl. No.	Description	Unit	ACSR CARDINAL
a)	Stranding and wire diameter	mm	54/3.38 (Al)+ 7/3.38 (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	484.5
d)	Total sectional area	Sq. mm	547.3
e)	Overall diameter	mm	30.42
f)	Approximate weight	kg/ km	1803
g)	Calculated d.c. resistance at 20oC	ohm/ km	0.05979
h)	Minimum UTS	kg	15381

2.3 Workmanship

2.3.1 The finished conductor shall be smooth, compact, uniform and free from all imperfections including kinks (protusion of wires), wire cross over, over riding, looseness (wire being dislocated by finger/hand pressure and/or unusual bangle noise on tapping), material inclusions, white rust, powder formation or black spot (on account of 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.

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 12 – 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**

5.1 **General**

All conductors buried in earth and concrete shall be of mild steel. All conductors above ground level and earthing leads shall be of galvanised steel, except for cable trench earthing.

5.2 **Constructional Features**

5.2.1 **Galvanised Steel**

a) The minimum weight of the zinc coating shall be 618 gm/sq. m. and minimum thickness shall be 85 microns.

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

5.3 **Tests**

In accordance with stipulations of the specifications galvanised steel shall be subjected to four one minute dips in copper sulphate solution as per IS : 2633// Equivalent BS standard.

6.0 **SPACERS**

6.1 **General**

The spacers are to be located at a suitable spacing to limit the short circuit forces as per IEC - 60865. Wherever Employer's 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 to 80.

k) Ultimate Tensile Strength Test

The UTS of the retaining rods shall be measured. It shall not be less than 35 kg/Sq. mm.

6.3.3 **Routine test**

a) Visual examination

b) Dimensional verification

7.0 **BUS POST INSULATORS**

The post insulators shall conform in general to latest IEC-60168, IEC 60273 and IEC-60815.

7.1 **Constructional Features**

7.1.1 Post type insulators shall consist of a porcelain part permanently secured in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand any shocks to which they may be subjected to by the operation of the associated equipment. Only solid core insulators will be acceptable.

7.1.2 Porcelain used shall be homogeneous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

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

7.1.4 The insulator shall have alternate long and short sheds with aerodynamic profile, The shed profile shall also meet the requirements of IEC-60815 for the specified pollution level.

7.1.5 When operating at normal rated voltage there shall be no electric discharge between conductor and insulators which would cause corrosion or injury to conductors or insulators by the formation of substance produced by chemical 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 galvanised. The zinc used for galvanising shall be grade Zn 99.95. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux ash, rust stains, bulky white deposits and blisters. The metal parts shall not produce any noise generating corona under the operating conditions.

7.1.8 a) Every bolt shall be provided with a steel washer under the nut so that part of the threaded portion of the bolts is within the thickness of the parts bolted together.

b) Flat washer shall be circular of a diameter 2.5 times that of bolt and of suitable thickness. Where bolt heads/nuts bear upon the beveled surfaces they shall be provided with square tapered washers of suitable thickness to afford a seating square with the axis of the bolt.

c) All bolts and nuts shall be of steel with well- formed hexagonal heads forged from the solid and shall be hot dip galvanised. The nuts shall be good fit on the bolts and two clear threads shall show through the nut when it has been finally tightened up.

7.1.9 Bidder shall make available data on all the essential features of design including the method of assembly of shells and metals parts, number of shells per insulator, the manner in which mechanical stresses are transmitted through shells to adjacent parts, provision for meeting expansion stresses, results of corona and thermal shock tests, recommended working strength and any special design or arrangement employed to increase life under service conditions.

7.2 **Tests**

In accordance with the stipulations of the specification, the post insulators shall be subject to type, acceptance, sample and routine tests as per IEC-60168.

7.2.1 In addition to acceptance/sample/routine tests as per IEC-60168, the following tests shall also be carried out.

a) Ultrasonic test as an acceptance test

b) Soundness test, metallurgical tests and magnetic test on MCI caps and pedestal tests as acceptance test.

c) All hot dip galvanised components shall be subject to check for uniformity of thickness and weight of zinc coating on sample basis.

d) The bending test shall be carried out at 50% minimum failing load in four directions as a routine test and at 100% minimum failing load in four directions as an acceptance test.

e) Acceptance norms for visual defects allowed at site and also at works shall be agreed in the Quality plan.

7.2.2 In accordance with the stipulation of specification, the following type tests reports of the post insulators shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

a) Power frequency withstand test (dry & wet)

b) Lightning impulse test (dry)

c) Measurement of R.I.V (Dry)

d) Corona extinction voltage test (Dry)

.

e) Test for deflection under load

f) Test for mechanical strength.

7.3 **Technical Parameters of Bus Post Insulators.**

Sl. No.	Description	36 kV	145 kV
a)	Type	Solid Core	Solid Core
b)	Voltage Class (kV)	36	145
c)	Dry and wet one minute power frequency withstand voltage(kV rms)	70	275
d)	Dry lightning impulse withstand Voltage (kVp)	± 170	±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
g)	Corona extinction voltage (kV rms) (min.)	….	105
h)	***Cantilever Strength***		
(i)	Total minimum cantilever strength (Kg)	600	600
(ii)	***Total minimum breaking strength (Kg)***	***720***	***720***
i)	Minimum torsional moment	As per IEC-273	As per IEC-273
j)	Total height of insulator (mm)	As req	As req
k)	P.C.D Top (mm)	As req	***127***
	Bottom (mm)		***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)	900	3165

7.3.1 11kV Bus Post Insulators.

a) Type Solid Core

b) Voltage class (kV) 12

c) Dry and wet one minute power 28

	frequency withstand voltage(kV rms)	
d)	Dry lightning impulse withstand Voltage (kVp)	±75
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)	300

7.3.2 If corona extinction voltage is to be achieved with the help of corona ring or any other similar device, the same shall be deemed to be included in the scope of the Contractor. Material of Corona ring shall be aluminium/ aluminium alloy of 63401W grade or equivalent.

8.0 GROUNDING SYSTEM

8.1 GENERAL

This specification covers the design, supply, delivery, installation and testing of the complete grounding system as described below. The complete station grounding work shall be in accordance with the recommendation in the "Guide for Safety in Substation Grounding" IEEE No. 80 and the requirements of this section.

8.2 GROUNDING INSTALLATION FEATURES

8.2.1 The installation shall be complete in all respects for efficient and trouble free service. All work shall be carried out in a first class neat workman like manner. Grounding conductors shall be handled carefully to avoid kinking and cutting of the conductors during laying and installation. All exposed ground conductors runs shall be taken in a neat manner, horizontal, vertical and parallel to building walls or columns and shall not be laid haphazardly.

8.2.2 For all connections made to equipment or to the structures, the grounding conductor, connectors and equipment enclosures shall have good clean 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 thermowelding process or compression type connector. The various joints shall have adequate mechanical strength as well as necessary electrical conductivity not less than that of the parent conductors of the joints. All accessories for grounding installation shall be of quality and design approved by the Employer. The earthing connection between earthing pad of equipment/structures shall be made by two earthing leads.

8.2.4 Ground conductors, when crossing underground trenches, directly laid underground pipe and equipment foundation, if any, shall be at least 300mm below the bottom elevation of such trenches/pipes.

8.2.5 The maximum size of each grid of grounding mat shall not exceed 4X4 meters. The terminals for connecting ground mat and equipment shall be terminated whenever necessary.

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 Aluminum 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 equipments shall be as per single line diagrams and layout drawings.

10.2 Bay Marshalling Kiosk:-

One no. of bay marshalling kiosk shall be provided for each 220 kV and 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/ Equivqlent 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 inter-pole 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 recom- mended 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 etc as specified and to be shown in detailed drawing. The size of the conduit/pipe shall be selected on the basis of 40% fill criterion.

15.27.2 Contractor shall have his own facility for bending, cutting and threading the conduits at site. Cold bending should be used. All cuts & threaded ends shall be made smooth without leaving any sharp edges. Anticorrosive paint shall be applied at all field threaded portions.

15.27.3 All conduit/pipes shall be extended on both sides of wall/floor openings. The fabrication and installation of supports and the clamping shall be included in the scope of work by Contractor.

15.27.4 When two lengths of conduits are joined together through a coupling, running threads equal to twice the length of coupling shall be provided on each conduit to facilitate easy dismantling of two conduits.

15.27.5 Conduit installation shall be permanently connected to earth by means of special approved type of earthing clamps. GI pull wire of adequate size shall be laid in all conduits before installation.

15.27.6 Each conduit run shall be painted with its designation as indicated on the drawings such that it can be identified at each end.

15.27.7 Embedded conduits shall have a minimum concrete cover of 50 mm.

15.27.8 Conduit run sleeves shall be provided with the bushings at each end.

15.27.9 Metallic conduit runs at termination shall have two locknuts and a bushing for connection. Flexible conduits shall also be suitably clamped at each end with the help of bushings. Bushings shall have rounded edges so as not to damage the cables.

15.27.10 Where embedded conduits turn upwards from a slab or fill, the termination dimensions shown on the drawings, if any, shall be taken to represent the position of the straight extension of the conduit external to and immediately following the bend. At least one half of the arc length of the bend shall be embedded.

15.27.11 All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed in an approved manner to prevent damage to threaded portions and entrance of moisture and foreign material.

15.27.12 For underground runs, Contractor shall excavate and back fill as necessary.

15.27.13 Contractor shall supply, unload, store and install conduits required for the lighting installation as specified. All accessories/fittings required for making the installation complete, including but not limited to pull out boxes, ordinary and inspection tees and elbow, checknuts, male and female bushings (brass or galvanised steel), caps, square headed male plugs, nipples, gland sealing fittings, pull boxes, conduits terminal boxes, gaskets and box covers, saddle terminal boxes, and all steel supporting work shall be supplied by the Contractor. The conduit fittings shall be of the same material as conduits.

15.27.14 All unarmoured cables shall run within the conduits from lighting panels to lighting fixtures, receptacles etc.

15.27.15 Size of conduit for lighting shall be selected by the Contractor during detailed engineering.

15.27.16 Exposed conduits shall be run in straight lines parallel to building columns, beams and walls. Unnecessary bends and crossings shall be avoided to present a neat appearance.

15.27.17 Conduit supports shall be provided at an interval of 750mm for horizontal runs and 1000mm for vertical runs.

15.27.18 Conduit supports shall be clamped on the approved type spacer plates or brackets by saddles or U- bolts. The spacer plates or brackets in turn, shall be securely fixed to the building steel by welding and to concrete or brick work by grouting or by nylon rawl plugs. Wooden plug inserted in the masonary or concrete for conduit support is not acceptable.

15.27.19 Embedded conduits shall be securely fixed in position to preclude any movement. In fixing embedded conduit, if welding or brazing is used, extreme care should be taken to avoid any injury to the inner surface of the conduit.

15.27.20 Spacing of embedded conduits shall be such as to permit flow of concrete between them.

15.27.21 Where conduits are placed alongwith cable trays, they shall be clamped to supporting steel at an interval of 600mm.

15.27.22 For directly embedding in soil, the conduits shall be coated with an asphalt-base compound. Concrete pier or anchor shall be provided wherever necessary to support the conduit rigidly and to hold it in place.

15.27.23 Conduit shall be installed in such a way as to ensure against trouble from trapped condensation.

15.27.24 Conduits shall be kept, wherever possible, at least 300mm away from hot pipes, heating devices etc. when it is evident that such proximity may reduce the service life of cables.

15.27.25 Slip joints shall be provided when conduits cross structural expansion joints or where long run of exposed conduits are installed, so that temperature change will cause no distortion due to expansion or 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 specialities of the items as per the field Q.P./instructions of the equipment Contractor or Owner without any extra cost to the Owner. The Contractor shall arrange all equipments instruments and auxiliaries required for testing and commissioning of equipments alongwith calibration certificates and shall furnish the list of instruments to the Owner for approval.

17.2 GENERAL CHECKS

(a) Check for physical damage.

(b) Visual examination of zinc coating/plating.

(c) Check from name plate that all items are as per order/specification.

(d) Check tightness of all bolts, clamps and connecting terminals using torque wrenches.

(e) For oil filled equipment, check for oil leakage, if any. Also check oil level and top up wherever necessary.

(f) Check ground connections for quality of weld and application of zinc rich paint over weld joint of galvanised surfaces.

(g) Check cleanliness of insulator and bushings.

(h) All checks and tests specified by the manufacturers in their drawings and manuals as well as all tests specified in the relevant code of erection.

(i) Check for surface finish of grading rings (Corona control ring).

(j) Pressure test on all pneumatic lines at 18.5 times the rated pressure shall be conducted.

17.3 STATION EARTHING

a) Check soil resistivity

b) Check continuity of grid wires

c) Check earth resistance of the entire grid as well as various sections of the same.

d) Check for weld joint and application of zinc rich paint on galvanised surfaces.

e) Dip test on earth conductor prior to use.

17.4 AAC/ ACSR STRINGING WORK, TUBULAR BUS WORK AND POWER CONNECTORS

a) Physical check for finish

b) Electrical clearance check

c) Testing of torque by torque wrenches on all bus bar power connectors and other accessories.

d) Millivolt drop test on all power connectors.

e) Sag and tension check on conductors.

17.5 **ALUMINIUM TUBE WELDING**

a) Physical check

b) Millivolt drop test on all joints.

c) Dye penetration test & Radiography test on 10% sample basis on weld joints.

c) Test check on 5% sample joints after cutting the weld piece to observe any voids etc.

17.6 INSULATOR

Visual examination for finish, damage, creepage distance etc.

17.7 All pre/commissioning activities and works work for substation equipment shall be carried out in accordance with owner's "Pre- Commissioning procedures and formats for substation bay equipments" by the contractor. This document shall be provided to the successful contractor during detailed engineering stage.

ANNEXURE – A

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

ANNEXURE-B

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 CARDINAL conductor:

ITEM	DESCRIPTION	UNIT	DATA
1.	ACSR "Cardinal"		
1.1	Conductor size	mm^2	547.3
1.2	Conductor type		ACSR Cardinal
1.3	Number and size of wires		
1.3.1	Aluminium	No.	54
		Dia mm	3.38
	1st Aluminium Layer	No.	11
	2nd Aluminium Layer	No.	18
	3rd Aluminium Layer	No.	24
1.3.2	Steel	No.	7
		Dia mm	3.38
	Core Steel	No.	1
	1st Steel Layer	No.	6
1.4	Cross section		
1.4.1	Aluminium	mm^2	484.50
1.4.2	Steel	mm^2	62.81
1.4.3	Total	mm^2	547.3
1.5	Conductor diameter	mm	30.42
1.6	Ultimate strength	Kg	15,381
1.7	Standard mass of conductor	Kg/Km	1833
1.8	Electrical D.C. resistance at 20°C	Ohm/Km	0.05979
1.9	Standard unjointed length on reel	m	2,000
1.10	Modulus of Elasticity	Kg/Sq mm	7,036
1.11	Mass of zinc coating	Gm/Sq.m	250
1.12	Co-efficient of Linear Expansion	per°C	19.3×10^{-6}
1.13	Direction of Lay of outer	-	Right Hand
1.14	Standards	BS 2015 PART 2 IEC 1089/IS 398 PART 2	

ANNEXURE-B

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	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**	%	±5
	length		
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%	

Harijan

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

ANNEXURE-C

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

5. Test Records:

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

a) Background noise before and after test.

b) Detailed procedure of application of test voltage.

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

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

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

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

ANNEXURE-D

MONITORING, TESTING AND ANALYZING EQUIPMENT

1. Online monitoring Equipment (Dissolved Gas Analyzer)

Technical Specifications

Application										
Online monitoring of fault gases, air components and moisture in transformer insulating fluids.										
Technology										
Gas measurements	Proprietary chromatographic method									
Gas extraction	Oil-immersed Teflon® tubing									
Moisture measurements	Oil-immersed relative saturation (RS) sensor									
Communications	Electrical isolation rated for substation environments									
Performance										
	H_2	CO	CH_4	C_2H_2	C_2H_4	C_2H_6	CO_2	O_2	N_2	H_2O
Lower detection limit (LDL)	ppm **1)**									2 ppm, or 2% RS
	0.5	10	0.2	0.2	0.2	0.2	15	500	2,000	
Range 1)	ppm									Saturation, or 100% RS
	0 - 20,000	0 - 30,000	0 - 100,000	0 - 100,000	0 - 200,000	0 - 200,000	0 - 100,000	0 - 100,000	0 - 150,000	
Accuracy 2)	(LDL plus X% of reading) ppm									3 ppm, or 3% RS
	X=5	X=5	X=5	X=5	X=5	X=6	X=5	X=15	X=15	
Repeatability	(LDL plus Y% of reading) ppm									2 ppm, or 2% RS
	Y=3	Y=3	Y=3	Y=3	Y=3	Y=4	Y=3	Y=10	Y=10	
Resolution at LDL	ppm									1 ppm, or 1% RS
	0.5	2	0.2	0.2	0.2	0.2	5	100	1,000	
Measurement interval	User configurable: 80, 160 and 240 minutes. Conditional cycle on alarm.									6 seconds
Step response (typical)	In 80 minutes: 95% H_2; 90% CO, CH_4, CO_2, O_2, N_2; 80% C_2H_2, C_2H_4, C_2H_6									95% in 20 minutes
Reliability										
Gas management	Continuous monitoring of carrier and calibration gas pressure to detect and report gas leak errors and to predict cylinder replacement time									
Enclosure and oil temperature conditioning	Improves measurement accuracy and extends the lifetime of internal components									
Power interruption protection	250 ms advanced power loss system									
Expected operating life (EOL)	> 15 years									
Operation										
Operating temperature range	-50 to +55 ºC; cold start -50 ºC									

Storage temperature range	-40 to +75 ºC
Operating oil temperature range	-40 to +120 ºC
Operating oil pressure range	Full vacuum to 40 psi
Operating humidity range	0 - 100% RH
Storage humidity range	5 - 95%, non-condensing, with caps installed on the carrier gas inlet and outlet of the monitor
Elevation range	Up to 4,000 m
Construction	
Width x height x depth	Instrument: 610 x 489 x 337 mm (24 x 19 x 13.3 in.)
Weight	Instrument: 45 kg / 99 lbs
Enclosures	Instrument: 304 S.S., gauge 16, lockable Carrier gas manifold: 304 S.S., gauge 14, lockable option
Oil circulation	Anti-cavitation reciprocating pump, 10 - 60 ml/min.
Oil flow monitoring	System with low flow error
Oil lines	⅜ in. OD stainless steel
Air bubble elimination	Intelligent Bubble Trap
Enclosure temperature conditioning	Thermoelectric feedback
Oil temperature conditioning	Passive heat exchanger plus thermoelectric feedback
Cooling	Forced air
Equipment protection	Thermal cut-off fuse (77 ^{O}C), over-current mains fuse
Oil sampling installation	External quick-connect port plus sampling accessories
Installation	
Calibration	On-board NIST traceable calibration gas, automatic calibration, aluminum cylinder.
Carrier gas requirements	99.9999% He, 3600 psi maximum
Maintenance	Visual inspection every 12 months Carrier gas replacement every 48 months Calibration gas replacement every 48 months
Electrical entry holes (standard)	5 x 22.2 mm / 0.875 in. diameter
Commissioning time	5 hours installation, plus 4 - 12 hours before first readings
Mounting	Shock mounts
Power requirements (no selection required)	100 - 240 VAC ±10% 4) , 50 - 60Hz, 1Ø, 350W 100 - 220 VDC ±10% 4), 350W / 10 A minimum client disconnect breaker
Power conductor size	Max. 2.05 mm / AWG 12
Oil supply line length	1.5 - 10.5 m / 5 - 35 ft
Oil return line length	1.5 - 10.5 m / 5 - 35 ft
Communication and Data	
Front panel interface	English 256 x 64 pixel display, vacuum fluorescent, day/night, screen-saver Three weatherproof, UV resistant buttons Menu functions for readings, alarms, databank, set-up and maintenance
Communication	SCADA: Modbus, DNP3 Level 2, Optional IEC 61850 kit Time Synchronization: SNTP HTTP: Manufacture's Web Server Integrator: Manufacturer's System Protocol)
Local communication port	USB 2.0 (cable provided)

Isolated communication ports (5 kV impulse, 2.6 kVAC)	RS-485, RS-232, 2 x copper Ethernet, *See options
Isolated analog ports (5 kV impulse, 2.6 kVAC)	1 assignable 4-20 mA input, *See options
Measurement alarms	Programmable dual-level and trend alarms for all readings
Relay outputs (250VAC, 5A; 48VDC, 1.5A)	5 NO/NC contacts assignable for set-up, self-test and measurement alarm conditions, *See options
Data storage	at least 8 years
Self-diagnostics	190 error codes with intuitive descriptions and recommended client actions
Interface Software	
	English, French, Simplified and Traditional Chinese Local and remote configuration, maintenance, data downloads and diagnostic downloads
Platforms	Windows XP / Vista / Windows 7 / Windows 8 / Windows 10
DGA data management and diagnostics	Software integrates DGA data from monitors and portable analyzers with laboratory oil quality data. Diagnostic tools for fleet wide transformer health management (sold separately).
Regulatory	
CE marking	Low Voltage Directive 2006 / 95 / EC EMC Directive 2004 / 108 / EC WEEE Directive 2012 / 19 / EC RoHS Directive 2011 / 65 / EC
EMC (Electromagnetic Compatibility)	IEC/EN 61326 IEC/EN 61000-6-5 IEC/EN 61850-3 FCC part 15 (US) Class A, ICES-003 (Canada)
Electrical safety	IEC/EN 61010 IEC/EN 60255-27
Ingress protection	IEC/EN 60529, IP 56
Shipping	
Gross weight	Instrument: 56 kg / 124 lbs Standard accessories: 9 kg / 20 lbs
Packaging dimensions	Instrument: 775 x 700 x 521 mm (30.5 x 27.5 x 20.5 in.) Standard accessories: 560 x 510 x 270 mm (22 x 20 x 10.5 in.)
Options (may be purchased as factory installed)	
	IEC 61850 Ethernet communication kit Ethernet outdoor connectivity kit (copper) Optional client communication cards (choose 2 maxima per Monitor); • Optical Ethernet card: Multimode, SC connector, 100BASE-FX, 1300 nm • 4-20mA card: 10 outputs plus 2 inputs (5 kV impulse, 2.6 kVAC) • Relay card: 5 NO/NC outputs (250 VAC, 5A; 48 VDC, 1.5A)
Accessories	

	Mounting Stand Precision oil temperature probe (4-20mA) All metal stainless steel flexible oil lines Low-temperature insulated oil lines Isolation valves Radio modem (RS-485) Cellular modem (Ethernet) Sun shield to reduce thermal load in extreme hot environments Breather drain kit for humid environments

2. Technical Specification of Three phase Relay Test Kit

The Test Kit should be versatile solution for testing protection relays and schemes. This power system simulator performs the simplest through the most complex tests.

1. It is required to test poly phase and single phase electro mechanical, solid state and numerical relays
2. Should be computer based fully automatic type and all functions shall be computer controlled.
3. Should have Modular design.
4. Should be able to perform steady state, dynamic state, transient simulation tests and automated (computer controlled) testing of all types of relays, testing of protection equipment using any previously recorded or any generated transient signal
5. Should be able to provide voltage and current sources along with logic inputs, outputs and times in a single compact unit
6. Shall have minimum six independent controlled current sources and four independent controlled voltage sources. Six voltage sources will be preferred.
7. Kit shall have multiple ranges on a current source
8. The kit shall deliver constant power across all the current ranges
9. The output current and voltage sine waves should be generated digitally to increase test accuracy and reduce the testing time
10. Independent control of magnitude, phase angel and frequency/harmonics of all sources should be available for testing and simulate power system condition
11. Shall have adequate isolated inputs and isolated outputs. Outputs should be user configurable for NO (Normally Open) or NC (Normally Closed) configuration. Inputs should be able to sense contact or voltage. Inputs and outputs should be able to withstand 250 V AC/DC. Input and output response time should be 100 micro seconds for semiconductor switches or 10 m sec for relays.
12. Must be able to test high burden electro mechanical earth fault relays, differential relays to modern multifunction numerical microprocessor based protection relays without the need for additional instruments
13. Should work as a simulator. It should be provided with necessary software to generate dynamic state simulation data and it should be possible to replay digitally recorded faults and COMTRADE compliant transient data
14. Shall be fully electronically over load and short circuit protected
15. The test equipment shall have built in DC source
16. Shall be supplied with a calibration certificate traceable to Institute of Standard and Technology
17. The specification of the instrument shall remain stable irrespective of the change in temperature, power factor, input voltage, frequency changes.

FEATURES

- Performs standard relay calibration and verification testing of high burden and microprocessor relays
- Analog testing of 1A and 5A protection devices
- Performs state simulation and transient testing
- Tests 0.2-class metering CTs and transducers
- Implements end-to-end testing of communications-based schemes with GPS time syncing
- Maximum of 12 Sources (six voltages, six current) configurable for bench testing and proof-of-concept testing for complicated relaying schemes
- Delivers full VA power with resistive, inductive and capacitive loads at maximum current rating (6x35, 3x70, 1x210 amps)
- Wi-Fi capable (optional)
- Control all sources from a tablet device for basic, manual protection testing

3. Technical Particular of Portable DC earth fault locator

S.No.	Particulars	Technical Parameters
1	Application	To identify the earth faults on live floating DC system in the Power Station/Substation without isolating any circuit.
2	Scope	This specification covers the design, manufacture, testing, supply & demonstration of operation of electronic DC Earth Fault Locator system capable of locating and pin-pointing earth faults in live upto 300 V DC as well as dead DC network. The offers shall include all accessories even though not specifically mentioned in this specification, but which are essential for satisfactory operation of the equipment offered as a whole.
3	Diagnosis method	On line, on live battery system. The kit shall be able to locate earth faults on live 220 V /110 V floating DC system, in EHV substations without isolating any circuits. Further the kit shall be able to detect the faults such as DC source mixing fault, Multiple location DC earth fault, High Resistance fault, Dead fault. Instrument shall have Noise / Harmonics free performance.
4	Multiple Location Fault	The equipment should be capable to identify fault even in the condition of multiple location earth fault.
5	Working of the DC Earth Fault Locator System	The equipment shall be suitable for use on underground power plant/switchyard circuits charged with voltage. It shall have noise free performance. The fault should be indicated by suitable audio-visual means without pre-calibration or parameter input on any other control and single button operation to check the fault is preferred.
6	Interference	Instrument during operation shall not cause any interference with the operation of sensitive protective relays, control equipment and communication network of the plant/substation. It shall be immune to 50 Hz substation environment as well. Maximum frequency of a transmitter for signal injection should be less than 20 Hz.
7	Range of operation	The equipment shall have fault detection range up to 400 kΩ in a charged DC system and function up to a distance of 1 KM. It shall be accurate enough to detect & pinpoint fault in the said range.
8	Power pack	Its power pack shall include built-in re-chargeable battery suitable for use from 230V, 50Hz AC mains through external adaptor or built-in charger.
9	Back Up	The equipment is provided with high back up more than 7 hours during critical fault diagnosis without any interruption
10	Sensitivity	Receiver sensitivity with Big Probe (50mm dia) & Small probe (15 mm dia) shall detect a small current of atleast 300 micro amps

11	Capacitive balance	The instrument should balance the capacitance of control cables automatically and the user should not be required to adjust any parameter for balancing the capacitance.
12	Voltage	The kit Source Voltage should not inject more than 10% of the DC System Voltage. i.e. less than 24 volts for 240 volts DC System. Maximum signal voltage of transmitter should be equal or less than 24 volts.
13	Digital display	Instrument should have digital display to indicate the Injected Voltage & currents
14	Provision to Adjust the signal strength of the Transmitter	Instrument should have provision to adjust the signal strength of the Transmitter to identify the DC earth leakages in highly induced noisy areas.
15	Short Circuit Current	The kit should inject no more than 3mA in order to avoid mal-operation of sensitive relays of protection system.
16	Sensors	The sensors should be suitable for use on the multicore control cables laid in the underground power station and over ground substation.
17	Calibration	The calibration of instrument should be stable over long periods of time without requiring calibration checks and adjustments.
18	Dual Battery System	The equipment shall be able to function satisfactorily in Dual Battery Bank System also.
19	Mixing of sources	The instrument shall find mixing of DC Sources, if any, in dual battery bank system without any need for manual capacitance balancing.
20	Minimum manual control	The kit should be simple to operate with very few controls and shall be automatic as far as possible.
21	Receiver waveform	Receiver unit should have provision to show the Graphical Trend wave form, Fault severity information to confirm the fault signals. It helps user to differentiate the between fault & Noise signals.
22	Service	The offered equipment shall be complete with all components necessary for their effective and trouble free operation available in India.
23	Environment	The instrument shall be highly rugged, light-weight, portable and of 'tropicalized' construction to enable it to withstand rough use under field conditions. It shall function reliably under ambient temperature range of 0-45 degree C and humidity up to 80% (noncondensing). The instrument kit shall conform to IP-67 degree of protection.

4. Technical Specifications for Earthing Resistance Tester

1) Voltage output: 70V P&P (At a test frequency different from 50Hz to avoid electromagnetic frequency)
2) Test frequency: 128 Hz
3) Resistance Range: 0.01 to 19.99 KΩ's(Auto Range and Digital)
4) Measurement Accuracy: ±2%
5) Resolution: 0.01Ω
6) Short circuit current: 20 mA
7) Principle: 4 peg method /for soil restivity and 3 peg method / Fall of potential method
8) Automatic suppression of interference
9) Should be able to test Earth Resistance of all points in the power station
10) The system should have Induction suppression filters & special filters designed for Power frequency leakage current & its harmonics to provide a rock steady & reliable, repeatable reading in power station environment & high accuracy.
11) Display: 4 & 1/2 digit Digital display

12) Protection control: Against Short circuit, over voltage, kit should have auto cut off features to protect the instrument

13) In built 12V 7AH rechargeable battery with advanced SMPS for long Duration usage

14) Battery charging: 230+/- 10% AC 50 Hz +/- 10%

15) Accessories: 4 pegs, suitable cables for high frequency operation carrying case Instruction manual and others

B) 5. NON CONTACT VOLTAGE DETECTOR ALONG WITH 5 METER TELESCOPIC FIBER GLASS ROD

1. SCOPE

1.1 Supply of High Voltage Detectors suitable for detection of liveness of 230V to 765 KV overhead line (bare conductor). The HV Detector starts producing visual indication as well as audio annunciation indicating that the line is LIVE and not safe to earth and carry any operation. As well High voltage detector should indicate the induced voltage presence on bare conductors.

2. TECHNICAL PARAMETERS:

Sl. No.	Description	Specification
1.	Standards Applicable	The performance and testing of the High Voltage Detector shall conform to the following Indian / International standards. Application of Non-contact voltage detector are used in Power Transmission lines, Distribution Lines & sub stations to detect the presence of the voltage in charged 230V to 765kV level on bare conductors & also detect the induced voltages in un charged substation Bays, Bus bars, Transmission Line, Distribution lines for safe operation do the maintenance activities.
2.	Detection Range	The High Voltage Detector should have the unique capability to warn the user of the presence of high voltage from a safe distance and must be exceptionally sensitive **1.5 meters for 66KV,** **2.2 meters for 132KV,** **3 meters for 220KV a** **4 meters for 400KV & 5 Meters from 765kV Voltage level.**
3.	Functions	1. Non-contact voltage detection 2. Induced voltage presence on un charged Lines
4.	Selectable Voltage range	Sensing voltage selector- 230V/11kV/33kV/66kV/132kV/220kV/400 KV & 765kV
5.	General & Constructional Requirements	1. High Voltage Detector shall be designed and constructed in such a way so as to avoid any danger to the operating personnel during use and under normal conditions. It should have the capability to warn the user by audio annunciation as well as visual indication of the presence of voltage from a safe distance.

Sl. No.	Description	Specification
		2. Bright high intensity LEDs (preferably red coloured) to provide clear visual indication even in unfavourable daylight conditions. A buzzer produces a loud beep which is audible even in noisy back grounds. 3. The High Voltage Detector should have Self-test button to test battery and proper functioning of HV detector and the facility of easy replacement of the power supply battery. 4. The High Voltage Detector should have universal connecting link for the attachment of the Telescopic rod. 5. The Telescopic rod should be of non-allergic, Premium Quality Fiber Glass Material with upper stick foam filled (High voltage tested material) with Piece to piece self-Locking arrangement. 6. All insulating material used in the construction of High Voltage Detector shall be no hygroscopic, non-ageing and of tested quality. 7. The detector should not have any external accessibility to change the voltage or the sensing distance to ensure the safety of the user.
6.	Detection Indication	1. The High Voltage Detector shall give the indication with High Intensity LED's with flashing arrangement there by providing the suitable indication in day light. 2. The High Voltage Detector shall give audible sound for the presence of live line so that it can be suitably used in populated and noise areas for easy operation.
7.	Self-Diagnostic Feature	The High Voltage Detector shall be capable of performing complete self-diagnostic check in off-line mode with buzzer & flashing LED to ensure the correct working of the probe.
8.	Power Supply	9V Battery or Rechargeable & replaceable Battery suitable to be charged through a single phase, 230V Supply.
9.	Suitable Carrying Case	The High Voltage Detector with accessories shall be supplied with the carrying case to be carried by the operating person easily.
10.	Environment	Temp: -10-60 Deg C. Humidity: 90% non-condensing The test kit shall meet the EMI/EMC requirement as per relevant IEC/IS/equivalent standard.
11.	Certifications	The tenderer shall furnish detailed type test certificates of the offered Instrument for all the tests as per relevant Indian Standard/ CPRI / International standards from NABL accredited Laboratory. With respect to High Voltage Test Techniques: 1. Measurement of leakage current before Humidity test 2. Humidity test

Sl. No.	Description	Specification
		3. Measurement of leakage current after Humidity test 4. Power Frequency Voltage Withstand test from CPRI Lab or any other NABL accredited 5. Insulation Resistance test 6. IP 54 rating for field usages or better

STRUCTURE

Table of contents

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 grammes /sq. m for anchor bolts/foundation bolts and for structural members. One additional nut shall be provided below the base plate which may be used for the purpose of leveling.

Contractor shall provide suitable arrangement on the equipment support structures wherever required to suit fixation of accessories such as marshalling boxes, MOM boxes, Control Cabinets, Junction box, surge counter, etc. in the equipment structure fabrication drawings.

2.0 DESIGN REQUIREMENTS FOR STRUCTURES

2.1 For design of steel structures loads such as dead loads, live loads, wind loads etc. shall be based on relevant British standard Codes (BS Codes) / 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 kgs. 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 structure are to be supplied by the Contractor.

7.4 All foundation bolts shall be fully galvanised so as to achieve minimum 610 grammes Per Sq.m. of Zinc Coating as per relevant British standard Codes (BS Codes) / 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.