NEPAL ELECTRICITY AUTHORITY
(An Undertaking of Government of Nepal)

Pangtan 132 kV Substation Project

TURNKEY BIDDING DOCUMENTS
FOR
SUPPLY AND CONSTRUCTION OF PANGTAN SUBSTATION PROJECT

TENDER NO: OCB No. PMD/EGMP/PSSP-077/78-01

VOLUME – II

TECHNICAL SPECIFICATION FOR 132/33/11 kV PANGTAN SUBSTATION AND ASSOCIATED 132 kV GIS BAY EXTENSION WORKS AT BAHRABISE SUBSTATION

(April 2021)

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VOLUME – II OF III

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SECTION - 1

GENERAL INFORMATION AND SCOPE

FOR

132/33/11 kV PANGTAN SUBSTATION AND ASSOCIATED 132 kV GIS BAY EXTENSION WORKS AT BAHRABISE SUBSTATION

CHAPTER 1 – PROJECT SPECIFIC REQUIREMENT (PSR)

FOR

132/33/11 kV PANGTAN SUBSTATION AND ASSOCIATED 132 kV GIS BAY EXTENSION WORKS AT BAHRABISE SUBSTATION

CHAPTER 1-Project Specification Requirement

1. GENERAL

Nepal Electricity Authority is establishing new 132/33/11 kV Substation at Pangtan, Sindhupalchok and associated GIS bay extension works at under construction 400/220/132 kV substation at Bahrabise, Sindhupalchok. The above project is being funded by ADB.

This specification describes the requirements for construction of the substations on a turnkey basis.

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

1.1 Associated Transmission System:

The following system is envisaged under Pangtan 132/33/11 kV Substation Project

1. Construction of 132/33/11 kV New AIS substation at Pangtan.
2. Construction of GIS line bays and associated works at 400/220/132 kV Bahrabise Substation.

2. INTENT OF SPECIFICATION

2.1 The specification includes design, engineering, manufacture, fabrication, testing at manufacturers works, delivery, unloading at site, storage, erection, testing and commissioning at site of the complete 132 kV switchyard, 33/11 kV outdoor/indoor equipments, 132/33 kV, 30 MVA Three Phase Power Transformer, 33/11 kV 6/8 MVA 3 ph Transformer, associated civil works, internal roads, drains, necessary switchyard buildings etc, 132 kV GIS line bays and associated works, Control & protection, Digital protection Coupler, FO based communication system and, other electrical and mechanical auxiliary systems and construction of residential buildings on turnkey basis.

2.2 A new AIS substation at Pangtan and two nos GIS line bays is to be constructed in the Bahrabise Substation which is under construction. New Pangtan Substation and Bahrabise substation is to be interconnected by 132 kV double circuit transmission line which is not under the scope of this project. In this Chapter, specification and requirements of works mentioned for GIS is solely applicable for Bahrabise SS as there is no scope of GIS works required at Pangtan SS. The Contractor is require to design and construct the substations as per the site condition based on the indicative layout drawings provided in **Section 24 Tender Drawings.**

2.3 It is the intent of this specification to describe primary features, materials, and design & performance requirements and to establish minimum standards for the work.

2.4 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.

As the Pangtan substation site is located at an attitude of 2,200 m, higher Basic Insulation Level (BIL) shall be required. If type tested equipment with the above BIL is not available, Bidders may propose equipment with higher BIL. Following may be the alternatives as these equipments are easily available:

a) 220 kV grade equipment for 132 kV system.

b) 52 kV grade equipment for 33 kV system.

Civil Works	External electrical Works	Transformers	Switchgear	Design and Integration
Access road. Transformer bays.	All equipment necessary to connect the new substation to the 132 kV supply	132/33 kV and 30 MVA 33/11kV, 6/8 MVA. Rating applicable to both secondary voltages.	132 kV AIS switchboard as described in the specification	The substation shall be designed by the contractor and shall follow NEA requirements.
132 kV GIS bay extension works	All equipment necessary to connect the Bahrabise substation to the 132 kV through GIS bay extension works			All equipment and protection shall be integrated by the contractor and commissioned in conjunction with NEA.
11 kV Switchgear room			12 kV switchboard as described in the specification	The substations shall be constructed as fully integrated turnkey packages.
Associated control rooms, battery room,				
Other facilities required by NEA and described in the specification				

3. SCOPE OF WORK

A. **132/33/11 kV Pangtan (New) Substation with the following bays as per Single Line Diagram & as indicated in BPS:**

- 2 nos. 132 kV bays for outgoing feeder towards Bahrabise 400/220/132 kV Substation.
- 1 Nos 132/33 kV, 30 MVA Transformer Bay
- 1 no. 132 kV Bus Coupler bay
- 33 kV line bays for 2 no feeders
- 12 kV Indoor Switchyard Panels for 4 nos outgoing feeders.

B. **400/220/132 kV Bahrabise Substation as indicated in BPS:**

- 2 nos. 132 kV GIS bays
- Associated Bay extension works for 2 nos. 132 kV GIS bays.

4. DETAILED SCOPE OF WORK

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

4.1 132/33/11 kV Pangtan Substation:

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

A. 132 kV AIS SYSTEM

Pangtan 132 kV Substation shall have 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 equipments with foundations.

Quantity of equipments shall be as per BPS. Description of **each type** is as follows:

a) 145 kV, 2000 A, 31.5 kA, 1 sec, 3 phase SF6 Circuit Breaker complete will all accessories for bus coupler.

b) 3 Nos.145 kV, 1250 A, 31.5 kA, 1 sec, 3 phase, and SF6 circuit breaker complete with all accessories (for 132 kV side of power transformer & 132 kV lines).

c) 2 sets 145 kV, 1250 A, 3 phase center break disconnecting switch with grounding switch complete with all accessories as per specification.

d) 2 sets 145 kV, 2000 A, 3 phase center break disconnecting switch without grounding switch complete with all accessories as per specification.

e) 2 sets 145 kV, 1250 A, 3 phase center break disconnecting switch with grounding switch complete with all accessories as per specification.

f) 10 sets 145 kV, 1250 A, 3 phase center break disconnecting switch without grounding switch complete with all accessories as per specification.

g) 12 Nos. 145 kV, 50 VA, 132/√3/110/√3 kV, Class 0.5/3P Voltage Transformer complete with all accessories as per specification.

h) 9 Nos. 145 kV, 30 VA 5 core current transformer for Line & Bus coupler complete with all accessories as per specification.

i) 3 Nos. 145 kV, 30 VA 5 core current transformer for power transformer complete with all accessories as per specification

j) 9 Nos. 120 kV, 10 kA Surge arrester (1 phase) including discharge counter complete with all accessories as per specification

k) 1 set 36 kV, 2000 A, 25 kA, 1 sec, 3 phase, Vacuum circuit breaker for incomer complete with all accessories

l) 3 sets 36 kV, 1250 A, 25 kA, 1 sec, 3 phase, Vacuum circuit breaker complete with all accessories

m) 1 set 12 kV Transformer incomer module (2000A) (IP-2) with all accessories as per specification

n) 4 sets 12 kV Line Module (1250A) (IP-1) with all accessories as per specification

o) 1 set 12 kV PT Module (1250A) (IP-3) with all accessories as per specification

p) 2 sets 36 kV, 1250 A, 3 phase disconnecting switch with grounding switch complete with all accessories as per specification.

q) 1 set 36 kV, 1250 A, 3 phase disconnecting switch without grounding switch complete with all accessories as per specification.

r) 4 sets 36 kV, 800 A, 3 phase disconnecting switch without grounding switch complete with all accessories as per specification.

s) 9 Nos. 36 kV, 50 VA, 33/√3/110/√3 V potential transformer complete with all accessories as per specification

t) 3 Nos. 36 kV, 30 VA 3 core current transformer complete with all accessories as per specification for 33 kV side of Power transformer.

u) 3 Nos. 36 kV, 30 VA 3 core current transformer complete with all accessories as per specification for incomer.

v) 6 Nos. 36 kV, 30 VA 3 core current transformer complete with all accessories as per specification for feeders.

w) 9 Nos. 30 kV, 10 kA Surge arrester (1 phase) including discharge counter complete with all accessories as per specification

x) 9 Nos. 9 kV Surge arrester (1 phase) including discharge counter complete with all accessories as per specification

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

a) 1 set 132/33 kV transformer control and relay panel complete with all accessories as per technical specifications for both HV and LV sides.

b) 1 set 33/11 kV transformer control and relay panel complete with all accessories as per technical specifications

c) 1 set 132 kV Bus bar/ Bus coupler control and relay panel complete with all accessories as per technical specifications

d) 2 sets 132 kV line control and relay panel complete with all accessories as per technical specifications

e) 2 sets 33 kV line control and relay panel complete with all accessories as per technical specifications

C. Control and Power Cable

a) 12 kV, 400 SQmm, single core XLPE power cable including termination joints for both ends with all accessories complete from LV side of 33/11 kV power transformer to indoor 11 kV switchgear room.

b) 12 kV, 240 SQmm, three core XLPE power cable armoured including termination joints for both ends , double pole structure and with all accessories complete for 4 Nos of outgoing feeders.

c) 33 kV HT armored Copper Cable (1CX240 SQmm) for 2 nos of 33 kV feeder line along with accessories including flexible pipe and termination equipments and structure at both end

4.2 145 kV GIS and AIS SYSTEM AT BAHRABISE SUBSTATION

The 145 kV SF6 gas insulated switch gear shall have double main bus bar arrangement. The Switchgear (50 Hz) shall be complete with all necessary terminal boxes, SF_6 gas filling, interconnecting power and control wiring, grounding connections, gas monitoring equipment & piping and support structures along with base plate & foundation bolts for fixing the switchgear with raft foundations.

The SF6 gas insulated switchgear shall be of the indoor metal enclosed type. Quantity of GIS modules shall be as per BPS. Description of **each type of GIS module** is as follows:

(A) Set of three phase, each comprising of :

a) 2 sets, 145kV, SF6 GIS Bus Bars Module with Extension Module [Module description as per Technical Project specification]. Extension Module shall be compatible with existing GIS and no separate payment shall be made for the extension module/interfacing module/adaptor module.

b) 2 sets, 145kV, SF6 GIS Line bay Module [Module description as per Technical Project specification].

c) SF6 Gas Insulated Bus Duct (GIB) outside GIS hall including Bus Duct support structure and associated accessories

d) 145 kV, SF6/Air Bushing for Connecting GIS to AIS along with support structure.

(B) 132 kV AIS equipments

e) 6 Nos. 120 kV Surge Arrestors (1-Phase).

f) 6 Nos. 8800pF, 145 kV Capacitive Voltage Transformer (1-Phase)

(C) Control and Power Cable

a) 2 km Power Cables (145kV grade);1Cx800 sq mm (XLPE) copper cable for line bay along with termination arrangement as per TS

(D) 145 kV Gas Insulated SF6 to Air Termination:-

If the bidder intent to use 132kV power cable for connection with line / Transformer feeder module outside of GIS hall, then the bus duct will not be applicable. The bidder must take the approval of the Employer. (If allowed as per BPS)

A tentative layout / GA drawing of the switchyard is enclosed with this specification for Bahrabise Substation. The GIB duct length shall be optimized further without affecting the switchyard arrangement and bay orientation and also any of the functional requirements specified. Detail design/drawing shall be provided to the successful bidder later.

4.3 Complete Sub-station automation system (SAS) including complete hardware and software along with associated equipment for present 132 kV, 33 kV & 11 kV bays as per Single line diagram (bay as defined in Technical Specification, Section 15 - Substation Automation). Further, the contractor shall also supply necessary BCUs for monitoring & control of Auxiliary system.

4.4 Complete relay and protection system as per section –Control and Relay panels including Bus Bar Protection for 132 kV Double Bus Bar Switching Scheme. Low Impedance numerical impedance relay with centralized type scheme is acceptable for 132 kV system.

4.5 One nos. 300 KVA, 33/0.400 kV, LT Transformers along with associated equipments. 300 KVA, 33/0.400kV auxiliary transformer shall be located in LT station area and HT side shall be connected with the 33 kV bay in the Indoor Switchgear through cable.

4.6 Fire Protection System for all Building and transformers as per technical specification. HVW spray system is envisaged for 132/33 kV Transformer.

4.7 Lattice or pipe structures (galvanized): Towers, Beams, LMs and equipment support (Pipe Type) structure shall be provided as per design and drawings to be developed by the Contractor.

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

4.9 Air Conditioning System for control room cum administrative building, 12 kV switchgear room, staff quarters and panel room of GIS hall

4.10 Ventilation system for control room cum administrative building, 12 kV switchgear room and panel room of GIS hall for GIS hall.

4.11 LT switchgear (AC/DC Distribution boards) considering present bays and future 132 kV bays including insulating Mats.

4.12 Batteries & Battery Chargers.

4.13 33 kV HT outdoor Switchgear for 2 lines, 12 kV line module with all accessories for 4 nos bays and 12 kV PT module with all accessories as per specification.

4.14 1.1 kV grade Power & Control cables along with complete accessories, including Cable for oil filtration units.

4.15 33 kV HT cable along with jointing Kit and other accessories for connection of LT Transformers and interconnection of LV side (33 kV) of 132/33 kV Transformer to Indoor LT Panel.

4.16 12 kV, 400 SQ mm, single core XLPE power cable including termination joints for both ends with all accessories complete from LV side of 33/11 kV power transformer to indoor 11 kV switchgear room and 12 kV, 240 SQ mm, three core XLPE power cable armored including termination joints for both ends, double pole structure and with all accessories complete for 4 Nos of outgoing feeders.

4.17 Lighting system for outdoor Switchyard, Substation area, Entrance & Internal Road, Boundary wall periphery, along the approach road (with support where necessary), Staff quarter area etc as per technical specification and Emergency DC lighting system complete for switchyard, entrance and staff quarter area.

4.18 Galvanized E.H.S. steel wires of size 7/3.35 for lightning shield wire in take-off and internal structures and Earthing of substation with conductors, electrode, grounding materials complete with all accessories complete with all accessories to complete the specified scope of works . Measurement of earth resistivity is in the scope of Contractor.

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

Pangtan-Bahrabise-132 kV D/C T/L

The specification of Digital Protection coupler is attached as Section 19- Digital Protection Coupler.

4.20 AIS CVT and LA

4.21 FOTS based Telecommunication system

4.22 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/equipments including future at Both the Pangtan and Bahrabise substations for all voltage level systems.

4.23 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.

4.24 Design, engineering, manufacture, testing, supply including transportation, insurance & storage at site of mandatory spares.

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

(a) Foundation of 132/33 kV and 33/11 kV Transformers along with jacking pads, rail track, Oil soak pit, sump pit, pylon support and fire resistant wall (s) as required.

(b) Construction of One (1) Control Building, Two (2) storied 2 Nos. staff quarter buildings having two (2) flats on each floor (Total eight (8) flats) as per specification Underground water tank, pump room shed. The design of the staff quarters building shall be of Nepalese architecture.

(c) Construction of Guard House Building at Main Gate of substation boundary wall

(d) Construction of septic tank & soak pit for control Room building, security room, Staff quarters.

(e) Foundation for structures of LM, 132 kV Towers, and equipment support structures 33 kV, 11 kV double pole structure and other equipments as per NEA norms.

(f) Foundation for Auxiliary LT transformers.

(g) Cable trenches outside control room building and GIS hall building along with covers and sump pits. The cable trench layout shall be prepared by the contractor.

(h) Cable trench crossings with roads, rail tracks, drains, etc.

(i) Switch yard and staff quarters Roads: All roads shall be as per specifications shown in GA drawing including culverts.

(j) Approach Road: The road shall be as per specifications with necessary works.

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

(l) Switch yard Chain link fencing and gates.

(m) Drain and culverts, Drain Layout shall be developed by the contractor based on various type of drains.

(n) All civil works including foundations associated with erection of SF6 gas insulated metal enclosed switchgear along with its SF6 ducts inside the building.

(o) Foundation for SF6 duct supporting structures (outside building), SF6/Air bushings. Foundation loads for GIS bus duct supports (Vertical, shear and moment) shall be provided with detailed calculation.

(p) Cable trenches inside GIS building & control room cum administrative building.

(q) External water supply arrangement for control room cum administrative building, Firefighting tank, staff quarters & guard house. Underground water tank of sufficient capacity as per requirement shall be constructed

(r) External sewerage system for control room cum administrative building, staff quarters & guard house.

(s) Foundation for lighting poles, panels and control cubicles of equipments wherever required

(t) Soil investigation,

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

(v) Pumps: Dewatering Pumps, booster pump for underground water tank of staff quarter.

(w) Vehicle Parking Sheds,

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

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

4.26 The bidders are advised to visit the substation sites and acquaint themselves with the topography, infrastructure and also the design philosophy. Before proceeding with the construction work of the new Sub-stations and substation under construction, the Contractor shall fully familiarize himself with the site conditions and General arrangements & scheme etc. Though the consultant/NEA shall endeavor to provide the information, it shall not be binding for the consultant/NEA 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 for civil works enclosed with tender drawings are for information only. However civil drawings shall be developed by the contractor as per his design.

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

4.28 Design of substation and its associated electrical & mechanical auxiliaries systems includes preparation of single line diagrams and electrical layouts including layout arrangement for transformers, foundation layout, cable trench layout, earthmat 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 and drawings, design of firefighting system and 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.

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

4.30 The technical specification for various equipments and works for different voltage levels have been standardized. Items, which are not applicable for the scope of this package as per schedule of quantities described in BPS, the technical specification for such items should not be referred to.

4.31 Specific exclusions

i) Employer's site office.

5. PHYSICAL AND OTHER PARAMETERS

5.1 Location of the Substations –

The substations (Pangtan & Bahrabise) of Nepal Electricity Authority are in the North-Eastern part of Kathmandu Valley

a)Altitude above sea level :

2200 m from MSL (Pangtan Substation) and 1203 m MSL (Bahrabise Substation)

b) Ambient Air Temperature :

40ºC(max)/ -10 ºC(min)

c)Average Humidity (in %) :

80 (max), 20(min)

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

e) Seismic Requirement for Substations: 0.15g (Horizontal peak acceleration value).

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

5.2 The substation area for:

Pangtan: 27,000 Sq.m, Stepped land, Google Map Coordinates: $27^0$53'36", $85^0$48'03"

Bahrabise: 80,000 Sq.m, Sloped and stepped land, Google Map coordinates: $27^0$43'26.26", $85^0$25'49.93"

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

S.NO.	Voltage Level	Fault Level Pangtan	Fault Level Bahrabise
1	132 kV	31.5kA for 1 Sec	31.5kA for 1 Sec
2	33 kV	25kA , 3 sec	25kA , 3 sec

6. SCHEDULE OF QUANTITIES

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

All equipments/items and civil works for which 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 not indicated, 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.

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 Owner.

7. BASIC REFERENCE DRAWINGS

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

7.2 The reference drawings, which form a part of the specifications, are given at Section-24, Tender Drawings. 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 Owner.

7.3 The auxiliary transformers shall be used to feed the substation auxiliaries. HT side of auxiliary transformer shall be connected through 33 kV HT cable to LT Panel. These auxiliary transformers should not be used for construction purpose. The detailed scheme is shown in the single line diagram.

8. ORDER OF PRECEDENCE OF DIFFERENT PARTS OF TECHNICAL SPECIFICATION

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

Section - 1	Project Specific Requirement	
Section - 2	General Technical Requirements	
Section - 3	Power and Distribution Transformers	
Section - 4	Circuit Breaker Outdoor	
Section - 5	Disconnecting Switches	
Section - 6	Instrument Transformers	
Section - 7	Lightning Arrester	
Section - 8	Control & Relay Panel	
Section - 9	11 kV Switchgear	
Section - 10	Station Auxiliary supply	
Section - 11	Battery & Battery Charger	
Section - 12	Grounding and Lightning System	
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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 equipments, requirement of individual equipment chapter shall prevail.

9. SPARES

Mandatory Spares

The Mandatory Spares shall be included in the bid proposal by the bidder. The prices of these spares shall be given by the Bidder in the relevant schedule of BPS and shall be considered for evaluation of bid. It shall not be binding on the Owner 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.

10. SPECIAL TOOLS AND TACKLES

The bidder shall include in his proposal the deployment 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 BPS. In addition to this the Contractor shall also furnish a list of special tools and tackles for the various equipment in a manner to be referred by the Employer during the operation of these equipment. The scope of special tools and tackles are to be decided during detail engineering and the list of special tools and tackles, if any shall be finalized**.**

11. FACILITIES TO BE PROVIDED BY THE OWNER

a. NEA shall make available the auxiliary HT power supply on chargeable basis at a single point in the Sub-station. The prevailing energy rates of the state shall be applicable. All further distribution from the same for construction and permanent auxiliary supply shall be made by the contractor. However, in case of failure of power due to any unavoidable circumstances, the contractor shall make his own necessary arrangements like diesel generator sets etc. at his own cost so that progress of work is not affected and NEA/Consultant shall in no case be responsible for any delay in works because of non-availability of power.

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

12. SPECIFIC REQUIREMENT

a. The Bidders are advised to visit Sub-stations site and acquaint themselves with 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 co-ordinate and obtain Electrical Inspector's clearance before commissioning. Any additional items, modification due to observation of such statutory authorities shall be provided by the Contractor at no extra cost to the Owner.

- 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 132/33/11kV bays under present scope at Pangtan and 132 kV bays at Bahrabise substations shall be integrated by the contractor with SIEMENS (Power 7) SCADA system installed at Master Station i.e. Nepal Electricity Authority Load Dispatch Centre (located in Siuchatar, Kathmandu). The integration shall include all hardware and software required at the Control Centre as well as necessary data base, display generation and upgrades for proposed control and monitoring of station and Network Analysis. The manufacturers of the existing SCADA system are:-

LDC facilities: Siemens Germany

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

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

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

i) Training at Manufacturer's works. The Contractor shall include in the training charges payment of per Diem allowance to NEA trainees @ USD 100 per day per trainee for the duration of training abroad towards accommodation, meals and other incidental expenses and to and fro economy class air ticket from Nepal to place of training. The duration of training shall be excluding travelling period.

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

1. Control & Protection and Substation Automation System: 5 Days. (3 Nos. Trainees)
2. GIS: 5 Days. (3 Nos Trainees)
3. Transformer: 5 Days. (3 Nos. Trainees)

ii) On Job Training in Nepal: The traveling and living expenses of Owner's personnel for the training programme conducted in Nepal shall be borne by the Owner.

The training shall be provided to Employer's personnel in the field of erection, testing, operation and maintenance at substation site as per following for 3 Nos. Trainees each:-

1. Control & Protection: 5 Days.

2. Substation Automation System including integration aspect of existing SCADA (of Siemens supplied SINAUT spectrum) at Load Dispatch Centre: 5 days.

3. GIS: 5 days.

4. Transformers - 5 days

g. 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.

h. 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.

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

j. One number each Energy meter for the record and revenue purpose is to be provided for each 132/33/11 kV bays (Bus coupler bays to be excluded) at Pangtan and Bahrabise substations under present scope of contract, meeting the requirement as specified at Section-8, Control and Relay panels..

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

l. Non CFC refrigerant shall be utilized for Air conditioning system

m. The layout drawing for connection arrangement of 132/33 kV Transformer at Pangtan 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

n. The switchyard panel room as detailed in section Sub-station Automation System is not required for GIS station. The contractor shall place their panels i.e. Bay level units, relay and protection panels, Digital RTCC panels, DPC panels etc. For 132 kV in respective GIS hall(s) or in a separate room in the GIS buildings. The room shall be air-conditioned and the supplier shall submit detailed heat load calculation during detailed engineering. Further, the temperature of enclosure /room shall be monitored through substation automation system by providing necessary temperature transducers.

o. In the Sub-station automation system, each gas tight GIS compartments shall be monitored individually per phase basis, as applicable. In case it is not possible to monitor the gas tight compartment individually, the contractor shall supply additional BCU without any additional cost implication to Owner.

p. The price of Bus-duct inside the GIS hall shall be integral part of the respective bay module and it will not be paid separately. However, the payment of bus-duct for outside the GIS hall along with support structure shall be paid as per running meters in line with provision of Bid Price schedule. Therefore, bidder is required to quote for 132 kV GIB (SF6 Gas insulated Bus Duct) of Line/Transformer feeder module required outside GIS hall with support structure and SF6/Air bushing for interconnecting with its respective gantry / equipment (Overhead connection) separately as per provision of Bid price schedule.

q. 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.

r. The conditions of roads, capacity of bridges, culverts etc. in the route shall also be assessed by the bidders. The scope of any necessary modification/ extension/ improvement to existing road, bridges, culverts etc. shall be included in the scope of the bidder. The contractor shall carry out the route survey along with the transporter and submit the detail proposal and methodology for transportation of transformers within three months from the date of award. However provision for up gradation/protection of road for ease of transportation of material/equipments up to Pangtan SS site where the road width is insufficient has been made. The Contractor shall perform the survey works and submit his proposal and

with prior approval of the Employer in this regard, payment for the same shall be done in accordance to the BoQ.

s. Illumination for Staff Quarters" 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, guard house etc.

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

u. Specification of 11 kV outdoor equipments is attached at Section-9, 11kV Switchgear

v. For Pangtan S/S having indoor type 11 kV switchgear, each outgoing 11kV line feeder, take off gantry/tower shall be suitable for accommodating 01 set structure mounted isolator and 01 set surge arrestor.

w. Power Cables

Major sizes of power cables for the following application shall be as given below:

Sl. No.	From	To	Cable Size	Cable type
1	MV LV side of transformer	Indoor switchgear room.	12 kV, 400 sq. mm single core XLPE power cable (Cu)	12 KV XLPE
2	MV Indoor switchgear panel	outdoor double pole structure for outgoing feeders	12 kV, 240 sq. mm three core XLPE power cable (Cu)	12 KV XLPE
3	MV switchyard	outgoing feeder termination point	1Cx240 sq. mm XLPE power cable, (Cu)	33 KV XLPE
4	HV for Line Bays at Bahrabise SS		1Cx800 sq. mm XLPE power cable, (Cu)	145 kV grade, XLPE

13. 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, continuous 72 (Seventy two) hours period start after such rectification.

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

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

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SECTION - 2

GENERAL TECHNICAL REQUIREMENT

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2 GENERAL TECHNICAL REQUIREMENT

2.1 General

The following provisions shall supplement all the detailed technical specifications and requirements brought out herein. The contractor's proposal shall be based on the use of materials complying fully with the requirements specified herein.

All works described herein and other works necessary to complete the job for proper coordination and operation, even if not stated, shall be within the scope of the Contractor's work and the cost of such works shall be considered to be included in the bid price.

The Contractor shall provide spare parts and tools for the substations as specified in this specification; furnish qualified supervision and construction personnel for the installation, testing, commissioning and remedying defects within warranty period and checking out of the equipment necessary to complete the scope of works as mentioned above and detailed in the Price Schedule. The work shall be performed in close cooperation with the Employer.

Coordination of the substation works with the installation of others shall be the responsibility of the Contractor. The Employer will furnish the information needed to coordinate the substation works with other works.

Locally available goods, construction materials including stones, fuel, lubricating oil, cement, timber, iron and steel goods, etc. shall be procured locally. Cost of such local materials will be limited to the cap specified elsewhere in the bidding document.

2.2 Engineering Data

The furnishing of engineering data by the Contractor shall be in accordance with the Schedule as specified in the Bidding Document. The review of these data by the Employer will cover only general conformance of the data to the specifications and not a thorough review of all dimensions, quantities and details of the materials, or items indicated or the accuracy of the information submitted. This review by the Employer shall not be considered by the Contractor, as limiting any of his responsibilities and liabilities for mistakes and deviations from the requirements, specified under these specifications.

All engineering data submitted by the Contractor after review by the Employer shall form part of the contract document.

2.3 Site Location and Access

132/33/11/ kV Pangtan substation will be located at an altitude of 2200 m above mean sea level at Pangtan in Sindhupalchok district, at about 102 Km away from Kathmandu, the capital of Nepal. The substation site is connected with Kathmandu through Balefi bazaar (which is 65 km from Kathmandu, Araniko Highway) through black top road and from Balefi bazaar to Pangtan (which is approx. 37 km) through partially black top and earthen road.

Location of Pangtan Substation is shown in Location Map of Pangtan Substation Project (DWG 001).

Site for both the Pangtan and Bahrabise substations is located in Sindhupalchok. The substation sites may not be easily accessible round the year. However, the Employer shall not be responsible for the condition of the roads and the transport. Transportation of the material to the work sites shall be the Contractor's responsibility.

The Contractor shall transport transformers taking into account the limitation on loading capacity of existing bridges (and equipped with appropriate shock recorder).

2.4 Climatic Conditions

All plant and equipment to be installed inside 132/33/11 kV Substation at Pangtan shall be entirely suitable for the climatic conditions prevailing at site. All structures shall be designed with the seismic factor of 0.15g.

Atmospheric pollution is low and special insulator design or washing shall not be required. Following climatic conditions shall be considered for design of equipment and system of 132/33/11 kV Pangtan substation.

- Maximum ambient shade temperature : 30 °C
- Minimum ambient shade temperature : 0 °C
- Maximum wind velocity : 47 m/sec
- Rainfall : 1,750 mm/annum
- Monsoon season : June-August
- Relative humidity, maximum : 100 %
  Minimum : 20 %
- Altitude : 2,200 m above Mean Sea Level
- Ice or snow : Expected Occasionally
- Atmospheric pollution : Medium
- Isoceraunic level (thunderstorm days) :50

2.5 Site Survey

The information in this section is given solely for the general assistance to Bidders. No responsibility for it will be accepted, nor will any claim based on this Clause be considered by the Owner.

The Bidder is advised to survey the sites covered under this Contract to acquaint himself with site conditions. The Contractor shall be responsible for surveying; geo technical investigation including measurement of soil resistivity at the precise locations as required for foundation and other design of the substation.

The Contractor shall locate, and record on the construction drawings, all interfacing utility lines or other obstructions. Damage to existing drainage (Kulo) along the boundary of the substation premises shall be repaired by the Contractor at his expense.

Contractor shall make the arrangement of water supply for construction work as well as for future use also. Contractor shall also make his own arrangement of power supply for construction work.

2.6 (A) Salient Features of 132/33/11 kV Pangtan Substation

The salient features and indicative layouts of 132/33/11 kV Pangtan Substation is shown in the following drawings:

i. Single Line Diagram of 132/33/11/ kV Pangtan Substation (Drawing No. DWG003)
ii. Layout of 132/33/11/ kV Pangtan Substation (Drawing No. DWG 004)

132/33/11 kV Pangtan Substation has the following major components.

a) Air Insulated outdoor 132 kV Substation with Two Main Bus Bar arrangement having the following bays.

- Two (2) bays for Bahrabise Double Circuit Line for evacuation of power.
- One (1) bay for 132 / 33 kV Transformer for feeding power to 33 kV systems.
- One (1) Bay for Bus Coupler
- There shall be space for eight (8) more bays to be added in future. These bays shall be used for connection of HEPs with Pangtan substation at 132 kV level.

b) One (1) no. 132/33 kV, 24/27/30 MVA power transformer with ONAN/ONAF1/ONAF2 Cooling and On Load Tap Changer.

c) Air Insulated outdoor 33 kV Substation with Single Bus Bar arrangement having the following bays.

- One (1) bay for Incomer from 132 / 33 kV Transformer for interconnection with 132 kV substation.
- Two (2) outgoing line bays for connection with Loop In Loop Out (LILO) formation as required.
- One (1) bay for 33/11 kV Transformer for feeding power to 11 kV switchgear.
- One (1) 300 kVA, 33 kV/ 400 V Station Transformer will be connected with 33 kV bus through Isolator and drop out fuse for supply of 400 V auxiliary power supply to the Substation auxiliaries and building.
- There shall be space for three (3) more bays to be added in future. These bays shall be used for connection of smaller capacity HEPs with Pangtan substation at 33 kV level.

d) One (1) no. 33/11 kV, 6/8 MVA power transformer with ONAN/OFAF Cooling and On Load Tap Changer.

e) 11 kV Indoor, Metal Enclosed Switchgear having the following feeders

- One Incomer from 33/11 kV Transformer
- Four outgoing line feeders for supplying power to the local areas.

f) Two (2) numbers two (2) km long 33 kV overhead lines on steel poles from Pangtan Substation including LILO connection as required.

g) Four (4) nos. Double Pole Steel Structures for connection with 11 kV overhead lines, complete with LA and cables connected with 11 kV switchgear.

The substation shall be located at an attitude of 2,220 m above the sea level. Due to limitation of the availability of flat land for construction of entire substation including twelve (12) nos. 132 kV bays and eight (8) nos. 33 kV bays and control building, indicative Layout of 132/33/11/ kV Pangtan Substation (DWG 004) has been prepared based on 132 kV two main bus with high and strung bus bar arrangement. In the indicative layout, two (2) levels have been considered, 132 kV substation including transformers and control building in one level and 33kV substation in another level.

However, the bidder is free to optimise his design and may propose alternate layout in one or multiple levels with low bus arrangement of 132 kV substation within the available land for approval of the Employer.

(B) Salient Features of Bahrabise Substation

(a) 2 sets, 145 kV, SF6 Bus Bar Module with Extension Module. SF6 Gas Insulated Bus Duct including Bus Duct support Structure and associated accessories as per TS.

(b) Other associated AIS equipment and facilities to complete the overall scope of interconnection with double circuit 132 kV lines from Pangtan to Bahrabise Substation works.

(c) Substation automation for with integration of all 132 kV bays under present scope with the SIEMENS (Power 7) SCADA system al Load Dispatch Center, Kathmandu including supply of hardware, software, accessories etc as per TS.

Note: Vendor for GIS equipments at Bahrabise Substation is of TBEA ZONFA Shanghai High voltage Switchgear Co. Ltd, China. All design, drawings and relevant documents regarding GIS system shall be made available to the successful bidder at the later stage.

2.7 Main System Parameters

Pangtan substation is proposed to be located at an altitude of 2200 m above mean sea level. Therefore, following major technical parameters shall be used for design of Equipments and system of 132/33/11 kV Pangtan Substation:

Table 2.1: System Parameters of 132kV, 33kV & 11kV Systems

Sl. No.	Description of Parameters	132kV System	33kV System	11kV System
1	System Operating Voltage	132kV	33kV	11kV
2	Max. Operating voltage of the System (V_{rms})	145kV	36kV	12kV
3	Rated Frequency	50Hz	50Hz	50Hz
4	No. of Phase	3	3	3
5	Rated Insulation levels			
a.	Full wave impulse withstand Voltage (1.2/50 microsec.)	750 kV_{peak}	250 kV_{peak}	95 kV_{peak}
b.	One minute power frequency dry and wet withstand Voltage (V_{rms})	325 kV_{rms}	95 kV_{rms}	28 kV_{rms}
6	Minimum creep age distance (25mm/kV)	4,650 mm	1,300 mm	NA
7	Min. Clearances in air			
a.	Phase to Phase	1,500 mm	480 mm	NA
b.	Phase to earth	1,500 mm	480 mm	NA
8	Rated Short Circuit current for 1 sec. duration	25 kA	25 kA	25 kA
9	System Neutral Grounding	Solidly Grounded	Solidly Grounded	Solidly Grounded

As the Pangtan substation site is located at an attitude of 2,200 m, higher Basic Insulation Level (BIL) shall be required. If type tested equipment with the above BIL is not available, Bidders may propose equipment with higher BIL. Following may be the alternatives as these equipments are easily available:

a) 220 kV grade equipment for 132kV system.
b) 52 kV grade equipment for 33kV system.

Whereas, Bahrabise Substation is located at an altitude of 1,203 m, standard Basic Insulation Level (BIL) is sufficient. Bidders may propose standard equipments for 132 kV system for Bahrabise Substation.

2.7.1 Electrical Auxiliary Power Supply

The electrical auxiliary and control power source shall be as follows:

a.	AC auxiliary power source	:	3 phase, 4 wire, 50Hz, 400V 1 phase, 50Hz, 230V
b.	DC control power source	:	110V
c.	DC power source for communication	:	48V

2.8 Codes and Standards

2.8.1 Applicable Standard

All equipment, materials, fabrication and tests under these specifications shall conform to the latest applicable standards and manuals contained in the following list or to standards, manuals and specifications approved by the Employer. Any details not specifically covered by these standards and specifications shall be subject to approval of the Employer.

ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standard Institute, Inc
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
AWS	American Welding Society
BS	British Standard Institution
EEI	Edison Electric Institute
IEC	International Electro technical Commission
NEMA	National Electric Manufacturers Association
IEEE	Institute of Electrical and Electronics Engineers
ITU-T	International Telecommunication Union
IS	Indian Standards

All plants and equipment supplied under this Contract shall conform to or be of higher quality than the latest applicable standard.

If the Specifications contained in this Contract conflict in any way with any of the reference standards, the Specifications shall take precedence. If there are conflicts between different specified reference standards covering the same material or equipment, the standard, which will provide the highest quality and most suitable application, as determined by the Employer shall prevail.

References to standards or to equipment of a particular manufacturer shall be regarded as followed by the words "or equivalent", except as otherwise noted.

The Contractor may propose alternative standards, or equipment, which shall be equal to those, specified unless the system requires specific equipment, as mentioned in the specification, to ensure compatibility. If the Contractor for any reason proposes alternatives to or deviations from the above standards, or desires to use equipment not covered by the above standards, the Contractor shall state the exact nature of the change, the reason for making the change, and shall submit, for their approval. The submittal shall include relevant specifications of the equipment in the original language, and in case that these specifications are written in language other than English, the English version shall be attached and shall govern. The decision of the Employer in the matter of equality will be final.

Notwithstanding the above, if the specification calls for equipment of specific manufacturers, only those manufacturers, which are specified, shall be acceptable to the Employer. Also, manufacturers having collaboration with the specified manufacturers will not be accepted.

2.9 Assistance by the Employer

The Employer will give assistance to the Contractor as much as possible in the following manner; this however will be without any obligations, legal or otherwise.

a) Facilitating access to all locations involved in carrying out the works.
b) General guidance to the Contractor for all negotiations with the Authorities in Nepal

2.10 Variation in Quantities of Work

The Quantities listed in the Price Schedule 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 effective date of contract. The actually required quantity may vary from the quantity as listed in price schedule.

Employer reserves the right to increase or decrease up to 15% (fifteen percent only) of contract value. The quantities of individual items may vary up to any extent after the detail design.

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 after the detailed and check survey and approve by the Employer.

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 after detail design as specified in the first paragraph of this sub clause.

2.11 Drawings and Documents

In addition to those stipulated in clauses regarding drawings in GCC/SCC, the following also shall apply in respect of Contractor Drawings.

All drawings submitted by the Contractor including those submitted at the time of Bid shall be with sufficient detail to indicate the type, size, arrangement, dimensions, material description, Bill of Materials, weight of each component break-up for packing and shipment, fixing arrangement required, the dimensions required for installation and any other information specifically requested in these specifications.

2.11.1 Tender Drawings

Drawings are to be submitted with the Bid, showing all essential details of supply and construction of various supplies. The drawings furnished by the Employer with the Bidding Document are preliminary only and the Contractor shall investigate the sites and design as per actual site requirement without any additional cost to the Employer.

Bidder shall submit the following drawings and documents with the Bid:

a) Brief Description of the plant and equipment offered.
b) Electrical Single Line Diagram.
c) Relay and Metering single line diagram.
d) Plot plan, Substation Plan and Section.
e) Control Building layout.
f) Bill of Material.
g) Sub vendor List.
h) Filled up datasheets.

2.11.2 Drawings and Documents for Approval

Prior to commencement of the work, the Contractor shall submit detailed design drawings and data to the Employer for approval. Should the Employer direct that modifications be made in order to satisfy the requirements of the Specifications, the Contractor shall submit revised drawings for approval. Alteration in the Contract price shall not be allowed by reason of the drawing modifications.

The Contractor shall prepare and furnish to the Employer such drawings, calculations, and data on materials and equipment (hereinafter in this provision called data) as are required for the proper control and completion of the work. This shall including but not be limited to those drawings, data and calculations specifically required elsewhere in the Technical Specifications.

The Contractor shall submit detailed drawings, instructions and maintenance books, and parts lists with recommended stock quantities for the equipment furnished, prepare and submit detailed engineering, design and construction drawings pertaining to all civil, structural, architectural, mechanical and electrical equipment and installations in substations. The drawings to be furnished by the Contractor shall include, but not be limited, to the following:

a) Electrical System Design
   - Design Basis Report
   - Single line and three line diagrams for AC and DC station service power supply
   - Relay and Metering Single Line Diagram.
   - CT & PT Sizing calculation.
   - Insulation Co-ordination
   - Substation grounding calculation
   - Direct Stroke Lightning Protection (DSLP) Calculation.

- Sizing calculation of Battery & Battery-Charger.
- Design Calculation for indoor and outdoor Illumination System
- Sag, tension and short circuit force calculation.
- Cable Sizing Calculation
- Calculation and coordination for selecting operation of protection relays
- Detailed material list

b) Plot Plan of Substation Premises

c) Substation Layout

- Electrical layout (Plan and section) of substations
- Electrical Clearance diagram.
- Erection key diagram for substations
- Electrical Layout of Control Building
- Cabling Layout including cable trench, cable tray, wire gutters, conduits, and specifying location.
- Substation grounding Layout, plans, elevations and details
- Control Room grounding Layout, plans, elevations and details
- Cable trench, duct and conduit layout plan, elevation and details.
- Substation lighting and convenience outlet plan, elevation, and details
- Installation details for equipment
- Cable schedule, specifying cable identification number, routing and length of the cable for the substation and cable summary.
- Detailed interconnection diagram for all substation equipment, AC and DC station service equipment and all building equipment.

d) Equipment drawings

- Dimensioned General arrangement drawings showing front and rear elevations and identification of each device and complete nameplate schedule
- Foundation Loading Details
- AC and DC diagram for control, metering, relaying, communication, alarm, etc. required to describe in detail the operation of all systems in the substation. Wire numbers and terminal numbers for each device shall be clearly marked on all AC and DC elementary and schematic diagram
- Communication system drawings
- Technical Catalogues
- Instruction Manuals for Erection, Testing and Commissioning
- Operation and Maintenance Manuals.
- Instruction books, spare parts lists, material lists and any other documents pertaining to the substation and required for construction, operation, maintenance and repair

e) Civil, Structural and Architectural Works

- Geo technical Investigation report
- Details of veiling and grading of substation area.
- Design Basis report
- Design/calculation of all Civil structural works
- Foundation Layout of Substations, plans and elevations indicating top of foundations, details for anchor bolt installation, plus all data required for civil works
- Structural erection and fabrication drawings and Bar Bending schedule for RCC structures and foundations.
- Details of slope protection and retaining walls
- Civil, Structural and architectural drawings for all buildings.
- Details of Road and Drains.

- Details of fences and gates.
- Details of stone spreading within substation area.

f) General Documentations
- Monthly Progress Report
- QA/QC Documentation including MQP and FQP for all Equipment & systems
- Testing and commissioning procedure of each equipment
- Design (Type) Test Reports as specified
- Routine Test Reports of all Equipment
- Field Test Reports

All rights of the design/drawing submitted by the contractor shall be strictly reserved with the Employer only and any designs/drawings/data sheets submitted by the contractor from time to time shall become the property of the Employer. Under no circumstances, the Contractor shall be allowed to use/offer above designs/drawings/data sheets to any other authority without prior written permission of the Employer.

2.11.3 Drawings and Documents Submission Schedule

The Contractor shall submit the drawings and data to the Employer for approval in the following manner and designated deadlines.

Table 2.2: **For Supply of Equipment and/or Installation Works**

Item	No. of Copies	Deadline & Remarks
Proposed work program (Master Network)	3	Within 28 days from the Effective date of the Contract.
Principal equipment drawings for approval	3	Within 90 days from the Effective date of the Contract.
Principal installation drawings for approval	3	Within 120 days from the Effective date of the Contract.
Final Bill of Quantity	3	Within 120 days from the Effective date of the Contract.
Revised drawings for approval	3	Within 14 days after receiving drawing for revision.
Final drawings with reproducible copies	5	Within 14 days after receiving approval
AutoCad files of Final Drawings in USB flash Drive	3	Within 14 days after receiving approval
Schedule of manufacturing and transportation	3	Within 45 days from the Effective date of the Contract.
Plan for shop tests	3	Not less than 30 days before testing
Results of shop tests for approval	4	Upon completion of tests
Records of shop tests	4	Upon approval of results of shop tests

Item	No. of Copies	Deadline & Remarks
Testing and commissioning procedure	3	Not less than 120 days before start of pre-commissioning activities.
Plan for field-tests	3	Not less than 14 days before testing
Report for field tests	4	Within 14 days after completion of each test
As-built drawings and documents	5	Within 30 days after completion of installation work
AutoCad / Electronic file of as-built drawings / document in USB flash Drive	3	Within 30 days after completion of installation work
Instruction manuals, O & M Manuals and drawings with reproducible copies for installation in USB flash Drive	5	Within 30 days after shipment of Equipment

Table 2.3: For Civil Works

Item	No. of Copies	Deadline & Remarks
Detail construction schedule & method	3	Within 45 days from the Effective date of the Contract.
Drawing for approval (principal drawings for construction)	3	Within 90 days from the Effective date of the Contract.
Revised drawings for approval	3	Within 14 days after receiving drawings for revision
AutoCad file of approved drawings in USB flash drive	3	Within 14 days after receiving drawings for revision
Reports of Field Tests	4	Within 14 days after completion of each test
As-built drawings and Documents	5	Within 30 days after completion of construction works
AutoCad/Electronic files of as-built drawings and documents in USB flash drive	3	Within 30 days after completion of construction works

Table 2.4: Others

Item	No. of Copies	Deadline & Remarks
Contractor's Organization Chart	3	Within 21 days from the Effective date of the Contract.
Drawing and Deliverable Schedule	3	Within 28 days from the Effective date of the Contract.
QA/QC Documentation	3	Within 28 days from the Effective date of the Contract.

Monthly Progress Reports with photographs	3	By 7th of following month
Packing list (copy)	5	At each shipment
Invoice (copy)	5	At each shipment
Bill of lading (copy)	5	At each shipment
Certificate of origin (copy)	1	At each shipment

2.11.4 Drawing Submission Schedule

Within 28 days from the effective date of the Contract, the Contractor shall prepare and furnish to the Employer a schedule for submission of all drawings and data. Each drawing to be submitted for the work of the Contract shall be listed in the Schedule, and the Schedule shall contain separate columns for scheduled submittal dates and actual submitted dates. The schedule will be reviewed by the Employer/Consultant and the Contractor shall correct any defects noted therein. The schedule shall at all times present a complete plan for orderly submission of such drawings and data and shall be updated and resubmitted monthly showing actual submittal dates and revised scheduling. The Contractor shall promptly notify the Employer of any occurrence requiring substantial revision of the schedule giving a detailed explanation of the cause of the revision. Revised schedules will be revised and corrected in the same manner as the original schedule.

2.11.5 Drawings: Titles, scales and Sizes

All drawings shall be prepared using Licensed AutoCAD software version 2000 or later only. Drawings, which are not compatible to AutoCAD software version 2000 or later, shall not be acceptable. After final approval all the drawings shall be submitted to the Employer in USB flash drive.

Each drawing submitted by the Contractor shall be clearly marked with the name of the Employer, the specification title, the specification number and the name of the Project. All titles, noting, markings and writings on the drawing shall be in English. All the dimensions should be to the scale and in S.I. units.

The title of the drawing, Contract Number, the signature of the Contractor's engineer and the date shall appear in the bottom right-hand corner of each drawing in the following format:

Nepal Electricity Authority
(Government of Nepal Undertaking)
Project Management Directorate

Pangtan Substation Project

Contract No…….
Name of the Substation: Pangtan Substation
Item No…….
Brief Description ……

Owner's Consultant
None

In general the scales of the drawings shall be 1:200. The Contractor, however, can prepare and submit drawing in any other appropriate scales with the prior approval of the Employer. The Contractor shall use any one of the following sizes for the preparation of drawings as appropriate:

A0	841 x 1189 mm	(33.11 x 46.81 in)
A1	594 x 841 mm	(33.39 x 33.11 in)
A2	420 x 594 mm	(16.54 x 23.39 in)
A3	297 x 420 mm	(11.69 x 16.54 in)
A4	210 x 297 mm	(8.27 x 11.69 in)

2.11.6 Employer's approval

A copy of each drawing reviewed will be returned to the Contractor as stipulated herein.

Copies of drawings returned to the Contractor will be in the form of a print with the Employer's marking, or a print made from a electronic copy of the marked up drawing.

The Employer will send comment/ approval each drawing/design/document within twenty-one (21) days after receipt at his office. One print of each of the drawings submitted for approval will be returned by the Employer or Employer's Representative, marked either "APPROVED", "APPROVED EXCEPT AS NOTED", or "RETURNED FOR CORRECTION".

a) The notations "APPROVED" or "APPROVED EXCEPT AS NOTED" will authorize the Contractor to proceed with the manufacturing drawings, subject to the corrections, if any indicated thereon. The notation "RETURNED FOR CORRECTION" shall require the Contractor to make the necessary revisions on the drawings and submit for approval.

   Resubmission of drawings marked "APPROVED EXCEPT AS NOTED" or "RETURNED FOR CORRECTION" shall be done by the contractor within 14 days after receiving drawings / comments for revision.

   Approval of the Contractor's drawings shall not in any way relieve the Contractor of any part of his obligation to meet all the requirements of the Contract or of the responsibility for the correction of the drawings.

b) Reproducible: Reproducible of all final approved drawings shall be made on USB flash drive.

The approval of the documents and drawings by the Employer shall mean that the Employer is satisfied that:

a) The Contractor has completed the part of the Works covered by the subject document (i.e. confirmation of progress of work).
b) The Works appear to comply generally with requirements of Specifications.

In no case the approval by the Employer of any document does imply compliance with technical requirements or the absence of errors in such documents.

If errors are discovered any time during the validity of the contract, then the Contractor shall be responsible for consequences.

Neither the review nor lack of review of any drawing, calculation or data shall waive any of the Specifications or Contract drawings, or responsibility for correctness of the drawings, calculations or data. Defective work, materials, and equipment may be rejected notwithstanding conformance with drawings, calculation and data reviewed by the Employer/the Employer's representative. The Employer shall have the right to require the Contractor to make any changes in the design which may be necessary, to make the apparatus/works conform to the requirements and intent of the Specifications, with no additional cost to the Employer.

Approval of the Contractor's drawings (including cases of un-noticed/un-known deviations) shall not in any way relieve the Contractor of any part of his obligation to meet all the requirements of the Contract or of the responsibility for the correction of the drawings. The ultimate responsibility of meeting all the requirements of the technical specifications and fulfill contractual obligations shall rest on the Contractor.

Any drawings changed by the Contractor during the development of his design after review by the Employer shall be submitted for approval.

The work shall be performed by the Contractor strictly in accordance with these drawings and no deviation shall be permitted without the written approval of the Employer, if so required.

All manufacturing, fabrication and erection work under the scope of Contractor, prior to the approval of the drawings shall be at the Contractor's risk. The contractor may incorporate any changes in the design, which are necessary to conform to the provisions and intent of the contract and such changes will again be subject to approval by the Employer.

2.12 Design Improvements

The Employer or the Contractor may propose changes in the specification and if the parties agree upon any such changes and the cost implication, the specification shall be modified accordingly.

2.13 Design Co-ordination

Wherever, the design is in the scope of Contractor, the Contractor shall be responsible for the selection and design of appropriate material/item to provide the best co-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.

2.14 Design Review Meeting

The contractor will be called upon to attend design review meetings with the Employer, and the consultants of the Employer during the period of Contract. The contractor shall attend such meetings at his own cost at the Corporate Office of the Employer or at mutually agreed venue as and when required. Such review meeting will be held generally six (6) times in a year or as and when required.

2.15 Quality Control

The Contractor shall provide and maintain a quality control program to ensure compliance with quality standards throughout all phases of the work. Within 28 days from the effective date of the Contract, the Contractor shall furnish to the Employer three (3) copies of his complete quality control procedures, manual, and a description of the quality control organization.

The Employer/ Consultant will monitor the Contractor's methods, procedures and processes for compliance with the quality control program and the quality standards of these Specifications. Failure of the Contractor to effectively maintain the quality control program throughout all phases of the work will be considered a failure to execute the work with the diligence required by the Contract documents.

2.16 Quality Assurance, Inspection & Testing

2.16.1 Quality Assurance Manual

To ensure that the supply 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 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 shall be finalized after discussions before the award of Contract. The detailed programme shall be submitted by the contractor after the award of contract and finally accepted by the Employer after discussion. A quality assurance manual / quality plan of the Contractor shall generally cover but not limited to 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 Contractor's Project Manager.
d) The procedure for purchase 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 including process controls and fabrication and assembly controls.
f) Control of non-conforming items and system for corrective action.
g) Control of calibration and testing of measuring and testing equipments.
h) Inspection and test procedure for manufacture.
i) System for indication and appraisal of inspection status.
j) System for quality audits.
k) System for authorizing release of manufactured product to the Employer.
l) System for maintenance of records.
m) System for handling storage and delivery, and
n) A quality plan detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to each item and equipment and materials furnished and/or services rendered.

The Quality plan shall be mutually discussed and approved by the Employer after incorporating necessary corrections by the Contractor as may be required.

2.16.2 Quality Assurance Documents

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

The Employer or his duly authorized representatives reserves the right to carry out Quality Audit and quality surveillance of the systems and procedures of the Contractor's/his vendor's Quality Management and Control Activities.

2.16.3 Employer's Supervision

To eliminate delays and avoid disputes and litigation to the Contract, all matters and questions shall be resolved in accordance with the provisions of this document.

The manufacturing of the product shall be carried out in accordance with the specifications. The scope of the duties of the Employer, pursuant to the contract, will include but not be limited to the following.

a) Interpretation of all the terms and conditions of these Documents and Specifications.
b) Review and interpretation of all the Contractor's drawings, engineering data etc.
c) Witness or authorize his representative to witness tests at the manufacturer's works or at site, or at any place where work is performed under the contract.
d) Inspect, accept or reject any equipment, material and work under the Contract, in accordance with the Specifications.
e) Issue certificate of acceptance and/or progressive payment and final payment certificate.
f) Review and suggest modification and improvement in completion schedules from time to time, and
g) Supervise the Quality Assurance Program / quality plan implementation at all stages of the works.

2.16.4 Inspection & Inspection Certificate

The Employer, his duly authorized representative and/or outside inspection agency acting on behalf of the Employer shall have, at all reasonable times, access to the premises and /or works of the contractor and/or their sub-contractor(s)/sub-vendors and shall have the right, at all reasonable times, to inspect and examine the materials and workmanship of the product during its manufacture.

The Contractor shall give the Employer's Inspector fifteen (15) days (in case of domestic testing) and thirty (30) days (in case of foreign testing), as the case may be, written notice of any material being ready for testing. All such inspections shall be to the Contractor's account except for the expenses of the Employer’s inspector. The Employer’s inspector, unless witnessing of the tests is virtually waived, will attend such tests within fifteen (15) days (in case of domestic testing) and thirty (30) days in (in case of foreign testing) of the date of which the equipment is notified as being ready for test/inspection or on a mutually agreed date, failing which the Contractor may proceed 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 test reports / certificates in four (4) sets.

The Employer’s Inspector shall, within fifteen (15) days from the date of inspection, 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 make the modifications that may be necessary to meet the said objections.

When the factory tests have been completed at the Contractor’s or Sub-Contractor’s works, the Employer’s inspector shall issue a certificate to this effect within fifteen (15) days after completion of tests but if the tests are not witnessed by the Employer’s inspector, the certificate shall be issued within fifteen (15) days of receipt of the Contractor’s Test Certificate by the Employer’s Inspector. The completion of these tests or the issue of the certificate shall not bind the Employer to accept the equipment should it, on further tests after erection, be found not to comply with the Contract.

In all cases where the Contract provides for test whether at the premises or works of, the Contractor or of any Sub-Contractor, the Contractor except where otherwise specified shall provide free of charge such item as labor, materials, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Employer’s 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 Employer's Inspector or to his authorized representative to accomplish testing.

The inspection by Employer and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed Quality Assurance Program forming a part of the Contract.

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

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

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

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

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

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

All gauges and templates necessary to satisfy the Employer shall be supplied by the contractor.

The specified grade and quality of steel shall be used by the Contractor. If the Contractor uses other grades of steel other than specified, the Contractor shall prove by design calculation that the required stress is met and that towers meet all the design requirements mentioned in the specifications. However, the Contractor shall not use the lower grade steel than the minimum grade mentioned. To ascertain the quality of steel used, the inspector may at his discretion get the material tested at an approved laboratory.

2.16.5 Tests

The type, acceptance and routine tests and tests during manufacture shall be carried-out on the material and shall mean as follows:

a) Type Tests shall mean those tests which are to be carried out to prove the process of manufacture and general conformity of the material to this Specification. These tests shall be carried out on samples prior to commencement of commercial production against the order. The Bidder shall indicate his schedule for carrying out these tests.

b) Acceptance Tests shall mean those tests which are to be carried out on samples taken from each lot offered for pre-dispatch inspection, for the purposes of acceptance of that lot.

c) Routine Tests shall mean those tests, which are to be carried out on the material to check requirements which are likely to vary during production.

d) Tests during manufacture shall mean those tests, which are to be carried out during the process of manufacture and end inspection by the Contractor to ensure the desired quality of the end product to be supplied by him.

e) The norms and procedure of sampling for these tests will be as per the Quality Assurance Program to be mutually agreed to by the Contractor and the Employer.

f) The standards and norms to which these tests will be carried out are listed against them. Where a particular test is a specific requirement of this Specification, the norms and procedure of the test shall be as specified in Annexure-A or as mutually agreed to between the Contractor and the Employer in the Quality Assurance Program.

g) For all type and acceptance tests, the acceptance values shall be the values specified in this Specification or guaranteed by the Bidder, as applicable.

2.16.6 Type Test

The bidders must offer type tested equipment only.

Bidders shall submit reports of type tests of the following equipment carried out by reputed independent testing laboratory on identical equipment* of each type in accordance with latest revision of IEC Publications / Indian Standards.

a) Power and Distribution Transformers
b) 132 kV and 33 kV Circuit Breakers
c) 132 kV and 33 kV Disconnect Switches
d) 132 kV and 33 kV Instrument Transformers
e) 132 kV and 33 kV Lightning Arrestors
f) 132 kV and 33 kV Control and Relay Panels
g) 11 kV Switchgear
h) 132 kV GIS Module
i) Substation automation/Communication/SCADA systems
j) Power Cable (12 kV/ 36 kV/ 145 kV grade)

Note: "*" Identical equipment shall mean having same voltage rating, current / MVA rating, and construction.

2.17 Tools and Appliances

All The Bidder shall propose complete, new and unused sets of all special tools or gauges and testing kits, which will be required for normal operation and maintenance. The Bidder shall furnish the list of tools and appliances and their prices under Price Schedule of this Tender Document. To the greatest extent possible, the tools for each specific operation shall be stored in a single, locked, portable, steel box suitably and clearly marked for convenient identification. In the event that such a box must be too large for convenient carrying by one man, it shall be provided with rubber-tired wheels of substantial construction.

2.18 Spare Parts

The Bidder shall propose spare required for three years' maintenance for trouble free operation and shall include a price list of these parts. Sufficient information shall be provided to permit the Employer to estimate spare parts requirements. This information shall be furnished under Price Schedule of this Tender Document.

Final quantity of spare parts shall be decided by the Employer and will inform the Contractor within 35 days from the submission of the final BOQ (with the name of the manufacturer and their type designation) by the Contractor pursuant to clause 2.10 (Variation in Quantities at work).

All spare parts supplied under the Contract shall be strictly interchangeable with the parts for which they are intended to replace. They shall be treated and packed for long storage under the climatic conditions prevailing at the site. Each spare part shall be clearly marked or labeled on the outside of its packing with its description and purpose. When more than one spare part is packed in a single case or other container, a general description of its contents is to be shown on the outside of such cases or container and a detailed list enclosed inside. All case containers and other packages must be suitably marked and numbered for purposes of identification.

All cases, containers or other packages are liable to be opened at the site for such examinations as the Employer may consider necessary and all such opening and subsequent repackaging shall be at the expense of the Contractor.

All spare parts must be delivered to Site in advance of the trial operation. Contractor shall ultimately prepare and deliver five (5) copies of the final consolidated spare parts list, arranged specification-wise, with unit prices and quantities supplied.

It shall be in the interest of the Contractor to organize the delivery and systematic storage of spare parts before the trial operation to avoid post erection difficulties and delays. Any spare part consumed by the Contractor before final acceptance shall be replaced without any cost to the Employer.

2.19 Technical Requirements

2.19.1 Design ambient Temperature

All equipment of Pangtan Substation shall be designed based on 40^0C (max) / -10^0C (min) design Ambient Temperature.

2.19.2 Guaranteed Technical Particulars

The Guaranteed Technical Particulars of the various items shall be furnished by the Bidders in one original and three (3) copies in the prescribed schedules of the Specifications. The Bidder shall also furnish any other information as in their opinion is needed to give full description and details to judge the item(s) offered by them.

The data furnished in Guaranteed Technical Particulars should be the minimum or maximum value (whichever is ruling condition as per the requirement of the specification) required. A Bidder may guarantee a value more stringent than the specification requirement. However, for testing purpose or from performance point of view, the material shall be considered performed successfully if it achieves the minimum / maximum value required, whichever is ruling condition, as per the Technical Specification. No preference what so ever shall be given to the bidder offering better/more stringent values than those required as per specification except where stated otherwise.

2.19.3 Packing

All the materials 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. The Contractor shall be responsible for any loss or damage during transportation, handling and storage due to improper packing.

The Contractor shall include and provide for securely protecting and packing the materials so as to avoid loss or damage during transport by air, sea, rail and road.

All packing shall allow for easy removal and checking at site. Wherever necessary, proper arrangement for attaching slings for lifting shall be provided. All packages shall be clearly marked with signs showing ‘up’ and

'down' on the sides of boxes, and handling and unpacking instructions as considered necessary. Special precaution shall be taken to prevent rusting of steel and iron parts during transit by sea.

The cases containing easily damageable material shall be very carefully packed and marked with appropriate caution symbols, i.e. fragile, handle with care, use no hook etc. wherever applicable.

Each package shall be legibly marked by the Contractor at his expenses showing the details such as description and quantity of contents, the name of the consignee and address, the gross and net weights of the package, the name of the Contractor etc.

2.19.4 Material for outdoor panels

All outdoor panels such as motor operated mechanism (MOM) box of disconnect switch, operating mechanism box of circuit breakers, CT & VT junction boxes shall be made of aluminium / aluminium alloy of suitable thickness.

This clause supersedes all other clauses specified elsewhere in this bidding document.

2.19.5 Degree of Protection of Enclosures

Following degree of protection as per relevant IEC shall be provided for all equipment of Pangtan / Bahrabise Substation:

S No.	Description of Panel/Equipment	Degree of Protection
1	11kV Switchgear:	
	a) Busbar chamber, Cable Chamber and Breaker Chamber.	IP42
	b) Low voltage Chamber.	IP43
		IP52
2	Control and Relay Panel	IP43
3	Battery Charger	IP42
4	All other Indoor Panels	IP43
5	Motor:	
	a) Outdoor	IP55
	b) Indoor	IP54
6	All outdoor Equipment:	
	a) Transformer Marshalling Kiosk	IP55W
	b) Operating Mechanism Box for Circuit Breaker and Disconnecting switches.	(Weather Proof)
	c) CT/VT Junction Boxes	
	d) Bay Marshalling Boxes.	
	e) Outdoor Lighting Panels	

2.19.6 Relays

a) All relays to be used for main and backup protection shall be numerical type only.

b) All main protection relays shall have the features like fault recorder and event logging functions. These functions shall be supplied and activated at no extra cost to the Employer. Necessary hardware (including Laptop) and software for automotive uploading/downloading data from the relay to station Laptop Computer and vice versa shall be supplied.

c) The relay shall have suitable communication facility for connectivity to SCADA. Communication protocol shall be IEC 61850.

2.19.7 Fuses and Links

Fuse and link carriers and bases shall be of such forms and materials that they protect personnel from shock and burns in normal service and maintenance. Furthermore, fuse links, fuse contacts and fixed contacts shall be shielded to prevent inadvertent contact with live metal whilst the fuse is being inserted or withdrawn.

Fuses shall be of the non-deteriorating HRC cartridge type complying with IEC 269 and fuse bridges shall be so designed as to permit detection of fuse rupturing without removing the bridge. 'Zed' and screw-in type fuses shall not be permitted except with the specific approval of the Employer.

Test links in current transformer circuits shall be of the bolted or plug-in type.

The labeling of fuses, carriers and bases shall comply with IEC 269. Identification labels fixed to panels, boards and desks for fuses and links shall describe their duty, voltage and rating.

Fuse and link carriers and bases shall be colored to the approval of the Employer. Fuses shall be used only for DC circuits. For AC circuits MCCB/MCB's of appropriate ratings shall be used.

2.19.8 Wiring

The equipment to be provided as part of this Contract shall be fully wired in accordance with the following general requirement.

a) All wiring shall be carried out with general-purpose 0.1 kV-volt grade PVC copper wire complying with the requirements of IEC. The wire core size shall not be less than 2.5 Sq. mm for current & voltage circuit. The wire core size for control circuits shall be less than 1.5 Sq. mm. All wire cores shall be multistranded and flexible.

b) Wires shall be neatly bunched and adequately supported so as to prevent sagging and strain on termination.

c) All inter panel wiring between panels that directly adjoin one another shall be made through the cable duct underneath the panels. All inter panel wiring shall start and terminate on terminal blocks; direct wiring between other items of equipment will not be acceptable.

d) Joints or splices in panel and inter panel wiring will not be acceptable.

e) The wiring of like panels, cubicles or kiosks shall be identical.

f) All wire termination shall be made with compression type connectors. Wires shall not be spliced or tapped between terminal points.

g) Not more than two wires shall be connected to any terminal at each end. If necessary, a number of terminals shall be jumpered together to provide additional wiring points.

h) Wiring leads and cable cores shall be permanently marked at both ends with an approved type of marking device having black letters and numbers impressed on a white background.

2.19.9 Terminal Blocks

a) Multiway terminal blocks complete with screws, nuts, washers and marking strips for terminal identification shall be furnished for terminating the internal wiring and outgoing cables.

b) Control terminals shall be washers head screw type, each suitable for connection of at least two numbers of copper conductor cables of requisite cross-section at each end through compression type (solder less) lugs. Screw type terminals with screw directly impinging on conductor or any other type of terminal, which does not accept compression type lugs, are not acceptable. The successful Bidder shall have to take prior approval of the terminals to be used in the block from the Employer/ the Employer's representative.

c) Each terminal shall be marked with designations obtained from schematic diagrams.

At least 20% spare terminals shall be provided in the terminal blocks.

2.19.10 Nameplate

a) Nameplates or rating plates shall be stainless steel and shall be engraved in English language. Instruction plates, warning signs and anti marking whatever on the equipment and parts and accessories thereof shall be both in the English and the Nepali language.

b) The switch handles shall be carved with the function number or work colored in white.

c) The details of the matters to be shown on the nameplates, etc. shall be indicated in the drawings for approval.

d) The Contractor shall provide nomenclature for all equipment installed in the substation. Such nomenclatures shall be as approved by the Employer.

2.19.11 Painting

All sheet steel works shall be phosphate in accordance with the following procedure and in accordance with BS 2569 and BS 5493.

a) Oil, grease, dirt shall be thoroughly removed by emulsion cleaning.

b) 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.

c) After phosphating, thorough rinsing shall be carried out with clean water, followed by final rinsing with dilute dichromate solution and even drying.

d) The phosphate coating shall be sealed by the application of two coats of stoving type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved.

e) After application of the primer, two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. Touch up shall be applied after completion of tests. The color for the finishing paint shall be light gray or as approved by Employer.

f) The final finished thickness of paint film on steel shall not be less than 100 microns.

g) Finished painted surface of panels shall present aesthetically pleasing appearance free from runs and drips.

h) A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the panels.

2.20 Compatibility

All equipment, structures, etc. offered by the Contractor shall be compatible with existing systems.

The Contractor shall pay utmost attention towards compatibility in design, supply, installation, interfacing and integration of the new Substation Automation/Communication/SCADA system with the existing one. The

Contractor shall be fully responsible for compatibilities and complete interfacing of the signal system, integration in the SINAUT Spectrum, located at Katmandu etc.

The Contractor shall undertake a detailed study of the existing relay and protective schemes and propose a suitable scheme along with relay settings of the proposed relays as well as for the existing relays in Bahrabise substations to ensure proper coordination of the relays in the system. If required, the Contractor shall also be responsible for undertaking necessary adjustments in the settings of the relays in neighboring substations. If necessary, the Contractor shall also be responsible for design / supplying / executing all necessary works for the proper functioning of the protection and communication schemes without additional cost to the Employer.

2.21 Environment Mitigation Measures

The Contractor shall be responsible for compliance with the finding / recommendation of IEE study reports in totality. The following mitigation measures shall be undertaken by the Contractor to reduce the adverse impacts on the environment during construction of the transmission line and substation.

2.21.1 Physical Environment

The following mitigation measures shall be undertaken to reduce the adverse impacts on the physical environment during construction of the substation.

a) **Changes in land use and landscape:** The construction activities will be planned properly. The construction material will be stored at the designated places and the haphazard dumping of the construction spoils will be strictly prohibited. Discharge of cement slurry, garbage and other solid wastes generated by the construction activities and workforce will be avoided where possible.

b) **Disposal of the construction spoils:** The excavated material will not be left haphazardly. It will be leveled on the ground. Further, the excess disposal material generated which cannot be leveled on the ground will be carried out to the acquired land for line/substation.

c) **Stockpiling of the construction materials:** The Contractor will have to negotiate with the owner of the property for the use of their premises even if it is for the short period.

d) **Nuisance to the nearby properties:** Although some nuisances may be unavoidable, the Contractor will have to minimize such nuisance. The Contractor will have to work in close-coordination with the local community while working in the settlement areas.

e) **Impact on the infrastructure:** The Contractor shall ensure that there will be no interference with the existing infrastructure including utility facilities during construction.

2.21.2 Biological Environment

None

2.21.3 Socio-economic and cultural Environment

In the construction phase following mitigation measures shall be adopted in accordance with the IEE report to minimize the impacts:

a) **Loss of farmland and other category of land:** Any damage to the farmland by the construction activity will have to be restored and rehabilitated.

b) **Occupational safety and hazard:** The Contractor will provide appropriate training in handling equipment and machinery to the workers and laborers before contraction. All workers employed by the Contractors shall be insured against accident.

c) **Loss of standing crops:** The Contractor shall make compensation for the loss of standing crops due to project activities.

d) Control of adverse socio interactions between local communities and construction work force.
e) Awareness program regarding health and safety of substation work.
f) Awareness program for workforce.
g) Insurance against health and safety.

2.21.4 Employment

Priority shall be given to the local project affected people while hiring workers and labors during construction of the project. Nepal being a signatory to the International Convention against Child Labor, the Contractor shall not employ child Labor in construction.

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SECTION - 3

POWER AND DISTRIBUTION TRANSFORMERS

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3 POWER AND DISTRIBUTION TRANSFORMERS

3.1 General

This specification covers the design, manufacture, assembly, shop test, supply, delivery, installation field test and commissioning of the power and distribution transformer complete with all accessories, fittings and auxiliary equipment for efficient and trouble-free operation as specified herein under.

The equipment specified in this Section shall conform to the latest edition of the appropriate IEC standards are applicable and/or other recognized international standards. In particular the following standards:

IEC 60076	Power transformer
IEC 60137	Insulating bushings for alternating voltages above 1 kV
IEC 60156	Insulating liquids - Determination of the breakdown voltage at power frequency – Test method
IEC 60296	Specification for unused mineral insulating oils for transformers and switchgear
IEC 60551	Determination of transformer and reactor sound levels
IEC 60616	Terminal and tapping markings for power transformer
IEC 60722	Guide to the lightning impulse and switching impulse testing of power transformers and reactors

3.2 Design Requirement

The transformer shall be connected to three phase 50 Hz system of 132 kV, 33kV and 11 kV systems as specified. The transformers shall be located at the attitude of 2200 m above mean sea level.

The transformer shall be installed outdoor in a hot, humid atmosphere. The transformer shall be oil immersed and designed for the cooling system as specified in Technical Schedules (Section 21).

The transformer shall be capable of operating continuously at its rated output without exceeding the temperature rise limits as specified in Technical Schedules (Section 21).

The transformer windings shall be designed to withstand short circuit stresses at its terminal with full voltage maintained behind it for a period as per IEC- 60076.

The transformer shall be capable of continuous operation at the rated output under the following conditions:

a. The voltage varying ±10 % of rated voltage
b. Frequency varying ±5 % of the rated frequency

The transformer shall be capable of delivering its rated output at any tap position.

The transformer shall be free from annoying hum and vibration when in operation even at 10 % higher voltage over the rated voltage. The noise level shall be in accordance with respective IEC standards.

The transformer shall be designed and constructed so as not to cause any undesirable interference in radio or communication circuits.

The transformer shall be designed to take care of third harmonics not to exceed 2% of fundamental frequency. However, tertiary winding shall be provided on transformers with capacity 50 MVA and above.

All nuts bolts and pins shall be locked except those which are external to the transformer. If bolts and nuts are so placed as to be inaccessible by means of ordinary spanners, suitable special spanners shall be provided along with the transformer.

Labels shall be provided for all apparatus like relays, switches, fuses, etc. housed in any cubicle or marshaling kiosks. These shall be of incorrodible material with matt/satin finish and permanent lettering. Labels mounted on black surface shall have white letters & danger notices shall have red lettering on a white background. The labels shall be secured by means of brass screws or rust protected steel screws.

The proper & complete tightening of the nuts of the coil clamping bolts must be ensured by the manufacturers. The tightening of the nuts to the designed value and that the nuts of all the coils clamping bolts are tightened to same extent, should be carried out with torque spanners.

3.3 Construction Features

3.3.1 Tank

The tank shall be of all welded construction and fabricated from sheet steel of adequate thickness. All seams shall be properly welded to withstand requisite impact during short circuit without distortion. All welding shall be stress relieved and strong enough to allow the lifting of complete transformer with oil by means of a crane or jacks and transported to site without over-straining the joints etc. The base shall be so designed as to allow the transformer to be moved by skidding without any injury.

The main tank body shall be capable of withstanding a vacuum of 100.64 KN/m^2 (760 mm of Hg.)

Stiffener of structural steel for general rigidity shall reinforce the tank wall. The tank shall have sufficient strength to withstand mechanical shock during transportation and vacuum filling in the field without any deformation.

The tank cover shall be bolted on to the tank with weatherproof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops shall be provided to prevent over compression. Bushings, turrets, cover of access holes and other devices shall be designed to prevent any leakage of water into or oil from the tank. The tank cover shall also be provided with two (2) nos. of grounding pads and connected separately to tank grounding pads.

The transformer tank shall be provided with four sets of bi-directional flanged wheels for rolling the transformer parallel to either direction of center line on rail. Mounting rails and anti-earthquake device shall also be provided.

All heavy removable parts shall be provided with mounting rails along with eye bolt for ease of handling and necessary lugs and shackles shall be provide to enable the whole transformer to be lifted by a crane or other means. Manholes of sufficient size shall be provided for access to leads, windings, bottom terminals of bushings and taps.

3.3.2 Core & Coils

The transformer shall be of core type. The core shall be built up with interleaved grade non-aging, low loss, high permeability, grain-oriented, cold rolled silicon steel lamination properly treated for core material. Known as MOH High B Grade or superior grade CRGO steels of low lamination thickness especially suitable for transformer core. The coils shall be manufactured from electrolytic copper of suitable grade. They should be properly insulated and stacked.

The transformer should be so designed that the working flux density should not exceed 1.57 Tesla at normal voltage, frequency.

All insulating material shall be of proven design. Coils shall be so insulated, that impulse and power frequency voltage-stresses are minimum.

Coil assembly shall be suitably supported between adjacent sections by insulating spacers and barriers. Bracing and other insulation used in the assembly of the winding shall be arranged to ensure a free circulation of the oil and to reduce the hot spot of the winding.

The core shall be rigidly clamped and/or bolted to ensure adequate mechanical strength and to prevent injury from vibrations or short circuit stresses. The bolts used in the assembly of the core shall be suitably insulated and the clamping structure shall be constructed that the eddy currents will be minimum.

All leads from the windings to the terminal board and bushings shall be rigidly supported to prevent injury from vibration or short circuit stresses. Guide tube shall be used where practicable.

The core shall be provided with Lugs suitable for lifting the complete core and coil assembly of transformer. The Core & coil shall be fixed in the tank such that its shifting will not occur when the transformer is moved or when a short circuit occurs.

The supporting frame work of the core shall be so designed as to avoid the presence of pockets which would prevent complete draining of oil from the tank through the drain valve.

The frame work and clamping arrangement shall be earthed by connecting to the tank body through a copper strip.

The insulation of core to bolts and core to clamp plates shall be able to withstand a voltage of 2 KV RMS for one minute.

Core and windings shall be capable of withstanding shocks during transport, installation, service and adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

3.3.3 Tapping

On-load taps as specified in Technical Schedules shall be provided on the high voltage winding of the transformer.

The transformer shall be capable of operation at rated output at any tap position provided the primary voltage does not vary by more than ±10% of the rated voltage corresponding to the normal tap.

The winding including the tapping arrangement shall be designed to maintain the electromagnetic balance between H.V. and L.V. winding at all voltage ratios.

3.3.4 Tap Changing Equipment/On-Load Tap Changer (OLTC)

Each Transformer shall be provided with On load Tap changing equipment. The OLTC shall be offered from reputed makes like MR Germany/ABB Sweden or equivalent.

The continuous current rating of the tap changer shall be based on connected winding rating and shall have liberal and ample margin. Lower rated tap changers connected in parallel are not acceptable.

The tap changing mechanism shall be located in oil filled compartment separated from the main tank by suitable oil tight barrier. The oil in OLTC compartment shall have its own separate oil preservation system complete with conservator, Buchholz relay/ oil surge relay, breather, shut-off valves, oil level gauge, gas vent etc. However, one segregated compartment of the main conservator tank may be utilized for OLTC oil preservation. Bidder shall also has the option to propose high speed resistor type OLTC with vacuum technology.

The on-load tap changing equipment shall have the provision for mechanical and electrical control from local position and electrical control from remote position. For local mechanical operation, the operating handle shall be brought outside the tank for operation from floor level with provision to lock the handle in each tap position. Remote electrical operation shall have parallel operation mode and AUTO-MANUAL selection at remote location. When selected AUTO, the tap changing gear shall maintain steady voltage within practical limit on the transformer secondary bus from which the reference shall be taken within the range of number of taps provided. It shall not respond to transient variation of voltage due to grid disturbance, or system faults.

The required voltage relay shall not be sensitive to frequency variation and shall be suitable for sensing voltage from the secondary of potential transformer mounted on LV side. The secondary of potential transformer shall be 110V. The Bidder shall furnish detail of tap changing mechanism, wiring and schematic connections.

The tap changer shall be provided with over-current protection in order to prevent the tap-change operation during a short circuit, which would too greatly stress the contacts of the diverter switch. Three instantaneous and self-reset over-current relays shall be provided and the function of protection shall be arranged as follows:

a. Whenever over current occurs, the control circuit for commanding OLTC motor operation shall be blocked by the normally close contacts of the over current relays.
b. If during tap change over current occurs, the OLTC motor circuit shall be blocked through the mechanical cam switch, which is close from the very beginning to the very end of every tap change operation and the normally open contacts of the over current relays. The stop action of the motor shall be made through the motor brake contractor.

Any non oil filled enclosed compartment shall be adequately ventilated, thermostatically controlled heaters shall be provided in the driving mechanism chamber and in the marshaling box. All contactor & auxiliary relay coils or other parts shall be suitably protected against corrosion or deterioration due to condensation, fungi etc.

The design of the tap changing equipment shall be such that the mechanism will not stop in any intermediate position. However, if the mechanism through faulty operation does stop in an intermediate position, the transformer without injury must carry full load. The mechanical position indicator shall be equipped in the motor drive cubicle. The motor shall be designed to be of step control, which in any case the operation shall be of step by step.

The voltage-regulating relay shall be supplied together with the timer and under voltage relay. The signal order from the voltage regulating relay to execute the tap changer operation, when the regulating voltage is out of the voltage regulating level, shall be designed to be delayed by the adjustable timer. If the control voltage falls abnormally, the movement of the tap changer shall be locked by the contact of the under voltage relay, even if the contacts of the voltage-regulating relay are working.

The control circuit of the transformer shall be completely designed and provision shall be made for parallel operation with another transformer. MASTER-FOLLOWER operation mode shall be provided.
The following accessories, control and selector switches and other necessary accessories shall be furnished.

a. Remote control board

- "Parallel operation mode" selector switch
- "AUTOMATIC-MANUAL" selector switch
- "RAISE-LOWER" control switch
- Tap position indicator
- tap changer operation program indicator.

b. In transformer control cubicle

- "Remote-Local-Test" selector switch
- "AUTOMATIC-MANUAL" selector switch
- "RAISE-LOWER" control switch
- Tap position indicator
- Voltmeter

c. In driving mechanism cubicle

- "Raise-Lower" control switch
- Means for manual operation when power supply is lost
- Tap change operation counter

3.3.5 Insulating Oil

The insulating oil shall conform to the latest revision of IEC Publication 60296, and shall have following important characteristics after it is filled in the transformer (within 3 months of filling).

Sr. No.	Characteristics	Specification
1.	Electric Strength (BDV)	50 kV (min)
2.	Dielectric dissipation factor	0.01 (Max.) (Ten Delta)
3.	Specific resistance (Resistivity)	1500x10*12 (Min.) at 27^0C (ohm-cm)
4.	Flash point pensky-Mortion	1400C (Min.) (Closed)
5.	Inter facial tension at 27°C	0.04 N/m (Min.)
6.	Total activity	0.04 mg koh/gm (Max.)
7.	Water Content	50 (Max)

PREVENTION OF ACIDITY: The design and all materials and process used in the construction of the transformers shall be such as to reduce to a minimum the risk or the development of acidity in the oil. Special measures, such as nitrogen sealing or the use of inhibited oils shall be resorted to.

Particular attention shall be paid to deliver the oil at site free from moisture and of uniform quality throughout in non-returnable steels drums. The quantity of oil for first filling of each transformer shall be stated in tender along-with trade mark of the oil to be supplied. Use of inhibitors in oil shall not be resorted to. 10% extra oil of the total quantity of oil shall be supplied along with the transformer.

3.3.6 Oil Preservation System

Oil preservation shall be by means of conservator tank system.

The conservator tank with air cell shall be mounted on a bracket fixed on the tank.

The conservator tank may be provided with two compartments, one for the main transformer tank while the other is for the OLTC compartment. The partition barrier shall be provided so that OLTC oil shall not be mixed up with transformer oil under any circumstances. One compartment shall be connected with the main transformer tank by pipes through double float Buchholz Relay (gas operated relay) with valves at both ends. The other compartment shall be connected with OLTC compartment by pipes through single float Buchholz Relay/oil surge relay with valves at both ends.

The oil connections from the transformer tank to the conservator shall be at rising angle of 3 to 9 degrees to the horizontal upto Buchholz relay.

Using a flexible urethane air cell shall prohibit contact of the oil in the compartment for the main tank with atmosphere. The conservator shall be provided with oil preservation system, which should be suitable either to remove moisture continuously from air entering the air space with which they are connected or may not allow direct contact of atmospheric air with oil during operation, in addition to silicagel-breather.

Both compartments shall be provided with their own breather, filler cap and drain plug.

Each compartment of the conservator shall be provided with dial type level indicator visible from the ground level and fitted with low oil-level alarm contact. Plain oil level gauge shall also be provided to each compartment.

3.3.7 Temperature Indicators

One set of winding temperature indicator shall be supplied and fitted locally so as to be readable at a standing height from ground level. Necessary current transformer and heating coil for obtaining thermal images of winding temperatures and a detector element shall be furnished and wired.

The above winding temperature indicator shall be provided with necessary contacts to take care of the following.

a. Starting of cooling units in stages, with rise of temperature
b. Alarm on high temperature
c. Trip on higher temperature

One set of oil temperature indicator with maximum reading pointer and electrically separate sets of contacts for alarm and trip shall be mounted locally so as to be readable at a standing height from ground level.

All contacts should be accessible on removal of the cover adjustable to scale. It shall also be possible to move the pointers by hand for checking the operation of contacts and associated equipment.

3.3.8 Buchholz Relay (Gas Operated Relay - For Conservator Type of Oil Preservation)

The Buchholz Relay shall be provided with two floats and two pairs of electrically separate contacts - one pair for alarm and the other pair for tripping.

Buchholz Relay shall be provided with the facility for testing by injection of air by hand pump and with cock for draining and venting of air. The relay shall be provided with a test cock to take a flexible connection for checking relay operation.

3.3.9 Pressure relief device

Pressure relief device with a sudden gas pressure relay shall be furnished and mounted on top of the tank in the region of the gas space. The relay shall respond to sudden increase in internal gas pressure in the transformer due to internal arcing. The relay shall be provided with trip contact.

Above relay shall be stable during change in oil or gas pressure due to change in ambient temperature and/ or loading.

3.3.10 Transformer Bushings

All bushings shall conform to the requirements of the latest revisions of IEC Publication 60137.

The bushing shall be located so as to provide adequate electrical clearances between phases and also between phase and ground as per relevant standards.

All bushings shall be porcelain type and shall be furnished complete with terminal connectors of adequate capacity including arcing horns. The porcelain used in bushings shall be homogeneous, nonporous, uniformly glazed to brown color and free from blisters, burns and other defects.

Stresses due to expansion and contraction in any part of the bushing shall not lead to deterioration.

Liquid/oil-filled bushings for 36 kV and above shall be equipped with liquid level indicators and means for sampling and draining the liquid. The angle of inclination to vertical shall not exceed 30 degree.

Oil in oil-filled bushings shall meet the requirement of the transformer oil standards specified.

Bushings rated for 72.5 kV and above shall be of the oil-filled condenser type with a central tube and draw-in conductor which shall be connected to the connector housed in the helmet of the bushings. The pull through lead shall be fitted with a gas bubble deflector. Condenser type bushings shall be equipped with following in addition to requirements indicated elsewhere.

a. Provision for testing capacitance and loss angle (tan δ) without disconnecting main leads
b. Stress rings and lower end shields
c. Current transformers shall be provided as specified, and the bushing shall be so arranged that it can be removed without disturbing the current transformers and secondary terminals
d. Bushing turrets shall be provided with vent pipes, which shall be connected to route any gas collection through the Buchholz relay.

3.3.11 Marshalling Box

A sheet steel weatherproof marshaling box of IP-55W construction shall be provided. The box shall contain all auxiliary devices except those which must be located directly on the transformer. All terminal blocks for external cable connections shall be located in this box.

The marshaling box shall have the following but not limited to them

a. Load disconnect switch for incoming power supply for auxiliaries
b. Cooler fan motor starters and necessary protection
c. FAN START-STOP control switch
d. AUTO-MANUAL selector switch
e. Oil Temperature Indicator
f. Winding Temperature Indicator
g. Wiring and termination individually of the following alarm contacts for remote pretrip alarm

- Buchholz relay alarm for main tank (for conservator type)
- Buchholz/oil surge relay alarm for OLTC
- Winding temperature high alarm
- Oil temperature high alarm
- Tank oil level low alarm
- OLTC oil level low alarm
- Tap change incomplete alarm
- OLTC out of step

h. Wiring and termination individually of the following trip contacts for remote trip and trip alarm

- Winding temperature high trip
- Oil temperature high trip

- Buchholz relay trip or sudden gas and sudden oil pressure relay trip
- Pressure relief device

Cubicle illumination lamp with door switch and space heater with thermostat and ON-OFF switch shall be provided.

Wiring shall be as specified in section under General Technical Specifications.

3.3.12 Cable Termination

Marshaling box shall be designed to facilitate cable entry from bottom. Removable plates shall be furnished with compression type cable glands to make entry dust tight and no weight is transferred on the terminal. The glands shall be suitable for terminating cable armour. Sufficient space shall be provided to avoid sharp bending and for easy connection. A minimum space of 200 mm from the gland plate to the nearest terminal block shall be provided.

3.3.13 Terminal Blocks

Terminal blocks shall be as specified in Technical Requirements under section in General Technical Specifications.

3.3.14 Painting

Painting works shall be as specified in Technical Requirements under section in General Technical Specifications.

3.3.15 Auxiliary supply

All indications, alarms and trip contacts provided shall be suitable for operation on a nominal 110V DC system.

Tap changing gear shall be suitable for operation of 400V ± 10%, 3 phase, 4 wire, 50Hz, AC.

Cooling fans shall be rated at 400V ± 10% 3 Ph, 50Hz, AC.

The tap changing and cooler control supply voltage shall be 400/230V, 50Hz AC.

3.4 Auxiliary Equipment to be Furnished

3.4.1 Bushing Current Transfer

Each transformer shall be provided with one (1) set of current transformer each on the HV and LV terminal bushings to be used for transformer differential relaying.

The transformer shall be provided with neutral bushing current transformer to be used for earth fault protection in High/Low Voltage sides.

Current transformer rating and accuracy class shall be as per Technical Schedule (Section 20) and shall be designed to withstand the electromagnetic stresses developed during short circuit.

The current transformer secondary leads shall be wired up to a separate disconnecting type terminal block within the marshaling box. The terminal blocks shall be complete with shorting links.

3.4.2 Lightning Arresters

If required, Tank mounted lightening arresters shall be provided on 33 kV sides of the transformers. The lightning arresters shall comply with the specifications in the chapter "Lightening Arrester". The Contractor shall coordinate the insulation.

3.4.3 Cooling Equipment

Each transformer shall be equipped with a sufficient number of radiators or cooling units to operate as a self-cooled unit or with forced cooled ratings, as specified. Single stage or double stage fans shall be provided as specified in Technical Schedules (Section 20). Fans shall be automatically controlled by a transformer winding temperature relay.

Fan motors shall be of totally enclosed design and control equipment shall include a circuit breaker with thermal and magnetic trip for each group of fans, contactors with overload protection, and selector switch for MANUAL-AUTOMATIC operation.

3.5 Tests

3.5.1 Routine Tests

On completion, each transformer shall be subjected to the following Routine Tests. As far as practical, the procedure of IEC 60076 shall be followed.

a. Applied voltage test
b. Induced voltage test
c. No-load loss and excitation current test
d. Impedance voltage and load loss test
e. Winding resistance measurement
f. Ratio test
g. Polarity and phase-relation test
h. Leakage test
i. Insulation resistance test
j. Insulation power factor test, etc.

3.5.2 Special Tests

The following tests shall be performed on each transformer:

a. Zero phase sequence impedance measurement
b. After fabrication, the tank fitted with all valves, covers, conservator tank etc., shall be completely filled with transformer oil and subjected to a pressure of 25 % over the normal pressure of oil. This pressure shall be maintained for 12 hours during which time there shall be no leakage of oil nor shall there be any permanent set when pressure is released. If any leakage or permanent set occurs, the test shall be conducted again after rectification of defects.
c. Excitation loss and current measurements shall be made at 90%, 100%, and 110% of rated voltage.
d. Measurement of third harmonic voltage.
e. Measurement of accusoustic noise level.
f. Measurement of harmonics of the no-load current.
g. Temperature rise test.

3.5.3 Design Tests

Following design tests shall be performed on any one of identical transformers of each type in accordance with latest revision of IEC Publication 60076: *(identical shall mean having same rating and construction)*

a. Impulse voltage withstand test
b. Short circuit test -only design calculations to be submitted confirming withstand Capability

3.5.4 Tests on Miscellaneous Components

The various components of the transformer such as insulating oil, bushings, current transformers, etc. shall be tested in accordance with the latest revision of relevant standards listed in this Specification. Such test report shall be submitted during inspection or prior to dispatch for the Employer approval.

The ON-LOAD tap changer shall be tested in accordance with the relevant IEC standard.

3.5.5 Test Certificates

Test certificates shall be furnished in required number of copies for approval.

If the inspection is waived, the routine, special and design test certificates of the transformer as well as miscellaneous equipment shall be furnished for approval before the dispatch of the equipment from the factory.

3.5.6 Field Test

After installation at Site, the transformer shall be subjected to the following field tests:

a. Construction inspection
b. Insulation oil test for

- Dielectric strength
- Acidity contain
- Dissolved gas analysis

These tests shall be conducted in the laboratory of the Employer at the Employer's approved rate at the cost of the contractor.

c. Measurement of insulation resistance
d. Ratio tests
e. Polarity tests
f. Tap change operation test, etc.
g. Magnetizing balance test
h. Calibration of WTI and OTI
i. Setting of alarm, trip and cooler controls and operation check.

3.6 Tender Evaluation and Guaranteed Losses

3.6.1 Capitalization of Transformer Losses

The transformer losses will be capitalized as follows for evaluation purpose:

a.	No load losses	:	USD 4684 per kW
b.	Load losses	:	USD 1180 per kW

c. Loss associated with cooling fan load : USD 393 per kW

3.6.2 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 3.6.1 for no load losses and load losses shall be deducted from the Contract Price of the successful Bidder.

3.7 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 Bidder's Contract. In case of loss capitalization, no tolerance shall be permitted for the guaranteed value. The transformer will be rejected, if the measured no-load and load losses (excluding fan loss) exceed the guaranteed value by over 15 % provided that the total losses do not exceed 10% as specified.

3.8 Drawings, Data & Manuals

Submission of Drawings Data & Manuals by the Bidder along with the Bid Document and that after the award of Contract for approval shall be as follows:

3.8.1 Along with the bid

Typical general arrangement drawing of the proposed equipment shall be submitted along with the bid.

3.8.2 After Award of Contract

After award of Contract, the successful Bidder shall submit the required number of copies of following data for approval.

a. Outline dimensional drawing showing the general arrangement, indicating the space required for:
   - Cable termination arrangement
   - Wheel base dimension & detail

b. Head clearance required for detanking of core and coil assembly
c. Foundation plan and loading
d. Transport/ shipping dimension with net weight and weights of various parts
e. Final calculation of impedance for each transformer at normal, lowest and highest taps.
f. Schematic flow diagram of cooling system showing the number of cooling units
g. Technical details along with control schematic and wiring diagram for marshaling box, on load tap changer and remote tap-changer control panel.

Any other relevant data, drawing and information necessary for review of the items under Clause No. 3.8.2 whether specifically mentioned or not, shall be furnished along with these information.

3.9 Name Plate

Each transformer shall be provided with a nameplate of weather resistant material fitted in a visible position showing but not limited to the following items:

a. Kind of transformer

b. Manufacturing standard
c. Manufacturer's name
d. Year of manufacture
e. Manufacturer's serial number
f. Number of phases and frequency
g. Rated power
h. Rated voltages and currents
i. Connection symbol (Vector group)
j. Percentage impedance at normal, highest and lowest taps at max. base MVA
k. Type of cooling
l. Total weight
m. Weight of insulating oil
n. Weight of transportation and untanking
o. No-load and Full load losses values in kW
p. Temperature rise
q. Connection diagram
r. Insulation levels
s. Details regarding tappings.

3.10 Spare

The spare parts shall be provided in required quantities as listed in the Price Schedule. Further spare-parts as recommended by the manufacturer shall also be included in the Price Schedule.

3.11 Transportation

The core and coils shall be completely dried before shipment and assembled with tank and with oil or dry nitrogen depending upon the size of the transformers. In order to facilitate handling and shipping, as many external accessories as practical, including bushings, shall be removed and replaced by special shipping covers. The Contractor shall give special attention to the limitation of bridge capacity in Nepal and make necessary transportation arrangements accordingly. Shock recorders shall be installed on the Transformers to record maximum shock forces during shipment/transportation. This value shall not exceed the value provided by the manufacturer as per standard.

Bushings, radiators and other accessories, which may be affected by moisture, shall be packed in moisture proof containers.

APPENDIX A-1: TRANSFORMER ACCESSORIES

Each transformer furnished under this specification shall be equipped with the following:

a. Oil conservator with air cell having two compartments each with filler caps and drain plugs.
b. Two sets of Silica Gel breathers with connecting pipe and oil seal.
c. Air release plug.
d. Double float Buchholz Relay with electrically separate trip and alarm contacts for transformer tank.
e. Two Nos. of shut-off valves at both sides of each Buchholz Relay.
f. Mechanically operated self resetting type pressure relief device with visible operation indicator and trip contact.
g. 150 mm Dial Magnetic Oil Level Gauge with low level alarm contact.
h. Direct Reading Plain Oil Level Gauge.
i. 150 mm Dial Oil Temperature Indicator with maximum reading pointer and individually adjustable electrically separate sets of contact for alarm and trip.
j. 150 mm Dial Winding Temperature Indicator with individually adjustable electrically separate sets of contact for two stage cooler control, alarm and trip with detector element complete with heating coil, CT's etc.
k. Drain valve with threaded adapter.
l. Sample valve (top and bottom).
m. Filter valves with threaded adapter (top and bottom).
n. Cover lifting eyes.
o. Jacking pads, hauling and lifting lugs.
p. Bi-directional flanged wheels.
q. Rails.
r. Clamping device with nuts and bolts for clamping the transformer on foundation rails.
s. Ladder with safety device for access to the transformer top and Buchholz Relay.
t. Ground pads each with two (2) nos. tapped holes, bolts and washer for transformer tank, radiator bank and cable-end box grounding.
u. Rating plate and terminal marking plate.
v. Marshaling box for housing control equipment and terminal connections.
w. Any other standard accessories including arcing horns, as required.

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SECTION - 4

OUTDOOR CIRCUIT BREAKER

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4 OUTDOOR CIRCUIT BREAKER

4.1 General

This specification covers the design, manufacture, assembly, shop test, supply, delivery, installation, field test and commissioning of outdoor circuit breaker complete with all accessories for efficient and trouble free operation as specified herein under. 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.

The equipment specified in this Section shall conform to the latest edition of the appropriate IEC specifications and/or other recognized international standards. In particular:

IEC 60056	High-voltage alternating switchgear
IEC 62271	High-voltage alternating switchgear and control gear
IEC 60376	Specification and acceptance of new sulphur hexafluoride
IEC 60529	Degree of protection provided by enclosures
IEC 60694	Common specifications for high-voltage switchgear and control gear standards

4.2 Design Requirements

The circuit breakers shall be suitable for 3 phase, 50 Hz and shall be installed outdoor in the vicinity of industries. The circuit breaker shall be located at an attitude of 2200 m above Mean Sea Level.

All equipment and accessories shall be provided with sub-tropical finish to prevent fungus growth.

The maximum temperature rise in any part of the equipment at specified rating shall not exceed the permissible limits as stipulated in relevant standards.

The support structure of circuit breaker shall be hot dip galvanized. Exposed hardware items shall be hot dip galvanized or Electro-galvanized.

The rated peak short circuit current or the rated short time current carried by the equipment shall not cause:

a) mechanical damage to any part of the equipment
b) separation of contacts
c) Insulation damage of "Current Carrying Part"

Technical particulars of the circuit breaker shall be as specified in the in schedule A.3 of Section-20.

All auxiliary equipment shall be suitable for 3 phase-4 wires, 400 V or single phase 230 V, 50 Hz system. All controls shall be suitable for 110V DC.

4.3 Construction Features

The circuit breaker shall be outdoor, three-phase, (single-throw), spring charged motor operated, trip free in any position, complete with operating mechanism and supporting structure.

The 145 kV circuit breaker shall be SF6 gas type whereas the 36 kV circuit breaker shall be Vacuum type.
The circuit breaker shall be capable of interrupting the steady state and transient magnetizing current corresponding of power transformers.

The circuit breaker shall also be capable of:

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

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

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 in schedule A.3 of Section-20.

4.3.1 Reclosing operation

The circuit breaker for outgoing/incoming line for voltage level 66 kV and above shall be capable of making reclosing operation.

4.3.2 Contacts

The contacts shall be designed to have adequate thermal and current carrying capacity for carrying full-rated current without exceeding the allowable temperature rise as specified by IEC standards. They shall be designed to have long life so that frequent replacement or maintenance will be unnecessary. The surfaces of either of both moving and stationary arcing-contacts that are exposed directly to the arc shall be faced with suitable arc resisting material.

The gap between the open contacts shall be such that it can withstand at least the rated phase to ground voltage for 8 hours at zero gauge pressure of SF6 gas due to the leakage. The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. 2 p.u. across the breaker continuously, for validation of which a power frequency dielectric with stand test conducted for a duration of at least 15 minutes is acceptable).

4.3.3 Gas Density Detector for SF6 circuit breaker

The circuit breaker shall be provided with gas density detector, responding to the gas temperature and pressure, which shall have two different functions according to the gas condition: the first step gives alarm and the second step locks the operating mechanism. A gauge shall also be provided to indicate the gas-pressure.

4.3.4 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.

4.3.5 Local Test Switch

Each mechanism shall be equipped with a local test switch for electrically testing the closing and tripping operations of the circuit breaker. A separate manually operated cut-out device to disconnect the circuits from remote closing, reclosing and tripping devices shall be provided on each circuit breaker. A warning nameplate requiring operation of this device before operation of the local test switch shall be mounted adjacent to the local test switch.

4.3.6 Emergency Trip

Each circuit breaker shall be provided with an emergency hand trip device. This device shall be provided with mechanically interlocked contacts to disconnect circuits from remote closing and reclosing devices. The trip button shall be mounted in such a way that it can be operated from outside of the operating box.

4.3.7 Position Indicator

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. The indicator shall be provided for each pole.

4.3.8 Tripping Circuit

Two (2) sets of tripping coils shall be provided in two separate current and magnetic circuits in order to make possible primary and backup tripping of circuit breaker. Provision for trip circuit supervision shall be provided.

The tripping circuit mechanism and the closing control circuit mechanism shall each have a nominal voltage rating of 110 volts DC. The tripping circuit shall operate satisfactorily for a tripping operation over a voltage range of 70-110%. The closing control circuit shall operate satisfactorily over a voltage range of 85-110%.

4.3.9 Motor-operated Spring-Charged Mechanism

A complete and separate spring-operating system shall be furnished and installed to operate the circuit breaker. The mechanism shall be housed in a weather proof and dust proof control cabinet. The closing action of breaker shall charge the opening spring for tripping.

The operating mechanism shall be strong, rigid, not subject to rebound.

The mechanism shall be anti pumping and trip free (as per IEC definition) under every method of closing.

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.

After failure of power supply to the motor one close open operation shall be possible with the energy contained in the operating mechanism.

Breaker operation shall be independent of the motor which shall be used solely for charging the closing spring. Each operating mechanism shall be provided with a spring charging motor with a common control cabinet.

- The time required to charge the closing spring after the closing operation shall not exceed 30 seconds.
- Under voltage alarm relay suitable for operation on DC circuit to permit remote indication of loss of potential on the AC to the control gear.
- Spring charged indicator shall indicate the state of energy store in the spring. Indication for fully charged spring shall be provided both at local and remote control panel.
- 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.
- Means shall be provided to prevent the operation of the mechanism when maintenance work is being done. The mechanism shall be so arranged that emergency manual charging and release of the spring is possible without electrical means. One (1) CO-operation shall be possible after failure of supply.

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.

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, erection, commissioning, troubleshooting, servicing and overhauling instructions.

4.3.10 Operating Cubicle

Circuit breaker operating mechanisms, auxiliary switches and associated relays, control switches, control cable terminations, and other auxiliary equipment shall be housed in sheet steel vermin-proof and weatherproof cubicles. The enclosure protection of the cubicle shall be IP55W. Where appropriate, the cubicles may be free standing with front and rear access.

Cubicles shall be of rigid construction, preferably folded but alternatively formed on a framework of standard rolled steel sections and shall include any supporting steel work necessary for mounting on the circuit breaker or on concrete foundations. The thickness of the sheet steel shall be at least 2 mm. All fastenings shall be integral with the panel or door and provision made for locking. Doors shall be rigid and fitted with weatherproof sealing materials suitable for the climatic conditions specified. The structure design shall be such that during operation of circuit breaker vibrations are reduced to minimum.

Cubicles shall be well ventilated thorough vermin-proof louvers comprising a brass gauze-screen attached to a frame and secured to the inside of the cubicle. Divisions between compartments within the cubicle shall be perforated to assist air circulation. In addition, thermostat- controlled space heater with ON-OFF switches rated 230 V, 1 phase, 50 Hz shall be provided to prevent condensations within the cubicle.

A local control switch connected with a remote-local selector switch shall be furnished and wired in the control circuits of the breaker. The local control switch shall be operative from within the operating cubicle only when the selector switch is in local position.

4.3.11 Terminal Connector Pad

The circuit breaker terminal pads shall be made up of high quality electrolytic copper or aluminum the terminal pad shall have protective covers which shall be removed before interconnections.

4.3.12 Bushings

The bushings shall be of the porcelain gas filled, designed to have ample insulation, mechanical strength and rigidity for the conditions under which they will be used.

4.4 Accessories

The Contractor shall furnish following accessories as an integral part of each circuit breaker:

a) Padlocks and duplicate keys.
b) Cable glands (Double compression type), Lugs, Ferrules etc.
c) Space heaters equipped with thermostatic controls.
d) Local/remote control switch.
e) Fuses as required.
f) Operation counter.
g) Earthing pad (two) for each pole.
h) Terminal boards with six spare terminals.
i) Two earthing terminals for each mechanism box.
j) Auxiliary relays.
k) Motor contactor with thermal release for spring charging motor.
l) Rating and diagram plate in accordance with IEC incorporating year of manufacture. .
m) Special tools and tackle for operation and maintenance of equipment including gas leakage detector and gas filling device for the circuit breaker supplied.
n) Other necessary accessories.

4.5 Spare Parts

For each type of circuit breaker, the spare parts shall be provided in required quantities as listed in Price Schedule. Further spare parts as recommended by the manufacturer shall also be included in the Price Schedule.

4.6 Tests

4.6.1 Routine Tests

On completion, each circuit breaker shall be subjected to following routine tests. As far as practical, the procedure of IEC shall be followed:

a) Construction Inspection
b) Leakage Test (for SF6 circuit breaker)
c) Operating Speed Check
d) Dielectric test
e) Control and secondary wiring check test
f) Mechanical operation test
g) Operating mechanism system check
h) Voltage withstand test on auxiliary circuits
i) Measurement of resistance of main circuit of each pole
j) Power frequency voltage withstand test on main circuit of each pole and the combination of poles and breaker frame.

4.6.2 Design Tests

Following design tests shall be performed on the offered model.

The circuit breaker design tests shall include following:

a) Dielectric withstand test
b) Temperature rise test
c) Radio interference voltage test
d) Short-time withstand current and peak withstand current tests
e) Verification of the protection
f) Electromagnetic compatibility tests

The Bidder shall submit type test report as specified in section-2 of this specification for the circuit breaker of the offered model along with the bid.

4.6.3 Field Tests

After installation at Site, the circuit breaker shall be subjected to the following field tests:

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 compressed air plant and all accessories.
i) Functional checking of control circuits interlocks, tripping through protective relays and auto reclose operation.
j) Insulation resistance of control circuits, motor etc.
k) Resistance of closing and tripping coils.
l) SF6 gas leakage check.
m) Dew Point Measurement
n) Operation check of pressure switches and gas density monitor during gas filling.

o) Checking of mechanical 'CLOSE' interlock, wherever applicable.
p) Testing of grading capacitor.
q) Resistance measurement of main circuit.
r) Checking of operating mechanisms
s) Check for annunciations in control room.
t) Point of wave switching test(wherever applicable)

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 manufacturer's representative.

4.7 Performance Guarantee

The performance guarantee figures quoted on the schedule of Technical Data shall be guaranteed within the tolerances permitted by relevant standard and will become a part of successful Bidder's Contract.

4.8 Drawings, Data and Manual

The outline drawings of the breaker and control cubicle with accessories shall be furnished along with the Bid. After award of Contract the successful Bidder shall submit the required number of copies of the following drawings and data for approval of the Employer.

a) General equipment layout
b) Outline drawings of the breaker and control cubicle with accessories
c) Loading data and foundation detail
d) Elementary control wiring diagrams
e) Internal wiring diagrams
f) External connection diagrams, showing terminal boards and other external Connection points for each assembly and the required interconnecting wiring
g) Drawings showing typical cross-sections of the operating mechanism and the breaker mechanism
h) Drawings showing typical cross-section and assembly of interrupting device
i) Drawings showing assembly of principal component parts and accessories
j) Drawings showing details of bushings or porcelain supporting columns, including dimension details of flanges and outline dimensions
k) Drawing to show details at all points where adjustments may be made to operating dimension mechanism, breaker mechanism and contact
l) Any other drawings and data required for design and installation of circuit breaker.
m) Instruction manual for storage, installation, operation and maintenance of circuit breaker and operating mechanism.

4.9 Nameplate

Circuit breaker shall be provided with a nameplate of stainless steel material fitted in a visible position. It shall show the following items as a minimum.

a) Circuit Breaker (Note: Circuit breaker and operating cubicle nameplates may be combined)

- Manufacturer's name
- Manufacturer's serial number and type designation
- Year of manufacture
- Rated voltage, kV
- Rated insulation level, kV
- Rated frequency, Hz
- Rated nominal current, A
- Rated short-circuit breaking current, kA
- Rated short circuit making current, kA

- Rated operating cycle (duty cycles)
- Rated short time current & duration, kA/s
- Rated operating sequence (duty cycles)
- Type of operating mechanism
- First pole to clear factor
- Rated interrupting time, cycles
    - Rated operating pressure (SF6), kg/cm2
    - Weight of circuit breaker, kg
    - Parts list number

b) Operating cubicle (Note: Operating cubicles and circuit breaker nameplates may be combined.)

- Manufacturer's name
- Manufacturer's serial number and type designation
- Year of manufacture
- Rated supply-voltage of closing and opening devices, V
- Rated supply-frequency of closing and opening devices, Hz
- Closing current, A
- Tripping current, A
- Rated supply-voltage of auxiliary circuits, V
- Rated supply-frequency of auxiliary circuits, Hz
- Parts list number

4.10 Special Tools

In addition to the tools, which are regularly furnished with such breakers, the Contractor shall also supply all necessary special tools or equipment for assembling and disassembling the breaker. The Contractor shall submit an itemized list of such equipment in the Price Schedule.

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SECTION - 5

DISCONNECTING SWITCH

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5 DISCONNECTING SWITCH

5.1 General

This specification covers the design, manufacture, assembly, shop test, supply, delivery, installation works, field test and commissioning of outdoor type disconnecting switches complete with all accessories for efficient and trouble free operation as specified herein under.

The equipment specified in this Section shall conform to the latest edition of the appropriate IEC specifications and/or other recognized international standards. In particular:

IEC 60129 High-voltage alternating current disconnectors and earthing switches
IEC 60529 Degree of protection provided by enclosures

5.2 Design Requirements

The disconnecting switches shall be used for the 50Hz, 3 phase system. Earth switches shall be provided on disconnecting switches wherever called for. The disconnecting switches shall be installed at an attitude of 2200 m above mean sea level.

Complete disconnecting switches with all the necessary items for successful operation shall be supplied.

The equipment shall be installed outdoor. All equipment, accessories and wiring shall be provided with sub-tropical finish to prevent fungus growth.

The maximum temperature rise in any part of the equipment at specified rating shall not exceed the permissible limits as stipulated in relevant standards.

The rated peak short circuit current or the rated short time current carried by the disconnecting switches & earth switches shall not cause;

a) Mechanical damage to any part of the equipment
b) Separation of Contacts
c) Insulation damage of "Current Carrying Part".

The disconnecting switches shall be centre break or center rotating for 33 kV and centre break for 132 kV with contact blades moving through horizontal plane.

The rating, the accessories to be furnished and the schedule of equipment are detailed in schedule A.4 of Section-21.

The disconnecting switch shall be able to carry the rated current continuously and rated short circuit current for one second without exceeding the temperature.

The disconnecting switches shall be capable of withstanding the dynamic and thermal effects of maximum possible short circuit current.

In case of disconnecting switch with grounding switch, the grounding switch shall be capable of making to a dead short circuit without damage of the equipment or endangering operator. It shall be provided with and interlocking with the corresponding disconnecting switch so that the earth switches can be operated only when the disconnecting switches is open and vice versa.

The earthing Switches shall be capable of discharging trapped charges of the associated lines. Disconnecting switches and earth switches shall be able to bear on the terminals the total forces including wind loading and electrodynamic forces on the attached conductor without impairing reliability or current carrying capacity.

5.3 Construction Features

The 3-pole disconnecting switches shall be gang-operated type so that all the poles make and break simultaneously.

The disconnecting switches shall be designed for upright/vertical mounting on steel structure. The disconnecting switches shall be provided with a galvanized steel base provided with holes and designed for mounting on a lattice/pipe support structure. Disconnecting switches to be mounted on gantry structure shall include necessary steel channels, bolts, nuts, etc. The position of movable contact system (main blades) of each of the disconnecting switches and earthing switch shall be indicated by a mechanical indicator at the lower end of the vertical rod of shaft for the disconnecting switches and earthing switch. The indicator shall be of metal and shall be visible from operating level. The disconnecting switches shall have padlocking arrangement in both "open" and "closed" positions.

All current carrying parts shall be of non-ferrous metal or alloy. 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 equivalent. The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces.

All metal parts shall be of such material and treated in such a way as to avoid rust, corrosion and deterioration due to atmospheric conditions. Ferrous parts shall be hot-dip galvanized.

Bolts, nuts, pins, etc. shall be provided with appropriate locking arrangement such as lock nuts, spring washers, key, etc.

Bearing housing shall be weatherproof with provision for lubrication. The design, however, shall be such as not to require frequent lubrication.

All bearings in the current path shall be shorted by flexible copper conductor of adequate size (minimum – 150 mm^2) to allow the specified fault current through it without injury.

The design of linkages and gears be such so as to allow one man to operate the handle with ease for disconnecting switches and earth switch.

5.3.1 Main contacts

The disconnecting switches shall be provided with high pressure current carrying contacts on the hinge/ jaw ends and all contact surfaces shall be silver plated and controlled by powerful springs designed for floating and pressure point contact. The thickness of silver plating should not be less than 25 microns. The contacts shall be accurately machined and self aligned.

The contacts shall have sufficient area and pressure to withstand the electromagnetic stresses developed during short circuit without excessive heating liable to pitting or welding.

Contacts shall be adjustable to allow for wear, shall be easily replaceable and shall have minimum movable parts and adjustments.

The moving blade shall be made of electrolytic-copper/aluminum tube for centre rotating type disconnecting switch. Rotating feature of the blade at the end of tube travel for contact wiping shall be provided.

Arcing horns shall be provided to divert the arc from main contacts to the separating horns after the main contacts have opened. Arcing horns shall be renewable type.

5.3.2 Insulators and Terminals

Insulators shall be post type, brown glazed and solid core single stage type.

The porcelain used for insulators shall be manufactured by wet process and shall be homogenous and free from cavities and other flaws.

Caps and pins shall be of the highest quality malleable iron or forged steel and smoothly galvanized.

Arcing horns as required shall be furnished.

All insulators of identical ratings shall be interchangeable.

The terminals of the disconnecting switch shall be provided with terminal connectors.

5.4 Operating Mechanism

5.4.1 Disconnecting Switches

The operating mechanism for 132 kV disconnecting switches shall be motor operated. The driving motor of the motor operated disconnecting switch shall be suitable for operating on 400/230 V AC supply. The mechanism shall also be equipped with dependable manual operating device for emergency operation when the power operating mechanism is inoperative.

The operating mechanism for 33 kV disconnecting switch shall be manual. The operating handle shall be such that it can be operated easily from standing height from ground level. Grounding of handle through copper flexible conductor of adequate size shall be provided.

The control shall be such that the disconnecting switch can be opened or closed from local as well as remote. LOCAL/REMOTE selector switch and OPEN/STOP/CLOSE push buttons shall be provided at the local "Mechanism Box" for local electrical operation. The LOCAL/REMOTE selector switch shall be lockable type.

Starters, relays and limit switches shall be provided as required for operation, indication and interlocks. All electrical controls shall be suitable for 110V DC.

The disconnecting switch shall be provided with a minimum number of eight (8) normally closed and eight (8) normally open electrically separated (Voltage free) auxiliary contacts for system interlock in addition to the auxiliary contacts required for its own indication and operational requirements so as to have a trouble free operation of the system. The contacts shall be convertible type so that normally open contact may be converted to normally closed contact and vice-versa at site. The auxiliary contacts shall be suitable for 0.5A, 110V DC inductive breaking duty.

All auxiliary contacts shall be wired up to terminal block in local mechanism box. All auxiliary contacts shall be silver plated and shall have positive wiping action when closing.

The auxiliary contacts shall be adjustable type to suit the following requirements.

a) Signaling of "closed position" shall not take place unless main power contacts have reached a position so that rated normal and short time current can be carried safely.
b) Signaling of "open position" shall not take place unless the main power contacts are at a safe isolating distance.

The operating device, auxiliary switches and all other devices shall be housed in a weatherproof box of sheet steel / aluminum alloy construction. The enclosure protection of the mechanism box shall be IP-55W as per IEC. The thickness of the sheet steel shall be at least 2mm. In the case of aluminum alloy, the operating box shall be of robust design. The box shall have gasket-hinged door with lock and key. The box shall be suitable for fixing on disconnecting switch steel structure. A 4mm thick removable gland plate shall be provided at the bottom of the box for cable entry. The box shall be mounted at a safe working clearance from the live parts of switches. Thermostat-controlled space heater with ON-OFF switches rated 230V, 1 phase, 50Hz shall be provided to prevent condensation within the mechanism box.

5.4.2 Grounding Switches

The grounding switch shall be triple pole manually and gang operated. The mechanism shall be such that one operator alone shall be able to operate without undue effort. Electrical and mechanical interlocking shall be provided for the safe operation of grounding switch.

Where grounding Switches are specified these shall include the complete operating mechanism and auxiliary contacts. The grounding Switches shall form an integral part of the disconnecting switches and shall be mounted on the base frame of the disconnecting switches. Grounding Switches shall be suitable for local operation only. The grounding Switches shall be constructional interlocked with the disconnecting switches so that the grounding Switches can be operated only when disconnecting switches is open and vice versa.

The grounding switch shall be capable of withstanding the electrical and mechanical stresses developed by a short circuit current specified in schedule A.4 of Section-20. The cross-section of the flexible copper connection between rotating shaft and structure shall be capable to allow specified fault through it without injury but of minimum size 150 mm^2.

Arrangement shall be provided to padlock the grounding switch in open and closed positions.

The operating handle shall be such that it can be operated easily from standing height from ground level. Grounding of handle through copper flexible conductor of adequate size shall be provided.
Each grounding switch shall be provided with four (4) normally closed and four (4) normally open contacts for remote indication and interlocking purpose.

All the auxiliary contacts and interlocking coils shall be housed in a mechanism box. The box shall be suitable for fixing on grounding switch steel structure. A 4mm thick removable gland plate shall be provided at the bottom of the box for cable entry.

Auxiliary contacts shall be suitable for 0.5A, 110V DC inductive breaking duty.

The auxiliary coils shall be suitable for 110V DC supply.

5.5 Tests

5.5.1 Routine Tests

On completion each disconnecting switch shall be subjected to following routine tests. As far as practical, the procedure of IEC shall be followed:

a) Construction Inspection
b) Power frequency voltage dry test
c) Measurement of resistance of main circuit
d) Control and secondary wiring check tests
e) Mechanical operation test

5.5.2 Design Tests

The disconnecting switch design tests shall include following:

a) Dielectric tests, including impulse withstand tests
a) Radio interference tests
b) Temperature rise tests
c) Short-time withstand current tests
d) Operating and mechanism endurance test
e) Voltage drop test.

The voltage drop across one complete phase of a switch shall be measured when carrying rated current.

The Bidder shall submit type test report as specified in section-2 of this specification for the disconnecting switch of the offered model along with the bid.

5.5.3 Field Tests

After installation at Site, the disconnecting switches shall be subjected to the following field tests:

a) Construction inspection
b) Measurement of insulation resistance of main and auxiliary circuits
c) Mechanical operation test
d) Measurement of resistance of main contact

5.6 Drawings, Data and Manuals

The General arrangement drawing with Technical leaflets shall be furnished with the Bid.

After award of Contract the successful Bidder shall submit the required number of copies of the following drawings and data for approval of the Employer.

a) Outline dimensional drawings of the equipment showing general arrangement and location of fittings.
b) Transport/shipping dimensions with weights.
c) Foundation and anchor bolt details including loading condition.
d) Assembly drawings for erection at site with part numbers and schedule of materials.
e) Electrical schematic and wiring diagram.
f) Any other relevant drawings and data necessary for erection, operation and maintenance.
g) Instruction manual and data sheets.
h) Any other relevant data, drawing and information necessary for review of the items stated above.

5.7 Spare Parts

For each type of disconnecting switch, the spare parts shall be provided in required quantities as listed in Price Schedule. Further spare parts as recommended by the manufacturer shall also be included in the Price Schedule.

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SECTION - 6

INSTRUMENT TRANSFORMER

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6 INSTRUMENT TRANSFORMER

6.1 General

This specification covers the design, manufacture, assembly, shop test, supply, delivery, installation, field test and commissioning of outdoor and indoor instrument transformers as specified herein under.

The equipment specified in this Section shall conform to the latest edition of the appropriate IEC specifications and/or other recognized international standards. In particular:

IEC 60044	Voltage transformers
IEC 60044	Instrument transformers
IEC 60529	Degree of protection provided by enclosures
IEC 60186	Capacitive Voltage transformers

6.2 Design Requirements

Instrument transformers shall be suitable for 50Hz, 3 phases with solidly grounded neutral system. All equipment shall be installed at an attitude of 2160m above mean sea level.

Instrument transformers shall be installed outdoor/indoor in a hot and humid climate. All equipment and accessories shall be provided with tropical finish to prevent fungus growth.

Capacitor voltage transformers shall be provided with accessories suitable for carrier equipment.

Technical particulars of instrument transformers shall be as per Technical Schedule (Section 20).

Burden of the instrument transformers stated herein is the minimum value required. Where higher burden is required to suit the designs, the Contractor shall supply the same without additional cost.

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

The external surface of instrument transformer, if made of steel, shall be hot dip galvanized or painted.

6.3 Construction Features

6.3.1 General

The instrument transformers of 132 kV voltage level shall be oil-filled construction and shall be designed for outdoor service and suitable for outdoor service and vertical mounting on steel structures.

The core and coils of current transformer shall be mounted in a steel tank on the top of the unit with the primary coil leads extending through insulated bushings for series or multiple connections. A steel base shall support the high voltage bushing and tank. The high voltage bushing shall be sealed to the tank and the base with oil-tight joints.

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.
The capacitor voltage transformers shall be of high Capacitance with two nominal voltage outputs of $110/\sqrt{3}$ volts each. They must be suitable for revenue metering and protection system.

The primary terminals of instruments shall include provisions for externally connecting the primary winding. The secondary terminals shall be enclosed in a weatherproof terminal box.

Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.

Porcelain bushings shall have adequate mechanical and electrical strength. The color of porcelain shall be brown. It shall be in one piece without any metallic flange joint.

The current / voltage transformers of 33 kV voltage level shall be epoxy resin encapsulated type suitable for outdoor mounting.

6.3.2 Junction Boxes

Junction boxes shall be rigid weatherproof type complete with terminal blocks suitable for cable size having the range up to 2 x 6mm^2 for termination of the secondary connections (such as delta or wye connection). They shall be made of metal, which will resist corrosion on both inside, and outside surfaces, otherwise galvanizing shall suitably protect them. Cover of the junction box shall be of hinge door type complete with door handle. Two drainage holes shall be provided at the bottom of the junction box. In case the junction boxes are steel sheet, the thickness of such steel sheet shall be at least 1.2 mm. Junction boxes shall be sized and arranged to provide easy access for external cables and adequate space for internal wiring and installed equipment. Enclosure protection class of the junction boxes shall be IP55W.

6.3.3 Insulating Oil:

Insulating oil to be used for instrument transformers shall be of EHV grade and shall conform to IS-335 / IEC - 60296 (required for first filling).

6.3.4 Terminations

a) Current Transformers

All current transformer secondary-winding terminals for each ratio shall be connected to terminals on terminal blocks located in the junction boxes.

b) Capacitive Voltage Transformer/ Voltage Transformer

All CVTs' secondary terminals (for each core) shall be connected to terminals for each ratio on terminal blocks located in the junction boxes.

6.3.5 Accessories

The following items shall be provided for each instrument transformer:

a) Nameplate
b) Oil level gauge
c) Oil valves or plugs
d) Power factor test terminals
e) Necessary terminal connections
f) Grounding terminals
g) Other necessary accessories

6.4 Tests

Test shall be performed as specified hereunder.

6.4.1 Current transformer

Routine tests

Each current transformer shall be subjected to following routine tests. As far as practical, the procedure of IEC shall be followed:

- Construction Inspection
- Verification of terminal markings
- Power frequency withstand test (primary & secondary)
- Partial discharge measurement
- Power frequency withstand test between sections of primary & secondary windings
- Inter turn over voltage test
- Determination of errors
- Ratio Test
- Accuracy Test

Design tests

The current transformer design tests shall include following:

- Short time current tests
- Temperature rise test
- Power frequency withstand voltage (wet) tests
- Lightning impulse withstand tests
- Switching impulse withstand tests
- Radio interference voltage measurement test

6.4.2 Capacitor Voltage Transformer

Routine Tests

Each capacitive voltage transformer shall be subjected to following routine tests. As far as practical, the procedure of IEC shall be followed:

- Construction Inspection
- Capacitance and dissipation factor measurement of the capacitor divider before and after power frequency withstand voltage (dry) test
- Power frequency withstand voltage (dry) test for capacitor divider
- Dielectric tests for electromagnetic unit
- Ratio Test
- Accuracy tests
- Polarity check
- Applied and Induced over voltage test, etc.

Design Tests

The capacitive voltage transformer design tests shall include following:
- Lightning Impulse tests
- Switching Impulse test
- Ferro-resonance tests
- Temperature rise tests
- Measurement of radio interference voltage

6.4.3 Inductive Voltage Transformer

Routine Tests

Each voltage transformer shall be subjected to following routine tests. As far as practical, the procedure of IEC shall be followed:

- Construction Inspection
- Verification of terminal marking

- Power frequency withstand test on primary winding
- Partial discharge measurement
- Power frequency withstand test on secondary winding
- Power frequency withstand test on between sections
- Ratio Test
- Determination of error

Design Tests

The inductive voltage transformer design tests shall include following:

- Temperature rise test
- Short circuit withstand capability test
- Lightning impulse test
- Switching impulse test
- Measurement of the radio interference voltage

6.4.4 Field Tests

After installation at site, all instrument transformers shall be subjected but not limited to the following tests:

a. Construction inspection
b. Polarity check
c. Ratio test
d. Measurement of insulation resistance

The Bidder shall submit type test report as specified in section-2 of this specification for the instrument transformers of the offered model along with the bid.

6.5 Drawings, Data and Manuals

The outline dimensional drawings of the equipment shall be furnished with the Bid.

After award of Contract the successful Bidder shall submit the required number of copies of the following drawings for approval of the Employer/ the Employer's representative.

a) Outline dimensional drawings of the equipment
b) Transport/shipping dimensions with weights
c) Foundation and anchor bolt details
d) Characteristic and performance data including ratings, ratio and phase angle curves, accuracy for standard burdens, and thermal burden ratings
e) Instruction books including technical description and complete information for installation, testing, operation and maintenance with renewal parts data
f) Any other relevant drawings and data necessary for review of the items stated above.

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SECTION - 7

LIGHTNING ARRESTER

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7 LIGHTNING ARRESTER

7.1 General

This specification covers the design, manufacture, factory test, delivery, installation, field test and commissioning of lightning arresters, complete with all accessories. The equipment specified in this Section shall conform to the latest edition of the appropriate IEC specifications and/or other recognized international standards. In particular:

IEC 60099-4 Metal-oxide Surge arrester without gap for a.c. system
IEC 60099-5 Surge arrester - Selection and application recommendations
IEC 60529 Degree of protection provided by enclosures

7.2 Design Requirements

The lightning arresters shall be of heavy duty station class and gapless type without any series or shunt gaps.

The lightning arresters shall be suitable for a nominal system of 3 phase, 50Hz solidly grounded system. Lightning arresters shall be provided at entry points of the overhead transmission lines and both HV & LV sides of the transformers.

The lightning arresters shall be capable of discharging over-voltages occurring during switching of unloaded transformers, reactors and long lines.

The lightning arresters shall be station type / transformer-tank-mounted, gap less metal oxide type of rated voltage of 120 kV for 132 kV systems and 30 kV for 33 kV system. The nominal discharge current shall not be less than 10 kA. The selection of Lightning arrester shall be done by the contractor based on insulation co-ordination study without any additional cost to the Employer.

145 kV class arrester shall be capable for discharging energy equivalent to class 3 of IEC for 145 kV system on two successive operations.

The active part of the lightning arresters shall be accommodated in single stacked porcelain insulators, which are suitably reinforced to prevent explosion of an arrester.

The lightning arresters shall be preferably mounted on galvanized steel structure. Terminal connectors for both line and ground terminals shall be furnished.

Surge monitoring device consisting of surge counter, leakage current measuring instrument etc., along with insulating bases for mounting at the bottom of the arrester, shall be furnished.

The duty cycle of CB installed in 132 kV System shall be O-0.3 sec-CO-3 min-CO. The lightning Arrester shall be suitable for such circuit breaker duties in the system.

The technical features of the lightning arresters are given in Technical Schedule (Section 21).

7.3 Constructional Features

The features and constructional details of surge arresters shall be in accordance with requirement stipulated hereunder:

a) The non-linear blocks shall be of sintered metal oxide material. These shall be provided in such a way as to obtain robust construction, with excellent mechanical and electrical properties even after repeated operations.
b) The surge arresters shall be fitted with pressure relief devices suitable for preventing shattering of porcelain housing and providing path for flow of rated fault currents in the event of arrester failure. Details shall be furnished in the bids along with quality checks.

c) The 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.
d) The end fittings shall be made of corrosion proof material and preferably be nonmagnetic.
e) The name plate shall conform to the requirements of IEC incorporating the year of manufacture.
f) The manufacturer will submit Data for rejection rate of ZnO blocks during manufacturing/operation for the past three years.

7.4 Fittings and Accessories

120 kV Arresters shall be complete with insulating base having provision for bolting to flat surface of structure.

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 mili 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.

Surge monitor consisting of discharge counters and mili 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 Lightning 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.

Grading/corona rings shall be provided on each complete arrester unit as required. Suitable terminal connectors shall be supplied by the Contractor.

7.5 Tests

7.5.1 Routine Test

Each lightning arrester switch shall be subjected to following routine tests. As far as practical, the procedure of IEC shall be followed:

a) Construction inspection
b) Measurement of reference voltage
c) Residual voltage test
d) Internal partial discharge test.

7.5.2 Design Test

The lightning arrester design tests shall include following:

a) Insulation withstand test
b) Residual voltage test
c) Long duration current impulse test
d) Operating duty cycle test
e) Artificial pollution test

The Bidder shall submit type test report as specified in section-2 of this specification for the Lightning arrester of the offered model along with the bid.

7.5.3 Pre-Commissioning Tests

An indicative list of tests is given below.

a) Operation checks of LA counter.
b) Insulation resistance measurement
c) Capacitance and Tan delta measurement of individual stacks.

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 Purchaser for approval.

7.6 Drawings and Data

The following documents shall be furnished along with the bid:

a) Standard catalogue identifying the models and ratings being furnished
b) Outline drawings including dimensions

The following drawings and data shall be furnished in required number of copies after award of Contract for approval of Employer:

a) Outline drawings including dimensions
b) Foundation and anchor details including dead load
c) Transport/shipping dimensions with weight
d) Any other relevant data, drawings and information

7.7 Name Plate

Each lightning arrester shall be provided with a nameplate of weather resistant material fitted in a visible position showing the following items as a minimum:

a) Manufacturer's name
b) Manufacturer's serial number and type designation
c) Year of manufacture
d) Rated voltage
e) Nominal discharge current

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SECTION - 8

CONTROL AND RELAY PANELS

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8 CONTROL AND RELAY PANELS

8.1 General

This specification covers study, design, manufacture, assembly, factory test, supply, delivery, installation, field test and commissioning of control and relay panels as specified herein under.

It is not the intent to specify completely herein all details of design and construction of equipment to be supplied. The major equipment to be supplied are specified in Appendix. However, the equipment supplied shall conform, in all respects, to high standards of engineering, design and workmanship and be capable of performing in continuous commercial operation up to Manufacturers' guarantee.

The relays specified in this specification are based on standard protection schemes generally adopted in 132 kV and 33 kV substations of Employer's Integrated Power System. However, the Contractor shall carry out detail system study of protection system of Integrated Power System with special regard to existing substations in the vicinity of the proposed works. Based on this study, the Contractor shall design a relaying scheme for the substations, prepare a detail relay schedule and recommend relay-setting values for relay co-ordination with existing ones and make all necessary adjustments in the relay settings of neighboring substations as well.

The indication and annunciation schemes intended for Pangtan and Bahrabise substations shall be compatible with the existing system as far as possible.

All major protection relays shall be of numerical type. Relays shall be only from short listed manufacturers.

8.2 Construction Features

8.2.1 Type of Panels

Al control and relay panels shall be simplex type.

Simplex panel consist of a vertical front panel with equipment mounted thereon and having wiring access from rear for control relay panels. In case of panel having width more than 800 mm, double leaf-doors shall be provided. Doors shall have handles with either built-in locking facility or will be provided with pad-lock.

For 132 kV system two (2) separate control and relay panel shall be provided for each feeder (bay). However, for 33 kV system one (1) single control and relay panel shall be provided.

Panels shall be completely metal enclosed and shall be dust, moisture and vermin proof. Panel enclosures shall provide a degree of protection not less than IP 43 as per IEC.

Panels shall be free standing, floor mounting type and shall comprise rigid welded structural frames enclosed completely with specially selected smooth finished, cold rolled sheet steel of thickness not less than 3 mm for front and rear portions and 2 mm for sides, top and bottom portions. There shall be sufficient reinforcement to provide level surfaces, resistance to vibration and rigidity during transportation and installation.

All doors, removable covers and panels shall be gasket all around with synthetic rubber gaskets Neoprene/EPDM generally conforming with provision of IS 11149. However, XLPE gaskets can also be used for fixing protective glass doors. Ventilation louvers, if provided, shall have screens and filters. The screens shall be made of either brass or GI wire mesh.

Design, materials selection and workmanship shall be such as to result in neat appearance inside and outside with no welds, rivets or bolt heads apparent from outside, with all exterior surfaces true and smooth.

Panels shall have base frame with smooth bearing surface, which shall be fixed on the embedded foundation channels/insert plates. Anti-vibration strips made of shock absorbing materials that shall be supplied & placed between panel & base frame.

Panels shall be suitable for floor mounting. Metal sills in the form of steel channels properly drilled shall be furnished along with anchor bolts and necessary hardware for mounting to a concrete floor. Any irregularity between the sills and flooring shall be sealed to prevent entry of dust, moisture and vermin.

Cable entries to the panels shall be from the bottom unless otherwise specified. The bottom plates of the panels shall be fitted with removable plates of adequate size for holding the cables using cable connectors to seal from dust and moisture. All cable connectors required shall be provided by the Contractor and shall be screwed type and shall be suitable for PVC armored cables. Cable gland plate fitted on the bottom of the panel shall be connected to earthing of the panel/station through a flexible braided copper conductor rigidly.

Control/Relay panels, if required to incorporate the provisions for SCADA as specified in the relevant chapter, shall be completely equipped and wired with necessary devices/equipment for control and other signals to be used for such systems. The detail requirements for SCADA system are furnished in the relevant chapters of these Specifications. Relay panels of modern modular construction would also be acceptable.

8.3 Component Mounting

All equipment on front/back of panel shall be mounted flush or semi-flush. In case of semi-flush mounting, only flange or bezel shall be visible from the front.

Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent equipment. Equipment mounted inside the panel shall be so located that terminals and adjacent devices are readily accessible without the use of special tools. Terminal markings shall be clearly visible.

Cutouts and wiring for free issue items, if any, shall be according to corresponding equipment-manufacturer's drawings. Cutouts, if any, provided for future mounting of equipment should include cover plates.

The centerline of switches, push buttons and indicating lamps shall be not at a height less than 750mm from the bottom of the panel. The centerline of relays with targets and/or requiring adjustment test switches, and recorders shall be not less than 450mm from the bottom of the panel. No components shall extend below 200 mm.

The centerline of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Likewise, the top lines of all meters, relays and recorders, etc. shall be matched. Indicating lamps shall be of LED type.

No equipment shall be mounted on the doors without prior approval of the Employer.

The standard phase arrangement when facing the front of the switchboard shall be R-Y-B from left to right, from top to bottom and/or front to back. All relays, instruments, other devices, buses and equipment involving three-phase circuit shall be arranged and connected in accordance with the standard phase arrangement.

8.4 Panel Internal Wiring

Panels shall be supplied complete with interconnecting wiring provided between all electrical devices mounted and wired in the panels and between the devices and terminal blocks for the devices to be connected to equipment outside the panels. When panels are arranged to be located adjacent to each other all inter panel wiring and connections between the panels shall be furnished and the wiring shall be carried out internally.

All wiring shall be carried out with 650V grade, single core, stranded copper conductor wires with PVC insulation. The minimum size of the multi-stranded copper conductor used for internal wiring shall be as follows:

a) All circuits except current transformer circuits and voltage transfer circuits meant for energy metering - one 1.5mm sq. per lead.

b) All current transformer circuits one 2.5 sq.mm lead.
c) Voltage transformer circuit (for energy meters): Two 2.5 mm sq per lead.

All internal wiring shall be securely supported, neatly arranged, readily accessible and connected to equipment terminals and terminal blocks. Wiring gutters & troughs shall be used for this purpose.

Auxiliary bus wiring for AC and DC supplies, voltage transformer circuits, annunciation circuits and other common services shall be provided near the top of the panels running throughout the entire length of the panels.

Wire termination shall be made with solder less crimping type and tinned copper lugs, which firmly grip the conductor. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wire and shall not fall off when the wire is disconnected from terminal blocks. All wires directly connected to trip circuit breaker or device shall be distinguished by the addition of red coloured unlettered ferrule.

Longitudinal troughs extending throughout the full length of the panel shall be preferred for inter panel wiring. Inter-connections to adjacent panel shall be brought out to a separate set of terminal blocks located near the slots of holes meant for taking the inter-connecting wires.

Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.

8.5 Mimic Diagram

Mimic diagrams shall be provided on control panels as required. Mimic diagrams shall be screwed on to panels and shall be made of anodized aluminum or plastic of approved fast color material, which can be easily cleaned. The mimic bus shall be 2mm thick. The width of the mimic bus shall be 10mm for bus bars and 7mm for other connections.

The colors for the various voltages in the mimic diagram shall be as follows:

System voltage	Mimic Color
132 kV	Signal Red
33 kV	Salmon pink

When semaphore indicators are used for disconnecting switch positions, they shall be so mounted in the mimic that the disconnecting switches' 'close' position shall complete the continuity of the mimic. When control switches of discrepancy type are mounted in the mimic, the 'close' position of the switch shall complete the mimic.

Coloured indicating lamp, one for each phase, for each bus shall be provided on the mimic to indicate live bus condition.

8.6 Annunciators

Alarm annunciation system shall be provided in the control panel by means of visual and audible alarm in order to draw the attention of the operator to the abnormal operating conditions or the operation of some protective devices. The annunciation equipment shall be suitable for operation on the voltages specified in this specification.

Annunciators shall be of facia type translucent plastic window for each alarm point. Annunciator facia plates shall be engraved in block letter with respective alarm inscriptions, which will be approved by Employer. Alarm inscriptions shall be engraved on each window and the size of the lettering shall be not less than 5mm. The inscriptions shall be visible only when the respective light is lighted.

Each annunciation window shall be provided with two white lamps in parallel to provide safety against lamp failure. Long life lamps shall be used. The transparency of cover plates and wattage of the lamps provided in the facia windows shall be adequate to ensure clear visibility of the inscriptions in the control room having high illumination intensity (350 Lux), from the location of the operator's desk.

The annunciators shall be suitable for operation with normally open fault contacts which close on a fault. When specified in bill of materials, some of the annunciator points shall be suitable for operation with normally closed faults contacts which open on a fault. It shall be possible at site to change annunciators from "open to fault" to "close to fault" and vice versa. Annunciators shall be suitable for accepting fleeting faults of duration not less than 15 milliseconds.

Annunciators shall be compact self-contained units with associated relays and/or necessary cards mounted. Annunciator facia units shall be suitable for flush/semi-flush mounting on panels. Replacement of individual facia inscription plates and lamps shall be possible from front of the panels.

One alarm buzzer common to annunciators on all the panels shall be provided. "Acknowledge", "Reset" and "Lamp Test" push buttons on all the panels shall be provided. These devices shall be located in the panels as determined by the Employer.

In case of static annunciator schemes, special precaution shall be taken by the Contractor to ensure that spurious alarm conditions do not appear due to false influence of external magnetic fields on the annunciator wiring and switching disturbances from the neighboring circuits.

All Trip facia shall have red colour and all Non-trip facia shall have white colour.

The audible alarm shall be provided by Buzzer/ Hooter /Bell having different sounds and shall be used as follows.

Hooter	Alarm Annunciation
Bell	Annunciation DC failure
Buzzer	AC supply failure

Sequence of Operation of the Annunciator shall be as follows:

Alarm Condition	Fault Contact	Audible Alarm	Visual Alarm
Normal	Open	Off	Off
Abnormal	Close	On	Flashing
Acknowledge	Close or Open	Off	Steady On
Reset	Close	Off	Steady On
	Open	Off	Off
Lamp Test	Open	Off	Steady On

In case 'RESET' push-button is pressed before abnormality is cleared, the lamps shall continue to glow-steady and shall go out only when 'Normal' condition is restored. These testing circuits shall be so connected that while testing is being done it shall not prevent the registering of any new annunciation that may land during the test.

Provision of testing facilities for flasher and audible alarm circuits of annunciators shall be provided. These testing circuits shall be so connected that while testing is being done it shall not prevent the registering of any new annunciation that may land during the test.

8.7 Switches

Control and instrument switches shall be rotary operated type with escutcheon plates clearly marked to show operating position and circuit designation plates and suitable for flush mounting with only switch front plate and operating handle projecting out.

The selection of operating handles for the different types of switches shall be as follows:

Breaker, Isolator control switches:	Pistol grip, black
Synchronising switches:	Oval, Black, Keyed handle
Selector switches:	Oval or knob, black
Instrument switches:	Round, knurled, black
Protection Transfer switch:	Pistol grip, lockable and black.

The control switch of breaker and isolator shall be of spring return to neutral type. The switch shall have spring return from close and trip positions to "after close" and "after trip" positions respectively.

Instrument selection switches shall be of maintained contact (stay put) type. Ammeter selection switches shall have make-before-break type contacts so as to prevent open circuiting of CT secondary when changing the position of the switch. Voltmeter transfer switches for AC shall be suitable for reading all line-to-line and line-to-neutral voltages.

Synchronizing switches shall be of maintained contact (stay put) type having a common key for a group of switches. The key shall be removable only in the OFF position and it shall be co-ordinate to fit in to all the synchronizing switches. These switches shall be arranged to connect the synchronizing equipment when turned to the 'ON' position. One contact of each switch shall be connected in the closing circuit of the respective breaker so that the breaker cannot be closed until the switch is turned to the 'ON' position.

Lockable type of switches which can be locked in particular positions shall be provided when specified. The key locks shall be fitted on the operating handles.

8.8 Indicating Lamps

Indicating lamps shall be of cluster LED type suitable for panel mounting with rear terminal connections. .Lamps shall be provided with series connected resistors preferably built in the lamp assembly. Lamps shall have translucent lamp covers to diffuse lights coloured red, green, amber, clear white or blue as specified. The lamp cover shall be preferably of screwed type, unbreakable and moulded from heat resisting material.

Lamps and lenses shall be interchangeable and easily replaceable from the front of the panel. Tools, if required for replacing the bulbs and lenses shall also be included in the scope of the supply.

The indicating lamps with resistors shall withstand 120% of rated voltage on a continuous basis.

8.9 Position Indicators

Position indicators of "SEMAPHORE" type shall be provided when specified as part of the mimic diagrams on panels for indicating the position of circuit breakers, isolating/earthing switches etc. The indicator shall be suitable for semi-flush mounting with only the front disc projecting out and with terminal connection from the rear. Their strips shall be of the same colour as the associated mimic.

Position indicator shall be suitable for 110 DC Voltage. When the supervised object is in the closed position, the pointer of the indicator shall take up a position in line with the mimic bus bars, and at right angles to them when the object is in the open position. When the supply failure to the indicator occurs, the pointer shall take up an intermediate position to indicate the supply failure.

The rating of the indicator shall not exceed 2.5 W.

The position indicators shall withstand 120% of rated voltage on a continuous basis

8.10 Synchronizing Equipment

The synchronizing instruments shall be mounted either on a synchronizing trolley or on a synchronizing panel. The panel/ trolley shall be equipped with double analog voltmeters and double analog frequency meters,

synchroscope and lamps fully wired. The size of voltmeters and frequency meters provided in the synchronizing panel shall not be less than 144 X 144 sq.mm. Suitable auxiliary voltage transformers wherever necessary shall also be provided for synchronizing condition. In case the synchroscope is not continuously rated, a synchroscope cut-off switch shall be provided and an indicating lamp to indicate that the synchroscope is energized, shall also be provided.

Synchronizing check relay with necessary ancillary equipment's shall be provided which shall permit breakers to close after checking the requirements of synchronizing of incoming and running supply. The phase angle setting shall not exceed 35 degree and have voltage difference setting not exceeding 10%. This relay shall have a response time of less than 200 milliseconds when the two system conditions are met within present limits and with the timer disconnected. The relay shall have a frequency difference setting not exceeding 0.45% at rated value and at the minimum time setting. The relay shall have a continuously adjustable time setting range of 0.5-20 seconds. A guard relay shall be provided to prevent the closing attempt by means of synchronising check relay when control switch is kept in closed position long before the two systems are in synchronism.

The synchronising panel shall be draw out and swing type which can be swivelled in left and right direction. The synchronising panel shall be placed along with control panels. The incoming and running bus wires of VT secondary shall be connected and run as bus wires in the control panels and will be extended to synchronising panel for synchronisation of circuit breakers. The selector switch provided for each circuit breaker in respective control panels shall be lockable type with a common key so that only one selector switch is kept in synchronising mode at a time.

Alternatively, the trolley shall be of mobile type with four rubber-padding wheels capable of rotating in 360 degree around the vertical axis. Suitable bumpers with rubber padding shall be provided all around the trolley to prevent any accidental damage to any panel in the control room while the trolley is in movement. The trolley shall have two meter long flexible cord fully wired to the instruments and terminated in a plug in order to facilitate connecting the trolley to any of the panels. The receptacle to accept the plug shall be provided on the panel.

8.11 Relays

All relays shall conform to the requirements of IS: 3231/IEC-60255 or other applicable standards. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear.

All main protective relays shall be numerical type & the communication protocol shall be IEC 61850. All protective relays shall be in draw out or plug-in type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied loose and shall be included in contractor's scope of supply.

All AC operated relays shall be suitable for operation at 50 Hz. AC Voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for 1/5 amp CT secondary. All DC operated relays and timers shall be designed for 110 DC voltage specified, and shall operate satisfactorily between 80% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.

The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. also required for the complete protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme, contacts shall be silver faced with spring action. Relay case shall have adequate number of terminals for making potential free external connections to the relay coils and contacts, including spare contacts.
All protective relays, auxiliary relays and timers except the lock out relays and interlocking relays specified shall be provided with self-reset type contacts. All protective relays and timers shall be provided with externally hand reset positive action operation indicators with inscription. All protective relays which do not have built-in hand-reset operation indicators shall have additional auxiliary relays with operating indicators

(Flag relays) for this purpose. Similarly, separate operating indicator (auxiliary relays) shall also be provided in the trip circuits of protections located outside the board such as Buchholtz relays, oil and winding temperature protection, sudden pressure devices, fire protection etc.

Timers shall be of the electromagnetic or solid state type. Pneumatic timers are not acceptable. Short time delays in terms of milliseconds may be obtained by using copper slugs on auxiliary relays. In such case it shall be ensured that the continuous rating of the relay is not affected. Time delay in terms of milliseconds obtained by the external capacitor resistor combination is not preferred and shall be avoided to the extent possible.

All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.

The setting ranges of the relays offered, if different from the ones specified shall also be acceptable if they meet the functional requirements.

Any alternative/additional protections or relays considered necessary for providing complete effective and reliable protection shall also be offered separately. The acceptance of this alternative/ additional equipment shall lie with the Employer.

The bidder shall include in his bid a list of installations where the relays quoted have been in satisfactory operation.

All relays and their drawings shall have phase indications as R-Red, Y-yellow, B-blue

Wherever numerical relays are used, the scope shall include the following:

a) Necessary software and hardware to up/down load the data to/from the relay from/to the Laptop computer.
b) The relay shall have suitable communication facility for future connectivity to SCADA. Communication protocol shall be IEC 61850.
c) In case of line protection, busbar protection and transformer / reactor protection, the features like fault recorder and event logging function including as available as optional feature in these relays shall be supplied & activated at no extra cost to the the Employer. Also, necessary hardware/software for automatic uploading to station Laptop computer (as applicable) shall be supplied.

8.12 Specific Protection Requirements

The protection scheme as shown in the Protection Single Line Diagram shall be employed. However, general requirement of the major protection schemes shall be as follows:

The Contractor shall provide state-of-the art numerical type relays (where specification does not call for specific type relay). The contractor shall furnish necessary probe and software, cable suitable for the relays supplied under this contract.

The Contractor shall provide at least duo Centrino Mobile Technology laptop computer, relays programming software and necessary probes & cables for setting the numeric relays. No separate payment for laptop, software, probes, cables etc. will be done and therefore all cost involved for these items shall be included in the cost of relay and control panels.

8.12.1 132 kV Transmission Lines

a) Main protection shall be with distance relay, which shall include:
   - transfer trip facility for each independent pole through optical link
   - reclose facility with auto synchrocheck.

b) Back-up protection shall be with directional IDMT overcurrent / earthfault (OC/EF) relays for parallel lines; and shall have additional definite time non-directional OC/EF for radial lines. Such directional

OC/EF relays shall not be operated in case of potential loss. And, loss of potential shall lead to the alarm annunciator.

Separate sets of relays shall be used for main and backup protection.

8.12.2 Power and Distribution Transformers

a) Main protection shall be with differential relay with inbuilt restricted earth fault.
b) As back-up protection:

- Non-directional OC/EF with high set Instantaneous protection shall be provided at HV side.
- Directional OC/EF and Non Directional OC/EF protection shall be used on LV side

Separate sets of relays shall be used for main and backup protection.

8.12.3 132 kV bus-bar protections

a) Current differential scheme with low impedance differential scheme shall be adopted.

8.12.4 33 kV sub-transmission line protection

a) IDMT over current/earth fault (OC/EF) relays with instantaneous feature shall be adopted.

8.12.5 Other Protection

Other protective relays such as Circuit Breaker Failure, Trip Circuit Supervision, Master Trip Relay and Synchro-Check etc shall be used as required.

8.12.6 Auto Recloser for 132 kV Transmission Lines

The auto reclose facility inbuilt in the relay shall provide delayed auto reclose and have a selector switch which can provide at least the following operating mode:

a) Single phase re-closing for single phase faults and three phases re-closing for multiphase faults.
b) Three phase re-closing for single phase or multiphase earth faults
c) No re-closing (for single phase faults or multiphase faults)

The auto reclose scheme shall have at least two blocking inputs and have single phase delay adjustable at least to three seconds and a three phase delay adjustable at least to five seconds and have a reclaim time adjustable at least to 60 seconds.

8.12.7 Differential Relay

The differential relays shall be used for transformer, and bus bar protection.

i. Transformer Differential Protection:

The differential relays shall be three phase with six through-current restraint inputs. The relay shall have built-in trip relay, indicator and test switch.

The harmonic restrained operate time of the relay shall be approximately 30 ms at 3 times pick-up current. Similarly unrestrained operate time shall be 10-20 ms at 2 times pick-up current with minimum impulse time of 3 minutes.

For transformer protection the relay shall have variable percentage restraint for external fault security, even at use of on-load tap charger.

The relay shall have second harmonic restraint from all three phases for inrush security and fifth harmonic restraint for all three phases for over excitation security. The sensitivity shall be 20 to 50 percent of rated current.
Unrestrained operation set-able to 20 times of rated current.

The relay shall be provided with separate interposing CT's if required for ratio and phase angle matching and equalizing of zero sequence current, or by other programming method.

Restricted Earth Fault protection shall be provided with the help of neutral CT on the HV or LV of the transformer.

Transformer differential relay have inbuilt event and fault recorders and self diagnostic features.

ii. Bus-bar differential scheme

The 132 kV bus-bar shall be protected with low impedance differential relay. The numerical busbar protection shall have following features:

a) fast operating time (<30 ms)
b) stability against CT saturation
c) suitable for 2 bus-bars sections and up to 20 feeders
d) event and fault recorders
e) Self diagnostic features.

8.12.8 Transmission Line Distance Protection

The directional distance relay shall be high speed numerical distance relay. The directional relays shall have following main features:

a) Have three forward zones and one reverse zone.
b) Have a maximum operating time of 50 mili seconds. for all types of faults within its Zone 1 reach.
c) Have a maximum re-setting time of 50 milliseconds.
d) Shall be capable to give single phase tripping and reclosing command
e) Be able to operate with communication schemes : permissive or blocking or step acceleration
f) Operate instantaneously when closing on the three phase Zero volt bolted fault.
g) Capable to indicate distance to the faulty point
h) Have inbuilt synchro check facility for auto reclose.
i) Have self monitoring feature.
j) Have event recording facility
k) Have fault recording facility.
l) Have a VT supply supervision facility
m) Have power swing blocking facilities

8.12.9 Over-current and Earth-fault Protection

These protection schemes shall be used as back-up protection of transmission lines and power transformers.

a) Non-directional phase over current protection shall:

- have an inverse characteristic with a definite minimum time of 3 seconds at 10 times setting.
- have a variable setting range of 20-200% of rated current
- have a high set instantaneous unit with a continuously variable setting range of 5-20 times of rated current.

b) Non-directional earth fault protection shall:

- have an inverse characteristic with a definite minimum time of 3 sec. at 10 times setting.

- have an adjustable setting of 10-80% of rated current.
- have a high set instantaneous unit with a continuously variable setting range of 5-20 times of rated current.

8.12.10 Directional Over-current Protection

This protection scheme shall be used as a back-up protection for power transformers low-voltage side, as back-up protection for parallel transmission lines and as main protection for parallel sub- transmission lines.

a) Phase over-current relay shall:

- have an inverse characteristic with a definite minimum time of 3 secs. at 10 times setting.
- have a variable setting range of 20-200% of rated current.
- have a characteristic angle of 45 degree.
- have a directional controlled low transient over-reach high set instantaneous unit of continuously variable setting range 5-20 times of rated current.
- be of voltage polarized directional controlled type.

b) Directional earth-fault over-current protection

Earth fault over current relay shall:

- be of zero sequence voltage polarized directional controlled.
- have an inverse characteristic with a definite minimum time of 3 secs. at 10 times setting.
- have an adjustable setting range of 10-80% of rated current.
- have a directional controlled low transient over reach high set instantaneous unit with a continuously variable setting range of 5-20 times of rated current.
- have a characteristics angle of 45 degree.

8.12.11 Local Breaker Back Up Protection (Circuit Breaker Failure Protection)

Provide a phase and ground fault breaker failure relay. This relay shall:

- be able to give a re-trip delayed order to the circuit breaker after initiation when one circuit breaker fails to open
- remedy to the breaker failure by tripping the adjacent breakers
- be able to operate even during adverse CT saturation conditions

8.12.12 Synchro Check Relay

The synchro check relay shall be provided for each 132 kV transmission line. This relay shall allow the control scheme to close the line breaker only when:

a) The line is alive and the bus is dead
b) The line is dead and the bus is alive or
c) The line is in synchronism with the bus.

The synchro check relay shall be static/ numeric relay shall:

a) measure difference in magnitude, phase angle and frequency between busbar and line voltage
b) have a voltage check unit for closing order with a dead line and live busbar, or dead busbar and live line
c) an adjustable setting of at least:

- 5% to 30% of rated voltage for voltage magnitude difference
- 5^0 to 30^0 for phase angle difference
- 0.05 to 0.5 Hz for frequency difference

8.12.13 Other Requirements

All auxiliary relays, if and when required for the completeness of the various protection schemes covered in this specification, shall be deemed to be included in the scope of supply whether or not such items are specifically mentioned in the enclosed bill of material.

All terminal blocks for CT and PT circuits shall be of disconnecting link type. Suitable plastic covers for all terminal blocks shall be provided in order to prevent dust accumulation.

Panels shall be mounted to concrete foundation on galvanized steel channels with an intervening layer of anti-vibration strips made of shock absorbing materials, which shall be supplied by the Contractor.

Cable entries for all the panels shall be from bottom. The bottom plates of the panels shall be fitted with 4mm thick removable plates of adequate size for holding cables and sealing from dust and moisture.

A ground bus of bare copper strip of minimum size 25 x 6mm along the length of each panel shall be provided and shall be connected to the ground mat of the station.

8.13 Energy Meters

Energy meters shall be numerical type manufactured by internationally reputed manufacturer. Each 132 kV and 33 kV line and transformer feeder shall be equipped with one set of 3 ph, 4wire kWh and kVARh meters suitable for import and export measurements as specified in Bill of Materials . The meters shall preferably be four quadrant type. In case of numerical type energy meters, the Contractor shall furnish probe, copy write software and other necessary items along with a portable laptop (serial port, suitable to connect these meters with laptop) for operational programming of the meters.

All kWh and kVARh meters shall be of 0.2 class accuracy. In addition to all the tests required to be performed at the manufacturing plant, each of these meters shall be tested at the Employer's laboratory also at the expense of the Contractor prior to installation and commissioning and as and when required by the Employer during the warranty period. Any meter, which fails the tests, will not be acceptable and the Contractor shall supply their replacements immediately. If the replacements too fail the tests, then the Employer reserves the right to replace the meters with new one at the expense of the Contractor. The test results from the Employer’s laboratory shall be final and binding upon both parties.

8.14 Multifunction Meters

Multifunction meters shall be numerical type. Each 132 kV and 33 kV feeders shall be equipped with one Multifunction Meter. As a minimum all Multifunction Meters shall display following parameters and also communicate all parameters to SCADA and shall have provision to communicate protection signals with each other directly over optical fibre.

- Three phase currents
- Line and Phase voltages
- Frequency
- Active Power
- Reactive Power
- Apparent Power
- Power factor

8.15 Miscellaneous Accessories

8.15.1 Space Heater

Each panel shall be equipped with automatic thermostat controlled space heaters to prevent moisture condensation within the enclosure and shall be completed with MCB units for power supply. Space heaters and MCB units shall be suitable for continuous operation.

8.15.2 Plug Point

A 230 V, 1 phase, 50Hz AC plug point shall be provided in the interior of each cubicle with on-off switch for connection of hand lamps.

8.15.3 Panel Lighting

Panel lighting with door switch shall be provided in the interior of the cubicle.

8.15.4 DC Control supply:

Independent supply for main protection trip-circuit shall be provided and another separate supply shall be provided for back up protection, control and metering.

8.16 Tests

8.16.1 Routine Tests

Relay and Control Panels shall be subjected the following routine tests at manufacturer's:

a) Works Construction Inspection
b) Mechanical operation test
c) Calibration test for meters
d) Characteristic test for relays
e) High voltage test of insulation (2000 volts for 1 minute)
f) Electrical control, interlock and sequential operation tests
g) Verification of wiring as per approved schematic diagram, etc.

Routine test certificates of all the relays supplied under this contract shall be submitted for the Employer's approval before dispatching the control and relay panel.

8.16.2 Field Tests

After completion of the installation, panels shall be subjected the following field tests:

a) Electrical control, interlock and sequential operation tests
b) Calibration test for meters
c) Measurement of insulation resistance
d) Characteristic test for relays, etc.

8.17 Drawings, Data and Manual

Outline drawings of Control and Relay panels along with make, model and catalogue of all main relays shall furnished along with the bids.
After award of Contract the successful Bidder shall submit the required number of copies of the following drawings and data for approval of the Employer.

a) General equipment layout
b) Outline drawings of panels showing front and rear elevations
c) Loading data and foundation detail
d) Elementary control wiring diagrams
e) Internal wiring diagrams
f) External connection diagrams, showing terminal boards and other external Connection points for each panel and the required interconnecting wiring
g) AC and DC diagram for control, metering, relaying, communication alarm etc.
h) Instruction manual for storage, installation, operation and maintenance of relay and accessories.

8.18 Relay Test Kit

Relay test kit shall have the following minimum features:

- *Single phase and Three phase testing capability*
- *Primary and secondary injection*
- *LCD touch screen*
- *Current generators and voltage generators which shall be individually adjusted with respect to amplitude, phase angle and frequency*
- *Applicable on high voltage substation and industrial environment*

Relay test kit shall comprise of following instruments:

- *Main instruments (Timing test, Determination of pick-up, drop-out, set-inject-measure)*
- *Ramping instrument*
- *Sequence instrument*
- *Impedance instrument*
- *CT magnetization instrument*
- *Pre fault-fault instrument*

After award of Contract the successful Bidder shall submit the details of relay test kit confirming the above minimum requirements for approval of the Employer.

APPENDIX 8-1: BILL OF MATERIAL

The bill of materials shall cover only the major equipment, as will be required by the Bidder for general information. The Bidder shall offer his own design or type of equipment, which shall cover all the requirements of the Employer, for Employers' approval. It is to be understood that, all other associated auxiliary equipment and accessories, although not listed in the bill of materials, but necessary for the complete and sound functioning of the control and relay panels, as described in this specification, shall be furnished by the Contractor.

A. MAJOR COMPONETS OF 132 kV LINE CONTROL PANEL

Item	Legend	Description	Quantity per Panel
1.	ANN	Annunciator assembly, 18 active points, 110V DC, 3 rows high by 6 columns wide, flush mounted with 3-separately mounted push buttons, 2-separately mounted indicating lamps, one white lamp, and one red lamp. Following minimum annunciations shall be provided:	1 Set
		1. Main protection trip	
		2. Back up protection trip	
		3. Trip circuit faulty	
		4. V.T. Fuse fail	
		5. Breaker failure protection trip	
		6. Pole discrepancy	
		7. C.B. trip	
		8. Auto-reclose operated	
		9. SF6 gas pressure low alarm	
		10. SF6 gas pressure low lockout	
		11.Carrier channel fail	
		12.Direct transfer trip signal received	
		13. A.C. supply failure Alarm	
		14. D.C. supply failure Alarm	
		15. spare	
		16. spare	
		17. spare	
		18. spare	
2.	A	Indicating ammeter with selector switch 0-300 A ; 0-600, 0-900 A (for CT ratios 900-600-300/1A)	1 Set
3.	V	Indicating voltmeter with selector switch	1 Set

Item	Legend	Description	Quantity per Panel
		0-150kV Scale, 132000/√3V/ 110/√3V with	
4.	MW	Digital (75mm high LCD Display) MW meter at the top of the Control Panel.	1
5.	MFS	Numerical type Multi Function Meter (A, V, F, MW, MVAR, MVA, PF) with communication facilities with SCADA/RTU.	1
6.	Energy meter (EM)	3 ph, 4w Quadrant type energy meter class 0.2, with impulse contact, 900- 600-300/1 A, 132000/√3/110/√3/110/√3	1
7.	CS	Breaker control switch, with 2-separately mounted indicating lamps for status indication.	1
8.	CS	Disconnecting control switch with 2-separately mounted indicating lamps for status indication.	3
9.		Electrically operated mimic disconnect device (semaphore indication), 110V DC, to indicate the position of disconnecting switch	3
10.		Electrically operated mimic disconnect device (semaphore indication), 110V DC, to indicate the position of line ground switch	
11.	SS	Synchronizing selector switch (ON-OFF) with key removable in "OFF" position only	1
12.	79CO	Re-closer On/Off switch	1
13.	MIMIC	Mimic Diagram	1 Set

B. MAJOR COMPONETS OF 132 kV LINE PROTECTION PANEL

Item	Legend	Description	Quantity per Panel
	Relay	Only main relays and instruments are listed here. All the trip relays and auxiliary relays required for satisfactory operation of the scheme shall be included by the Contractor.	
1.	21	Line distance protection with distance fault locator, measuring unit, synchro-check & auto reclose, power swing blocking and fuse failure facility	1
2.	67/67N	Directional Over-current and earth fault protection with instantaneous element	1
3.	50BF	Breaker failure protection	1
4.		Trip circuit supervision relay	2
5.		Fuse Failure Protection	1
6.	25	Synchro-check relay	1
7.	86	Master Trip Relay	1

C. MAJOR COMPONETS OF 132 kV BUS-COUPLER CONTROL PANEL

Item	Legend	Description	Quantity per Panel
1.	ANN	Annunciator assembly, 18 active points, 110V DC, 3 rows high by 6 columns wide, flush mounted with 3-separately mounted push buttons, 2-separately mounted indicating lamps, one white lamp, and one red lamp. Following minimum annunciations shall be provided:	1 Set
		1. Over-current trip	
		2. Earth fault trip	
		3. Trip circuit faulty	
		4. Pole discrepancy	
		5. C.B. trip	
		6. SF6 gas pressure low alarm	
		7. SF6 gas pressure low lockout	
		8. A.C. supply failure Alarm	
		9. D.C. supply failure Alarm	
		10. Bus-A protection operated	
		11. Bus-B protection operated	
		12. Breaker failure protection trip	
		13. Spare	
		14. spare	
		15. spare	
		16. spare	
		17. spare	
		18. spare	
2.	A	Indicating ammeter with selector switch 0-300 A ; 0-600, 0-900 A (for CT ratios 900-600-300/1A)	1 Set
3.	V	Indicating voltmeter with selector switch 0-150kV Scale, 132000/√3V/ 110/√3V with	2 Set
4.	VT	Voltage Transducer	2
5.	FT	Frequency Transducer	2
6.	CS	Breaker control switch with 2-separately mounted indicating lamps for status indication	1
7.	CS	Disconnecting control switch with 2-separately mounted indicating lamps for status indication	2

Item	Legend	Description	Quantity per Panel
8.	CI	Electrically operated mimic disconnect device (semaphore indication), 110V DC, to indicate the position of disconnecting switch	2
9.	SS	Synchronizing switch with key, removable in "OFF" position only	1
10.	f	a) Frequency meter b) Digital (75mm high LCD Display) frequency meter at the top of the panel with facility of change over in VT supply	2 1
11.	MFS	Numerical type Multi Function Meter (A, V, F, MW, MVAR, MVA, PF) with communication facilities with SCADA/RTU.	1
12.		Digital (75mm high LCD Display) Clock	1

D. MAJOR COMPONETS OF 132 kV BUS-COUPLER RELAY PANEL

Item	Legend	Description	Quantity per Panel
	Relay	Only main relays and instruments are listed here. All the trip relays and auxiliary relays required for satisfactory operation of the scheme shall be included by the Contractor.	
1.	50/51 50N/51N	Over current and earth fault protection with instantaneous element	1
2.		Trip circuit supervision relay	1
3.		Fuse failure protection	1
4.	25	Synchro-check relay	1
5.	86	Master Trip Relay	1

E. MAJOR COMPONETS OF 132 kV BUS BAR PROTECTION PANEL

Item	Legend	Description	Quantity per Panel
	Relay	Only main relays and instruments are listed here. All the trip relays and auxiliary relays required for satisfactory operation of the scheme shall be included by the Contractor.	
1.	87B	Bus-differential protection	2 Sets
2.	86BA	Master Trip Relay for BUS A	1
3.	86 BB	Master Trip Relay for BUS A	1
4.		All other auxiliary relays and accessories required to complete the Bus Bar Protection and Breaker Failure Protection.	2 Sets

F. MAJOR COMPONETS OF 132/33 KV TRANSFORMER CONTROL PANEL

Item	Legend	Description	Quantity per Panel
1.	ANN	Annunciator assembly, 24 active points, 110V DC, 3 rows high by 8 columns wide, flush mounted; with 3-separately mounted push buttons 2-separately mounted indicating lamps, one white lamp, and one red lamp. Following minimum annunciations shall be provided:	1
		1. Transformer differential protection operated	
		2. Transformer H.V. backup protection operated	
		3. Transformer L.V back up protection operated	
		4. Transformer H.V earth fault protection operated	
		5. Restricted earth fault protection operated	
		6. Transformer H.V CB trip	
		7. Transformer Buchholz alarm	
		8. Transformer Buchholz trip	
		9. Transformer low oil	
		10. Tap changer Buchholz trip	
		11. Tap changer Buchholz alarm	
		12.Tap changer low oil level	
		13.Transformer winding and oil temperature high alarm	
		14. Transformer winding and oil temperature extremely high trip	
		15. Transformer LV CB trip	
		16.Tap changer out of step	
		17. Transformer cooling system fail	
		18. Transformer H.V CB trip	
		19.Pressure relief device operated	
		20. C.B.in trouble	
		21. SF6 gas pressure low alarm	
		22. SF6 gas pressure low lockout	
		23. Spare 24. Spare	
2.	A	Indicating ammeter with selector switch	
		0-150A, 0-300A, 0-600A for 600-300-150/1A CT ratios. (for HV Side)	1 set for HV
		0-600, 0-800A for 800-600/1A CT ratio (for LV Side)	1 set for LV
3.	MFS	Numerical type Multi Function Meter (A, V, F, MW, MVAR, MVA, PF) with communication facilities with SCADA/RTU.	1 set for HV

Item	Legend	Description	Quantity per Panel
			1 set for LV
4.	Energy meter (EM)	3 ph, 4w Quadrant type energy meter class 0.2, with impulse contact, 600-300/1 A, 132000/√3/110/√3 V	1 set for HV 1 set for LV
5.	CS	Breaker control switch with 2-separately mounted indicating lamps for status indication	1
6.	CS	Disconnecting control switch with 2-separately mounted indicating lamps for status indication	2
7.	SI	Electrically operated mimic disconnect device (semaphore indication), 110V DC, to indicate the position of disconnecting switch	2

G. MAJOR COMPONETS OF 132/33 KV TRANSFORMER RELAY PANEL

Item	Legend	Description	Quantity per Panel
1	Relay	Only main relays and instruments are listed here. All the trip relays and auxiliary relays required for satisfactory operation of the scheme shall be included by the Contractor.	1 1
2.	87T	Differential protection for transformer with inbuilt REF (main)	1
3.	67/67N, 51/51N	LV backup protection	1
4.	50BF	H.V. Breaker failure protection	
5.	51/51N, 50/50N	H.V. backup protection of transformer	
6.		Trip circuit supervision relay	4
7.		Interlock, switching & tripping relay	1
8.		D.C. fail relay	1
9.	86	Master Trip Relay	1 set for HV 1 set for LV
10.	59	Over Voltage Relay	1 set for LV

H. MAJOR COMPONETS OF 33/11 KV TRANSFORMER CONTROL/RELAY PANEL

Item	Legend	Description	Quantity per Panel
1.	ANN	Annunciator assembly, 24 active points, 110V DC, 3 rows high by 8 columns wide, flush mounted; with 3-separately mounted push buttons 2-separately mounted indicating lamps, one white lamp, and one red lamp. Following minimum annunciations shall be provided:	1
		1. Transformer differential protection operated	

Item	Legend	Description	Quantity per Panel
		2. Transformer H.V. backup protection operated	
		3. Transformer L.V back up protection operated	
		4. Transformer H.V earth fault protection operated	
		5. Restricted earth fault protection operated	
		6. Transformer H.V CB failure trip	
		7. Transformer Buchholz alarm	
		8. Transformer Buchholz trip	
		9. Transformer low oil	
		10. Tap changer Buchholz trip	
		11. Tap changer Buchholz alarm	
		12.Tap changer low oil level	
		13.Transformer winding and oil temperature high alarm	
		14. Transformer winding and oil temperature extremely high trip	
		15. Transformer LV CB trip	
		16.Tap changer out of step	
		17. Transformer cooling system fail	
		18. Bus selections incomplete	
		19.Pressure relief device operated	
		20. C.B.in trouble	
		21. Spare	
		22. Spare	
		23. Spare 24. Spare	
2.	A	Indicating ammeter with selector switch 0-200A, 0-400A for 400-200/1A CT ratios.	1 set
3.	MFS	Numerical type Multi Function Meter (A, V, F, MW, MVAR, MVA, PF) with communication facilities with SCADA/RTU.	1 set
4.	Energy meter (EM)	3 ph, 4w Quadrant type energy meter class 0.2, with impulse contact.	1
5.	CS	Breaker control switch with 2-separately mounted indicating lamps for status indication	1
6.	CS	Disconnecting control switch with 2-separately mounted indicating lamps for status indication	1
7.	SI	Electrically operated mimic disconnect device (semaphore indication),	1

Item	Legend	Description	Quantity per Panel
		110V DC, to indicate the position of disconnecting switch	
8.	Relay	Only main relays and instruments are listed here. All the trip relays and auxiliary relays required for satisfactory operation of the scheme shall be included by the Contractor.	1 set
9.	87T	Differential protection for transformer with inbuilt REF (main)	1
11.	51/51N, 50/50N	H.V. backup protection of transformer	1
12.	64	Restricted Earth Fault Relay	1 set for HV 1 Set for LV
13.	51N	L.V. Backup Earth fault Protection	1
14.		Trip circuit supervision relay	4
15.		Interlock, switching & tripping relay	1
16.		D.C. fail relay	1
17.	V	Indicating voltmeter with selector switch 0-45kV Scale, 33000/√3V/ 110/√3V	1 Set

I. MAJOR COMPONETS OF 33 KV LINE CONTROL/RELAY PANEL

Item	Legend	Description	Quantity per Panel
1.	ANN	Annunciator assembly, 18 active points,110V DC, 3 rows high by 6 columns wide, flush mounted, and with:	1
		3-separately mounted push buttons 2-separately mounted indicating lamps, one white lamp, and one red lamp. Following minimum annunciations shall be provided: 1. Over current protection trip	
		2. Earth Fault protection trip	
		3. Trip circuit faulty	
		4. V.T. Fuse fail	
		5. Breaker failure protection trip	
		6. C.B. in trouble	
		7. spare	
		8. spare	
		9. A.C. supply failure Alarm	
		10. D.C. supply failure Alarm	

Item	Legend	Description	Quantity per Panel
		11. C.B trip	
		12. spare	
		13. spare	
		15. spare	
		16. spare	
		17. spare	
		18. spare	
2.	Relay	Only main relays and instruments are listed here. All the trip relays and auxiliary relays required for satisfactory operation of the scheme shall be included by the Contractor.	
	51/51N 50/50N	Over-current and earth fault protection	1
3.	A	Indicating ammeter with selector switch 0-400 A ; 0-200 A (for CT ratios 400-200/1A)	1 set
4.	MFS	Numerical type Multi Function Meter (A, V, F, MW, MVAR, MVA, PF) with communication facilities with SCADA/RTU.	1 set
5.	Energy meter	3 ph, 4w Quadrant type energy meter class 0.2, with impulse contact, 400-200/1 A, 33000/√3/110/√3 V	1
6.	CS	Breaker control switch, with 2-separately mounted indicating lamps for status indication.	1
7.	SI	Electrically operated mimic disconnect device (Semaphore Indication), 110V DC, to indicate the position of disconnecting switch	2
8.	SI	Electrically operated mimic disconnect device (Semaphore Indication), 110V DC, to indicate the position of Line Grounding switch	1

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11 kV SWITCHGEAR

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9 11 KV SWITCHGEAR

9.1 General

This specification covers the design, fabrication, properly packing for transportation, delivery, installation, testing and putting into efficient and trouble free operation of the 11 kV switchgear complete with all accessories.

9.2 Technical Requirement

The general constructional features of 11 kV Switchgears shall incorporate the following as a minimum:

- The switchgear shall be metal enclosed, fully drawout, free standing, dust and vermin proof, totally enclosed, fully compartmentalized, floor mounted type. The circuit breaker panels shall be drawout, multi-compartmental unit type. The unit shall be robust design to withstand the stresses encountered in the event of an electrical fault.
- Adequate lifting facilities such as hooks for ease of handling at site shall be provided. These hooks when removed shall not leave any openings in the switchgear.
- Front / Rear access shall be available to all components in cubicle which requires adjustment, maintenance or replacement.
- Rear access shall be available to all cable boxes and glands and terminal blocks. Rear side of cable chamber shall be provided with shrouds/segregation plates of non-flammable material, with high voltage danger notice board. It shall be possible to remove & install these shrouds/segregation plates after cables have been terminated.
- The individual panels shall comprise two main portions, i.e. the fixed and the moving portion. Fixed portion shall house bus bars, current transformers, relays and instruments. Moving portion shall be circuit breaker. The bus bar chamber shall be completely segregated from the rest of the panel. The bus bars shall be suitably sized and supported on insulators of suitable grade and shall be brazed to withstand the fault level specified. The connection between the bus bars and the terminals of the circuit breakers shall be suitably shrouded. Similarly, all Bus bar joints shall be shrouded.
- Each unit of switchgear shall have necessary interior sheet metal barriers to form separate compartments for buses, switching devices, entering cable connections, etc. Each compartment must be constructed and segregated to confine the damage caused by an internal fault to that compartment.
- Automatic safety shutters shall be provided to shroud bus side and cable side main disconnecting contacts of the circuit breaker when the circuit breaker is taken to test position. The shutters shall have Caution Label.
- In addition, caution board shall be provided on the vertical face separating circuit breaker compartment with other compartments. Current transformer shall be provided on the cable side of circuit breaker.
- The instrument / control chamber shall incorporate the indicating instruments, lamps and components of the control circuit. The instrument chamber shall be provided with a separate door which can be opened when the circuit breaker is 'ON'. The instrument chamber shall also be totally segregated from the rest of the panel. Wherever equipments are mounted on the door, the wiring shall be with flexible wires. The wires shall be neatly bunched and clamped and shall be sufficiently long so that the door can be opened without causing unnecessary stress on the terminations at the instruments. All instrument and relays belonging to one panel shall be mounted on the same panel. In case of shortage of space, rear instrument panel above cable chamber can be utilized.
- All barriers shall be of non inflammable material.
- Doors of all switchgears shall be gasketed to prevent entry of vermin and dust. No opening should be left. Steel screws, bolts and washers shall be plated.
- Adequate packaging against damage / deterioration shall be provided for transportation to site and subsequent storage prior to reassembly.
- Vendor shall take necessary measures to comply internal arc classification as per IEC 62271-200.
- The height of the panel throughout the length shall be uniform.

9.2.1 Bus bars

All bus bars and their main current carrying connections shall have the same sectional area throughout their length, Bus bars shall be sized to continuously carry the rated current without exceeding the final temperature of 90°C and the same shall be capable of withstanding the full fault level without any deformation. The continuous current rating of bus bars shall be as per Single Line Diagram. Bus bars shall be of Copper with proper plating at joints. The bus bars shall be provided with cast epoxy sleeving or nylon film of suitable insulation class throughout their lengths and vertical droppers and color coded. Joints in bus bars shall be provided with shrouds. For long bus bars, suitable expansion joints shall be provided.
The bus bars shall be supported by epoxy resin cast insulators with suitable Creepage distance & capable to withstand the specified fault level.

Bus bars and connections shall be secured in such a manner that the insulators are not subjected to bending forces under short circuit conditions Dynamic stresses shall be calculated on the basis of peak short circuit current.

The vertical droppers shall be sized to carry continuously at least the rated current of the connected circuit breaker.

Thermal design of the busbars shall be based on installation of the switchgear in poorly ventilated conditions. The cooling air volume shall take into account only the bus enclosure.

9.2.2 Circuit Breaker (CB)

The Circuit Breaker shall conform to the requirements of IEC- 62271- 200

Circuit breaker shall be Vacuum Circuit Breaker (VCB) type & shall be triple pole arranged for motor operated spring charged, independent closing and shunt tripping from suitable voltage from battery. The close / trip control switch shall be interlocked to trip before close. The closing and tripping circuits shall be self-opening on completion of their respective functions irrespective of the position of the control switch.

Mechanical OFF push actuators shall be provided on breaker mechanism door. This shall be operable without the need to open panel door.

All operating mechanism shall be designed to give trouble free service over extended periods and shall not require attention more often than every 2,000 operations or once a year, whichever is the shorter period. Each breaker shall be fitted with operation counter.

A visual ON / OFF indicator shall be provided positively coupled to the operating mechanism.
This indicator shall be visible through a glass window from the front with the cubicle door closed.

The circuit breaker shall have facility to charge the spring manually and close the breaker in the event of failure of motor / control supply to motor. The spring charging motor shall start after closing of breaker and not after opening of breaker. In case the limit switch fails to cut out the spring charging motor when the springs are fully charged, the motor shall be automatically de- coupled and annunciation for this shall be provided. Mechanical indication for spring charged / discharged shall be provided.

Mechanism shall be trip free and shall have anti-pumping facilities. Each circuit breaker shall be provided with two trip coil.

Each circuit breaker shall have necessary auxiliary contacts for indication, protection, interlocking supervision, metering and other purposes. Minimum 4 ‘NO’ + 4 ‘NC’ shall be provided for Employer's exclusive use. All spare contacts shall be wired up to the terminal blocks. All contacts shall be positively operated by main apparatus and all contacts shall be adequate to make, carry and interrupt the currents in their circuits. Auxiliary relay shall be used to multiply contacts. Service position contact of circuit breaker shall be used for the multiplying relay. The shunt trip of the circuit breaker shall be wired through an advanced `NO' contact which shall make before the main contact close.

Mechanical / Electrical interlocks shall be provided to prevent mal-operation and in particular to ensure the following.

- The breaker can be operated only if it is in service or in test position.
- Movement of the circuit breaker truck from service to test or test to isolated position OR in reverse order shall be possible only when circuit breaker is off.
- In the operating positions of the breaker, the circuit breaker shall be securely locked. It can be withdrawn or inserted only with appropriate operations of the interlocking levers.
- The operating lever facilitates to overcome the contact pressure at the main disconnecting contacts while pushing in or drawing out.
- Test to isolated position of circuit breaker can be achieved only when the control plug is removed.
- Isolated to test position of circuit breaker can be achieved only after inserting control plug.
- It shall not be possible to withdraw the breaker when it is in closed position.
- It shall not be possible to plug in a breaker with grounding switch closed.
- It shall not be possible to close the grounding switch with breaker plugged in.
- Pulling out of auxiliary circuit plug with breaker in service position shall not be possible.
- Pushing in breaker to service position with auxiliary circuit plug not in position shall not be possible.
- Opening of compartment door with isolating switch in ON position and vice versa shall not be possible.

All the non-conducting metal parts of the circuit breaker truck shall be bonded together and shall make perfect electrical connections to earth through substantial sliding contacts, at service and test positions. Such sliding contacts shall be arranged to make before power plug-in and interrupt after power drawout.

Arc extinguishing devices shall be easily removable for routine inspection of fixed contact assemblies. The mating contacts of the circuit breaker with busbar contact shall be provided with removable shrouds.

9.2.3 Grounding Switch (GS)

A galvanized steel grounding bus shall be provided at the bottom and shall extend throughout the length of each switchgear. It shall be bolted/ welded to the framework of each panel and each breaker / contactor grounding contact bar.

Separate Grounding Trucks shall be provided by the Bidder for maintenance work. These Trucks shall be suitable for grounding the Switchgear Bus bars as well as outgoing / incoming Cables or bus ducts. The trucks shall have a Voltage Transformer and an interlock to prevent grounding of any live connection. The Grounding Trucks shall in addition have a visual and audible annunciation to warn the Operator against grounding of live connections.

9.2.4 Current Transformers (CT)

Current transformers shall be cast resin bar primary type with the secondary terminals housed in a terminal box. The burden, ratio and class of accuracy shall be as given in the SLD. However, current transformers shall have sufficient capacity to operate with the burden imposed by the devices shown on drawings within their accuracy classifications.

Unless otherwise specified separate cores shall be used for metering and protection.

Current transformers shall be mounted in stationary part of switchgear.

These shall be capable of withstanding dynamic and thermal stresses originated by short circuit fault current for withstand time of the board.

Test terminal blocks shall be provided for each CT circuit.

CT terminal block shall be provided with shorting and disconnecting type links & terminals shall be suitable for termination of 4 sq.mm cable.

Unless otherwise required for proper relaying one side of current transformer secondary shall be grounded in the compartment with the meters or relays which they serve and each current transformer group shall be grounded with a separate identified lead which may be disconnected for testing.

CT secondary terminals shall be provided with plastic covers to prevent inadvertent contact.

CT circuits to have provision for remote metering in all the phases for all meters.

CT sizing shall be verified by vendor, based on relay make & relay manufacturers recommendation.

9.2.5 Voltage Transformers (VT)

The VT's shall be epoxy cast resin type. The burden and ratio and class of accuracy shall be as specified in SLD. Generally, VT shall have specified accuracy class from 10% to 120% of normal voltage. However, potential transformers shall have sufficient capacity to operate with the burden imposed by the devices shown on the drawing with their accuracy classification.

All VT's shall be draw out type and connections between the bus bars and VT shall be completely shrouded. Automatic shutter shall be provided to shroud the bus bars when VT is taken out.

It shall be possible to remove potential transformer from the circuit, whenever required.

Secondary shall be provided with a 4 pole MCB.

Plug-in type test terminal blocks shall be provided for each VT circuit.

Unless otherwise specified for proper relaying one side of potential transformer secondary shall be grounded at the transformer and the ground connection shall be identified and removable for testing.

The primary rated voltage shall be equal to the rated voltage (11,000/√3 V) if the voltage transformer is connected between phase and neutral. If not otherwise specified secondary voltage shall be 110/ √3V.

Selection and sizing of PT shall be verified by vendor based on relay make.

9.3 Relays

All relays shall conform to the requirements of IS: 3231/IEC-60255 or other applicable standards. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear.

All main protective relays shall be numerical type & the communication protocol shall be IEC 61850. All protective relays shall be in draw out or plug-in type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied loose and shall be included in contractor's scope of supply.

All AC operated relays shall be suitable for operation at 50 Hz. AC Voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for 1 amp CT secondary. All DC operated relays and timers shall be designed for the DC voltage specified, and shall operate satisfactorily between 80% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.

The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. also required for the complete protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme, contacts

shall be silver faced with spring action. Relay case shall have adequate number of terminals for making potential free external connections to the relay coils and contacts, including spare contacts.

All protective relays, auxiliary relays and timers except the lock out relays and interlocking relays specified shall be provided with self-reset type contacts. All protective relays and timers shall be provided with externally hand reset positive action operation indicators with inscription. All protective relays which do not have built-in hand-reset operation indicators shall have additional auxiliary relays with operating indicators (Flag relays) for this purpose

Timers shall be of the electromagnetic or solid state type. Pneumatic timers are not acceptable. Short time delays in terms of milliseconds may be obtained by using copper slugs on auxiliary relays. In such case it shall be ensured that the continuous rating of the relay is not affected. Time delay in terms of milliseconds obtained by the external capacitor resistor combination is not preferred and shall be avoided to the extent possible.

Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.

All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.

The setting ranges of the relays offered, if different from the ones specified shall also be acceptable if they meet the functional requirements.

Any alternative/additional protections or relays considered necessary for providing complete effective and reliable protection shall also be offered separately. The acceptance of this alternative/ additional equipment shall lie with the Purchaser.

The bidder shall include in his bid a list of installations where the relays quoted have been in satisfactory operation.

All relays and their drawings shall have phase indications as R-Red, Y-yellow, B-blue

Wherever numerical relays are used, the scope shall include the following:

- Necessary software and hardware to up/down load the data to/from the relay from/to the personal computer installed in the substation.
- The relay shall have suitable communication facility for future connectivity to SCADA. Communication protocol shall be IEC 61850.
- The features like fault recorder and event logging function including as available as optional feature in the relays shall be supplied & activated at no extra cost to the the Employer. Also, necessary hardware/software for automatic uploading to station HMI/DR workstation (as applicable) shall be supplied.

9.4 Specific protection requirements

In general, the major protection schemes to be employed are as follows:

For 11 kV incomer from distribution transformer and outgoing feeders, numerical IDMT over current/earth fault (OC/EF) relays with highest instantaneous feature shall be adopted.

Over-current and Earth-fault Protection

a) Non-directional phase over current protection shall:
   - have an inverse characteristic with a definite minimum time of 3 seconds at 10 times setting.
   - have a variable setting range of 20-200% of rated current
   - have a high set instantaneous unit with a continuously variable setting range of 5-20 times of rated current.

b) Non-directional earth fault protection shall:

- have an inverse characteristic with a definite minimum time of 3 sec. at 10 times setting.
- have an adjustable setting of 10-80% of rated current.
- have a high set instantaneous unit with a continuously variable setting range of 5-20 times of rated current.

Other Requirements

All auxiliary relays, if and when required for the completeness of the various protection schemes covered in this order, shall be deemed to be included in the scope of supply whether or not such items are specifically mentioned in the enclosed bill of material.

All terminal blocks for CT and PT circuits shall be of disconnecting line type. Suitable plastic covers for all terminal blocks shall be provided in order to prevent dust accumulation.

9.5 Energy Meters

Energy meters shall be numerical type manufactured by internationally reputed manufacturer. Each feeder shall be equipped with one set of 3 ph, 4w kWh and kVARh meters. The meters shall preferably be four quadrant type. In case of numerical type energy meters, the Contractor shall furnish probe, copy write software and other necessary items (serial port, suitable to connect these meters with laptop) for operational programming of the meters.

All kWh and kVARh meters shall be of 0.2 class accuracy. In addition to all the tests required to be performed at the manufacturing plant, each of these meters shall be tested at the Employer's laboratory also at the expense of the Contractor prior to installation and commissioning and as and when required by the Employer during the warranty period. Any meter, which fails the tests, will not be acceptable and the Contractor shall supply their replacements immediately. If the replacements too fail the tests, then the Employer reserves the right to replace the meters with new one at the expense of the Contractor. The test results from the Employer’s laboratory shall be final and binding upon both parties.

9.6 Multifunction Meters

Multifunction meters shall be numerical type. Each 132 kV and 33 kV feeders shall be equipped with one Multifunction Meter. As a minimum all Multifunction Meters shall display following parameters and also communicate all parameters to SCADA/RTU.

- Three phase currents
- Line and Phase voltages
- Frequency
- Active Power
- Reactive Power
- Apparent Power
- Power factor

9.7 Miscellaneous accessories

Space Heater

Each panel shall be equipped with thermostat controlled space heaters to prevent moisture condensation within the enclosure and shall be completed with MCBs for power supply. Space heaters and switch fuse units shall be suitable for continuous operation.

Plug Point

A 230 V, 1 phase, 50Hz AC plug point shall be provided in the interior of each cubicle with on-off switch for connection of hand lamps.

Panel Lighting

Panel lighting with door switch shall be provided in the interior of the cubicle.

DC Control supply:

Independent supply for protection trip-circuit shall be provided and another separate supply shall be provided for back up protection, control and metering.

9.8 Accessories

The Contractor shall furnish following accessories as an integral part of each switchgear panels:

a) Padlocks and duplicate keys.
b) Cable glands (Double compression type), Lugs, Ferrules etc.
c) Space heaters equipped with thermostatic controls.
d) Local/remote control switch.
e) Fuses as required.
f) Operation counters of circuit breaker.
g) Grounding terminals as required.
h) Auxiliary relays.
i) Motor contactor with thermal release for spring charging motor.
j) Rating and diagram plate in accordance with IEC incorporating year of manufacture. .
k) Special tools and tackle for operation and maintenance.
l) Other necessary accessories.

9.9 Spare Parts

For each type of circuit breaker, the spare parts shall be provided in required quantities as listed in Price Schedule. Further spare parts as recommended by the manufacturer shall also be included in the Price Schedule.

9.10 Tests

9.10.1 Routine Tests

On completion, each circuit breaker shall be subjected to following routine tests. As far as practical, the procedure of IEC shall be followed:

a) Construction Inspection
b) Safety interlock check
c) Functional checking of control circuits interlocks, tripping through protective relays.
d) Operating Speed Check
e) Dielectric test
f) Control and secondary wiring check test
g) Mechanical operation test
h) Operating mechanism system check
i) Voltage withstand test on auxiliary circuits
j) Measurement of resistance of main circuit of each pole
k) Power frequency voltage withstand test on main circuit of each pole and the combination of poles and breaker frame.

In addition to above the complete switchgear shall be subjected to following routine tests. As far as practical, the procedure of IEC shall be followed:

a) Construction Inspection
b) Dielectric test
c) Voltage withstand test on auxiliary circuits
d) Power frequency voltage withstand test on bus bar.

9.10.2 Design Tests

Following design tests shall be performed on the offered model.

The circuit breaker design tests shall include following:

a) Dielectric withstand test
b) Temperature rise test
c) Radio interference voltage test
d) Short-time withstand current and peak withstand current tests
e) Verification of the protection
f) Electromagnetic compatibility tests

The Bidder shall submit type test report as specified in section-2 of this specification for the circuit breaker of the offered model along with the bid.

9.10.3 Field Tests

After installation at Site, the circuit breaker shall be subjected to the following field tests:

a) Insulation resistance of each pole.
b) Check adjustments, if any suggested by manufacturer.
c) Breaker closing and opening time.
d) Trip free and anti pumping operation.
e) Minimum pick-up voltage of coils.
f) Dynamic Contact resistance measurement.
g) Functional checking of control circuits interlocks, tripping through protective relays.
h) Insulation resistance of control circuits, motor etc.
i) Checking of mechanical 'CLOSE' interlock, wherever applicable.
j) Resistance measurement of main circuit.
k) Checking of operating mechanisms
l) Check for annunciations.

The contractor shall ensure that erection, testing and commissioning of 11 kV Switchgear shall be carried out under the supervision of the circuit breaker manufacturer's representative. The commissioning report shall be signed by the manufacturer's representative.

9.11 Performance Guarantee

The performance guarantee figures quoted on the schedule of Technical Data shall be guaranteed within the tolerances permitted by relevant standard and will become a part of successful Bidder's Contract.

9.12 Drawings, Data and Manual

The outline drawings of the switchgear cubicle with accessories shall be furnished along with the Bid.
After award of Contract the successful Bidder shall submit the required number of copies of the following drawings and data for approval of the Employer.

a) General equipment layout
b) Outline drawings of switchgear with accessories
c) Loading data and foundation detail
d) Single and three Line diagrams of AC & DC circuits including relays, meters etc.
e) Elementary control wiring diagrams
f) Internal wiring diagrams
g) External connection diagrams, showing terminal boards and other external Connection points for each assembly and the required interconnecting wiring
h) Drawings showing typical cross-sections of the switchgear panel
i) Drawings showing assembly of principal component parts and accessories of circuit breaker
j) Drawings showing details of bus bar supporting arrangements.
k) Any other drawings and data required for design and installation of circuit breaker.

l) Instruction manual for storage, installation, operation and maintenance of circuit breaker and switchgear.

m) Instruction manual for Relays, meters, switches and other accessories.

9.13 Nameplate

Circuit breaker shall be provided with a nameplate of stainless steel material fitted in a visible position. It shall show the following items as a minimum.

a) Circuit Breaker
- Manufacturer's name
- Manufacturer's serial number and type designation
- Year of manufacture
- Rated voltage, kV
- Rated insulation level, kV
- Rated frequency, Hz
- Rated nominal current, A
- Rated short-circuit breaking current, kA
- Rated short circuit making current, kA
- Rated operating cycle (duty cycles)
- Rated short time current & duration, kA/s
- Rated operating sequence (duty cycles)
- Type of operating mechanism
- First pole to clear factor
- Rated interrupting time, cycles
- Weight of circuit breaker, kg

b) Switchgear cubicle
- Manufacturer's name
- Manufacturer's serial number and type designation
- Year of manufacture
- Rated voltage, kV
- Rated insulation level, kV
- Rated frequency, Hz
- Rated nominal current, A
- Rated short time current & duration, kA/s
- Rated control supply voltage, V

9.14 Special Tools

In addition to the tools, which are regularly furnished with such breakers, the Contractor shall also supply all necessary special tools or equipment for assembling and disassembling the breaker and/or other equipment/ accessories. The Contractor shall submit an itemized list of such equipment in the Price Schedule.

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STATION AUXILIARY SUPPLY

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10 STATION AUXILIARY SUPPLY

10.1 General

This specification covers the design, manufacture, assembly, shop test, supply, delivery, installation, field testing and commissioning of the station auxiliary supply system complete with all accessories, fittings and auxiliary equipment for efficient and trouble-free operation as specified herein under. The Contractor shall undertake all the works (complete supply and installation) relating to the connection of the station service transformer to the HV/LV control and distribution panels.

Major components of station auxiliary supply system consist:

a) One (1) 300 kVA, 33/0.400 kV, ONAN transformer.
b) Main AC Distribution Board (ACDB).
c) Main Lighting Distribution Boards, Indoor and Outdoor lighting panels etc.
d) 110 V DC Distribution Board (DCDB).

Entire station auxiliary supply system shall be designed and constructed to cater auxiliary power to the entire substation premises including future bays.

The equipment specified in this Section of the Contract shall conform to the latest edition of the appropriate IEC specifications and/or other recognized international standards. In particular:

IEC60076	Power transformers
IEC 60137	Bushings for alternating voltages above 1 kV
IEC 60156	Method of determination of electric strength of insulating oils
IEC 60296	Specification for unused mineral insulating oils for transformers and switchgear
IEC 60551	Measurement of transformer and reactor sound levels
IEC 60616	Terminal and tapping markings for power transformer
IEC 60722	Guide to lightning and switching impulse testing of power transformers

10.2 Transformer Construction

10.2.1 Tank

The station transformer shall be provided with a case of rigid construction, which shall be oil-tight and gas-tight complete with oil preservation system. The tank shall be capable of withstanding, without leakage or permanent distortion, a pressure 25% greater than the maximum operating pressure resulting from the system of oil preservation used. The tank cover shall be bolted and provided with suitable hand holes. Two grounding pads complete with clamp type terminal connector shall be provided on the tank wall near the base.

10.2.2 Core

Cores shall be constructed of high quality, non-aging, high permeability cold rolled grain oriented silicon steel. The steel shall be in thin laminations. Both sides of each sheet shall be insulated, with durable, rigidly clamped with positive locking devices to ensure adequate mechanical strength to support the windings and reduce vibrations to a minimum during operation. Cut type cores shall not be accepted. 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.

10.2.3 Winding

The design, construction and treatment of winding shall give proper consideration to all service factors. The complete assembly of core and coils shall be dried in a vacuum sufficient to ensure elimination of air and moisture within the insulating structure. After the drying process, the assembly shall be immediately impregnated with dry oil. The windings of the transformer shall be fabricated of copper materials. Aluminum winding materials shall not be accepted.

10.2.4 Oil Preservation

Each transformer shall be provided with an oil conservator complete with oil filter flange or cap at the top.

10.2.5 Short Circuit Capacity

The transformer shall be designed and constructed to withstand, without injury, the mechanical and thermal stress produced by short-circuit current limited by the impedance of the transformer only.

10.2.6 Tap Changer

An externally - operated tap changer shall be provided with the transformer which shall be operated only when the transformer is de-energized. The tap changer shall include an operating handle, visible indication of tap position and means for locking the tap changer in any desired position. The locking device shall be arranged to prevent locking the tap changer in an off position. Mechanical means shall be provided for limiting the maximum and minimum traveling of the extreme tap positions to be at the maximum and minimum position of the tap changer.

10.2.7 Insulating Oil

The insulating oil shall be refined mineral oil. Necessary quantity of oil for the transformer shall be furnished by the Contractor The oil supplied with transformer shall be unused and have the parameters for unused new oil conforming to IS:335 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.

10.2.8 Terminal Arrangement

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.

The neutral terminals of 400V winding shall be brought out on a bushing along with the 400 volt phase terminals to form a 4 wire system for the 400 volt. Additional neutral bushing shall also be provided for earthing.

10.2.9 Bushings

The bushings shall be made of homogeneous and well vitrified porcelain. The color of the insulator shall be brown and the surface shall have polished glaze.

The 33 kV bushings shall have bolted terminal lugs suitable for terminating ACSR DOG conductor.
The cable terminal box on the low voltage side shall consist bolted terminal lugs suitable for terminating stranded copper conductor cables of adequate size.

The low voltage neutral bushings shall include a lug for terminating a 25 x 6 mm. GS earth conductor in addition copper conductor of adequate size neutral circuit.

10.2.10 Temperature rise

Average winding temperature rise above maximum ambient temperature (40 Deg C) when carrying maximum continuous rated kVA shall not exceed 55 Deg C. The temperature rise of the insulating oil shall not exceed 50 Deg C when measured near the top of the main tank.

10.2.11 Accessories

The following accessories shall be provided with each transformer.

- Upper oil filter valve

- Lower oil filter and drain valve
- Oil sampling device
- Liquid level gauge
- Lifting Lug
- Name plate
- Hand Hole
- Tank grounding terminal connector suitable for grounding.
- Breather, oil conservator.

10.2.12 Tests

Up on completion the transformer shall be subjected to following routine tests. As far as practical, the procedure of IEC shall be followed:

- Applied voltage test
- Induced voltage test
- No load loss and excitation current test
- Impedance voltage and load loss tests
- Winding resistance measurement
- Ratio tests
- Polarity and phase relation tests
- Leakage tests
- Insulation resistance tests
- Insulation power factor tests, etc.

Design Test:

The Transformer design tests shall include following:

- Temperature rise tests
- Impulse voltage tests
- Pressure tests

The Bidder shall submit type test report as specified in section-2 of this specification or the transformer of the offered model along with the bid.

10.2.13 Current limiting power fuse

For the protection of the station transformer, high voltage (33 kV) current limiting power fuses with suitable cartridge holder, outdoor mounting shall be provided in a safe height. Cost of the power fuse its holder including installation shall be included in the price of the station transformer.

10.2.14 Disconnecting Switch

Gang operated single throw disconnecting switch shall be provided for the transformer. This switch shall be easily operable from ground and capable of disconnecting the transformer.

10.3 AC / DC PANEL

10.3.1 General

This specification covers the design, manufacture, assembly, testing at manufacturer's works, supply and delivery, installation, field testing and commissioning properly packed of low voltage distribution boards.

The equipment covered by this specification shall, unless otherwise stated, be designed, constructed and tested in accordance with the applicable section of the latest relevant IEC Specifications. The equipment conforming to any other national standards which ensures equivalent quality are acceptable. In such cases the Bidder shall

clearly indicate the standard adopted and furnish a copy of the English version of the standards along with the proposal. Should there be any dispute on design standards; the most stringent one shall be followed.

10.3.2 Design Requirements

The AC distribution board is meant for miscellaneous loads such as but not limited to battery charger, illumination, ventilation and air conditioning, space heater, transformer auxiliaries, etc including the loads of staff building store and gate post.

The DC distribution board is meant for distribution of DC power to switchgear, control, relay and metering panel, emergency lighting, fire protection system, etc.

The distribution boards will be located indoor in a hot and humid atmosphere. All equipment, accessories and wiring shall be provided with suitable finish for prevention of fungus growth.

The AC distribution board shall be designed for operation in a 400V (+/- 10%), 3 phase, 4 wire, 50Hz (+/- 5%) neutral grounded system. The DC distribution board shall be designed for both 110 V and 48 V DC, 2 wires system.

Sheet thickness shall not be less than 2 mm.

Design and selection of all equipment shall be made liberally providing a good margin safety-factor with prior approval of the Employer.

The incomer to the AC distribution board shall be connected to the LV side of the station transformer. The distribution board shall have compartments, such that supplies shall be made in modular way for station equipment, battery chargers, emergency lights, lighting and other utilities.

The AC and DC (48 and 110V) distribution boards shall also be provided with the compartment design.
110 V DC for 11 kV switchgears and control & protection panels in series shall be fed from two separate feeders at the end panels. One 48V feeder shall provide 48 V DC supply to only one telecommunication equipment. Also supply for main protection shall be independent.

Each distribution board must have sufficient number of spare feeder (20% of various sizes used in the Distribution Boards with a minimum 5 nos. on each bus). The incoming molded case circuit breakers and bus bar ratings shall be selected considering the spares also.

The distribution boards shall be complete with all accessories and materials.

Base channel frames shall be provided for the distribution boards for grouting in the floor complete with anchor bolts, nuts and leveling attachments.

Special tools and tackle shall be provided for erection and maintenance of the distribution boards and other equipment.

The Contractor shall furnish as many distribution boards as required to cater the complete requirement, without any additional cost. If additional feeders on any distribution board are required to meet the Employer's requirement, the same shall be supplied without any extra cost to the Employer.

10.3.3 Construction Features

The distribution boards shall be self standing sheet steel cubicle having following features:

a) The construction shall be compartmentalized.
b) All distribution boards shall be dead front type. All switches, circuit breakers, etc. shall be operable from the front.
c) All bolts and nuts exposed to external atmosphere shall be cadmium plated or zinc passivity.

d) The working height shall be limited to a maximum of 2,000 mm. The design shall be such as to permit easy extension of distribution boards at site on either end.
e) The distribution boards shall consist of vertical sections, fabricated from a minimum of 2mm thick sheet steel, shaped and reinforced to form a rigid free-standing structure.
f) The minimum clearance of the power terminal lug from the bottom plate shall be maintained as 200 mm.
g) The AC distribution board designed for 4 wire system shall have a fully insulated neutral bus of cross-section same as the main phase buses.
h) Foundation bolts and nuts for each distribution board shall be supplied along with the distribution board.
i) All distribution boards mounted indoor shall be provided with enclosure protection of IP 52 as per IEC.
j) Voltmeter and Ammeter with selector switch shall be provided at the incomer of the panel. AC distribution panel shall have energy meter with accuracy class not less than 1.

10.3.4 Bus Bars

a) Bus bars shall be of copper, liberally sized for the specified current ratings (both short circuit currents). Maximum temperature of the bus and bus connection shall be limited to 90 deg. C.
b) All bus bars, links, etc. shall be covered to prevent accidental contacts.
c) Buses shall be spaced with adequate clearance between phases and between phase and ground.
d) Bus supports shall be of molded insulators suitable for polluted atmosphere.
e) All bus works shall be braced to withstand stresses due to short circuit current, corresponding to the respective fault level of the system to which it is connected. The bus bars shall be able to withstand for 3 second the above short circuit current thermally.
f) Appropriate color code shall be used to identify the various phases of bus bars and the neutral (wherever applicable).

10.3.5 Specific Requirements

Molded Case Circuit Breakers (MCCB)

The molded case circuit breakers shall be of panel mounting type. It shall have all the live parts enclosed in a molded case and all contacts shall be silver plated. The breakers shall be trip-free and with quick-make and -break operating mechanism. The molded case circuit breakers shall be provided with magnetic short circuit protection and thermal overload device. The protection device of the incomer MCCB shall be coordinated with feeder MCCB. Each breaker shall have a common trip, causing an overload on one pole to trip all other poles.

The MCCB handle, after the breaker trips due to a fault, shall occupy a mean position. The breaker shall be capable of interrupting a RMS current corresponding to the fault level of the system to which the respective distribution board is connected.

It shall be possible to close and trip the breaker without opening the compartment door. The breaker shall be provided with mechanical ON-OFF indicator at the front properly marked. The rating of the MCCB's shall be approved by the Employer.

Appropriate MCBs shall be provided for DC circuits.

MCCB shall in general conform to IS: 13947 Part-2. All MCCB offered shall have Ics = 100% Icu rating. Type test reports for offered model of MCCB shall be submitted during detailed engineering for the Employer's acceptance.

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.

Miniature circuit breaker (MCB) shall conform to IEC: 898-1987 and IS: 8828.

Cable Termination

Distribution board shall be designed to facilitate cable entry from bottom. Removable plates shall be furnished with compression type cable glands to make entry dust tight and no weight is transferred on the terminal. The glands shall be suitable for terminating cable armor. Compression type cable lugs as required shall be furnished for termination of power and control cables.

Sufficient space shall be provided to avoid sharp bending and for easy connection. A minimum space of 200 mm from the gland plate to the nearest terminal block shall be provided.

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

Ground Bus

Copper strip of 25 X 6 mm size shall be provided as ground bus and connected to the station ground grid.

Instrument Transformers

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 40°C.

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.

All instrument transformers 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.

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.

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

Indicating Instruments

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.

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.

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

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

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

10.4 Nameplate

Nameplates showing: “Feeder Designation " shall be provided for each module of distribution board at front door top. Also nameplate shall be furnished at the top for each distribution board. Material for nameplate shall be plastic sheets, 3mm thick or approved equivalent. The letters shall be white on black background.

The nameplate shall be held by self tapping screws. The size of the nameplates shall be proportionate to the size of the modules. Also individual panel number and danger plate shall be furnished.

10.5 Space Heater

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

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 MCB's shall also be provided.

10.6 Tests

Each distribution board shall be completely assembled, wired, adjusted and tested for operation under simulated conditions to ensure correctness of wiring and proper functioning of all equipment.

All component parts such as MCCBs, MCB's, meters, etc. shall be tested in accordance with relevant IEC Specifications.

All current carrying parts and wiring shall be subjected to a high voltage test.
All routine tests shall be conducted on all distribution boards.

10.7 Drawings, Data and Manuals

After award of Contract, the successful Bidder shall submit the following drawings for approval of the Employer.

Confirmed outline dimensional drawing of all distribution boards, showing the general arrangement and indicating the following:

- Space required in the front and back
- Power cable entry points
- Bus bar clearance, phase to phase and phase to neutral
- Configuration of bus bars
- Technical details of supporting insulator and their spacing
- Outgoing power termination arrangement
- Transport/shipping dimensions with weights
- Foundation and anchor bolt details including dead load and impact load

Any other relevant drawing and data necessary for approval shall also be submitted.

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SECTION - 11

BATTERY AND BATTERY CHARGER

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11 BATTERY AND BATTERY CHARGER

11.1 General

This specification covers design, manufacture, assembly factory test, supply, delivery, installation, field test and commissioning of a stationary battery or batteries each complete with battery charger, distribution board and control gear.

Two set of batteries and two sets of battery chargers shall be provided for each of the following voltage levels. The operation shall be such that each set of battery shall be connected with two sets of chargers, out of which one set shall be for main supply and the other as a backup.

- 110 V DC shall be used for protection and control
- 48 V DC shall be used for communication/SCADA system.

It shall be ensured that the 110 V power supply system operates with both battery terminals free of earth, whilst that for communications, 48 V DC system with positive earthed, to detect faults on both the positive and negative poles.

48V Battery Charger shall consist of required numbers of MCB's of adequate capacity for supply of 48V DC supply required different panels loads.

11.2 Batteries

The Contractor shall offer maintenance free valve regulated lead-acid 110 V and 48 V batteries. The batteries shall be assembled in heavy-duty-steel structure designed for easy stack ability.

The battery cells shall be hermetically sealed, sturdy, weather proof and long lasting. The safety valves, if provided shall be explosion free. All the cells shall be mounted on racks of plastic-covered steel. More than 2 levels shall not be permitted. If the batteries are located together in two rows, provide enough space for maintenance access along the two long sides.

The arrangement of the rack shall be such as to allow easy access and adequate space for normal maintenance in battery room.

All battery stands shall be suitably protected against corrosion and attack by the battery electrolyte. Inter-cell connections shall be made of low resistance in a clean condition when bolted and protected against corrosion.

Battery banks shall be protected by appropriate fuses.

The lowest rack for accommodating battery cells shall be at a minimum of 30 cm above ground level.

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 up to 1.85V per cell.	Minimum Nos of cell
110 Volt	121 Volt	99 Volt	54
48 Volt	52.8 Volt	43.2 Volt	23

11.3 Battery Capacity Sizing

11.3.1 110 V DC Battery

Battery nominal capacity shall be not less than 400 AH. The nominal voltage of the battery at its terminal shall be 110 V. At the end of the rated discharge period of 10 hours, the voltage available at the battery terminals shall be not less than the minimum 94 V. Batteries shall be suitable for operation on a floating charge system and capable of providing the guaranteed output throughout the range of ambient conditions specified. The

battery rated output shall be available at the outgoing terminals, after making due allowance for the resistance of inter cell connections.

11.3.2 48 V DC Battery

The battery capacity shall not be less than 100 Ah.

The equipment shall be designed to operate within voltage limits specified below i.e. no spurious operations or false controls shall be initiated. 48 V DC power supplied shall have the following general characteristics:

- Provision for grounding positive terminal to station earth
- Voltage variation between 42 V to 48 V
- Battery autonomy: 10 hours

11.4 Battery Charging Equipment

The chargers shall be of the automatic constant voltage output type designed for float charge operation. They shall be suitable for operation from the 400 V ± 10% ac supply, 50 Hz.

The chargers for communications batteries shall be such that the phosphometric noise level does not exceed the equivalent of 2 milli-volts at a frequency of 800 Hz after weighing in accordance with CCIF, the charger output being at any point within its rating with the battery connected.

The DC output of each main charger unit shall remain within the limits of +3% and -2% under any of the following conditions:

a) System frequency between ±5% of the nominal value;
b) System rated voltage input ± 10%
c) Output of charger between 5% and 100% of rated output.

The constant voltage charge level on a cell shall be 2.25 V or any other value recommended by the offered battery manufacturer. The Battery charger output rating shall be 80 A for 110 V charger and 20 A for 48 V charger.

The equalizing and float voltage levels shall be adjustable and suitable for the range of operating conditions recommended by the battery manufacturer.

The static direct voltage variation shall be maintained as specified over an ambient temperature range of 0-40^{o}C.

The end switching / dropper diodes, if required, to limit equipment over voltage during equalizing charge shall be provided.
A voltmeter and charge and load ammeters on the front of the charger panels shall be provided. Provisions of AC and DC, under voltage and DC earth fault alarms with local indication (LED type indicator lamp) and separate electrically isolated contacts shall be made in the control panel.

The charger shall be equipped with automatic switch to transfer from the floating voltage to the equalizing voltage under the following conditions:

- When the voltage of the connected battery reaches the minimum prescribed value for a time longer than one minute.
- Every 30 days.

A manual override switch for selection of float charge and equalizing charge for test purposes shall also be provided.

An adjustable timer (6-24 hours) to determine the length of time the equalizing voltage shall be provided.

The AC component through the battery of the delivered DC shall not exceed 1 A rms per 50 Ah of battery capacity. The superimposed alternating voltage component shall not exceed 2% of the peak values during continuous charge operation. This applies for the entire frequency range.

The connection blocks for the connection of cables shall be of a minimum of 16 sq. mm. or as required as per voltage drop calculation.

The float charging voltage shall be between 2.1 to 2.25 volts per cell or at any other voltage recommended by the battery manufacturer. The battery charger shall have boost facility.

The boost-charging voltage shall be about 2.3 to 2.4 volts/cell or at any other voltage recommended by the battery manufacturer.

The equipment shall be designed to facilitate cable entry from bottom. Removable plates shall be furnished with compression type cable glands to make entry dust tight and no weight is transferred on the terminal. The glands shall be suitable for terminating cable armor. Compression type cable lugs as required shall be furnished for termination of power and control cables.

Sufficient space shall be provided to avoid sharp bending and for easy connection. A minimum space of 200 mm from the gland plate to the nearest terminal block shall be provided.

Terminal blocks shall be as specified in General Technical Requirements. A copper ground bus of 25mm x 6mm cross section shall be furnished near the bottom of panels and shall be connected to the station earthing mat with appropriate copper conductor. All devices shall be grounded to this ground bus.

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

Each Charger shall be furnished completely wired up to 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.
The insulation of all circuits, except the low voltage electronic circuits shall withstand test voltage of 2 KV AC for one minute.

The following accessories shall be furnished for the batteries:

a) one (1) connector bolt wrench
b) one (1) cell testing voltmeter with leads
c) Battery racks.

The charger shall be complete with the standard accessories including but not limited to the following.

a) Solid state surge protectors on the AC and DC sides.
b) AC failure alarm relay.
c) DC time delay low voltage relay.
d) Ground detection alarm for positive and negative leads.
e) Manual voltage adjust switch.
f) DC ammeter and voltmeter.

11.5 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)

Any other annunciation if required. Potential free NO Contacts of above abnormal conditions shall also be provided for common remote indication "CHARGER TROUBLE" in for future use. 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.

11.6 Tests

Type and routine tests at manufacturers' works and acceptance test at site shall be carried out on the battery/battery chargers as per stipulations of latest standard of IEC.

The tests shall include the following:

a) General inspection.
b) Leakage test and internal short test for each cell.

After initial charging, the following tests shall be performed at site:

a) Capacity test.
b) Efficiency test, etc.

The battery charger shall be subjected to the following tests at manufacturer's works:

a) Construction Inspection
b) Measurement on insulation resistance.
c) High voltage test.
d) Performance test.
e) Temperature rise test.

Test certificates shall be submitted to the Employer for approval.

11.7 Drawing, Data and Manuals

Technical leaflets on battery and battery charger shall be furnished with the Bid:

The following drawings and manuals shall be submitted by the successful Bidder for approval:

a) Dimensional layout arrangement of battery and battery charger.
b) Dimensional outline drawing of battery charger panel clearly showing the location of meters, switches etc.
c) Schematic and wiring diagram of battery charger panel.
d) Instruction manuals of battery and battery charger.
e) Battery and battery charger sizing calculation.

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SECTION - 12

GROUNDING AND LIGHTNING PROTECTION SYSTEM

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12 GROUNDING AND LIGHTNING PROTECTION SYSTEM

12.1 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.

12.2 Design Requirements

Pangtan substation lies in hilly terrain at an altitude of 2200 m above Mean Sea Level. It is flat and seems stable. After award of contract the Contractor shall conduct necessary soil investigation including soil resistivity on his own and 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.

The Contractor shall calculate the cross-section considering the maximum fault level of 25 kA.

The Contractor shall submit the details of calculations of the grounding system for the Employer's approval.

12.3 Grounding Conductor

12.3.1 Main Ground Grid

The main ground system shall consist of a grounding grid buried minimum 1.0 meter below grade level. The grounding grid shall consist of minimum 100 sq mm copper strip or conductor.

12.3.2 Ground Electrodes

The ground electrodes shall be of minimum 16 mm diameter and 3.0 meter long (min.) copper clad steel rod. These shall be driven into ground and connected to the main ground grid.

12.3.3 Risers

The risers shall consist of same conductor of main ground grid conductor connected at one end to the main ground mat and at the other end to the equipment.

12.4 Grounding Installation Features

The grounding installation shall be complete in all respects for efficient and trouble free service. All work shall be carried out in a good quality 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, foundations or columns and shall not be laid haphazardly.

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.

All lap, cross and tee connections between two grounding conductors shall be made by thermo-welding process or compression type connector. The various joints shall have adequate mechanical strength as well as necessary electrical conductivity not less than that of the parent conductors of the joints. All accessories for grounding installation shall be of quality and design approved by the Employer.

Ground conductors, when crossing underground trenches, directly laid underground pipe and equipment foundation, if any, shall be at least 300 mm below the bottom elevation of such trenches/pipes.

The maximum size of each grid of grounding mat shall not exceed 2X2 meters. The terminals for connecting ground mat and equipment shall be terminated whenever necessary.

Neutral points of systems of different voltages, metallic enclosures and frame works associated with all equipments and extraneous metal works associated with electric system shall be connected to a single earthing system.

Earthing conductors or leads along their run on cable trench, ladder, walls etc. shall be supported by suitable welding/cleating at intervals of 500 mm. Wherever it passes through walls, floors etc., galvanised iron sleeves shall be provided for the passage of the conductor and both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves.

Earthing conductor around the building shall be buried in earth at a minimum distance of 1500 mm from the outer boundary of the building. In case high temperature is encountered at some location, the earthing conductor shall be laid minimum 1500 mm away from such location.

Earthing conductors crossing the road shall be laid 300 mm below road or at greater depth to suit the site conditions.

Earthing conductor's embedded in the concrete shall have approximately 50 mm concrete cover.

12.4.1 Equipment and Structure Earthing

Earthing pads shall be provided for the apparatus/equipment at accessible position. The connection between earthing pads and the earthing grid shall be made by two short earthing leads (one direct and another through the support structure) free from kinks and splices.

Whether specifically shown in drawings or not, steel/RCC columns, metallic stairs etc. shall be connected to the nearby earthing grid conductor by two earthing leads. Electrical continuity shall be ensured by bonding different sections of hand-rails and metallic stairs.

Metallic pipes, conduits and cable tray sections for cable installation shall be bonded to ensure electrical continuity and connected to earthing conductors at regular interval. Apart from intermediate connections, beginning points shall also be connected to earthing system. Metallic conduits shall not be used as earth continuity conductor.

Light poles, junction boxes on the poles, cable and cable boxes/glands, lockout switches etc. shall be connected to the earthing conductor running along with the supply cable which in turn shall be connected to earthing grid conductor at a minimum two points whether specifically shown or not.

Earthing conductor shall be buried 2000 mm outside the switchyard fence. All the gates and every alternate post of the fence shall be connected to earthing grid.

Flexible earthing connectors shall be provided for the moving parts.

All lighting panels, junction boxes, receptacles fixtures, conduits etc. shall be grounded.

A continuous ground conductor of 16 SWG GI wire shall be run all along each conduit run. The conductor shall be connected to each panel ground bus. All junction boxes, receptacles, switches, lighting fixtures etc. shall be connected to this 16 SWG ground conductor.

100 sq mm, copper strip or conductor shall run on the top tier and all along the cable trenches and the same shall be welded to each of the racks. Further this flat shall be earthed at both ends and at an interval of 20 mtrs.

One number 16 mm dia, 3000 mm long copper clad steel electrode with test link, Test pit and cover shall be provided to connect each down conductor of surge arresters, capacitive voltage transformers, lightning masts and towers with peak, and shield wires.

12.4.2 Jointing

Earthing connections with equipment earthing pads shall be bolted type. Contact surfaces shall be free from scale, paint, enamel, grease, rust or dirt wherever possible. Two bolts shall be provided for making each connection. Equipment bolted connections, after being checked and tested, shall be painted with anti corrosive paint/compound.

Connection between equipment earthing lead and main earthing conductors and between main earthing conductors shall be welded type. For rust protections, the welds should be treated with red lead and afterwards coated with two layers bitumen compound to prevent corrosion.

Steel to copper connections shall be brazed type and shall be treated to prevent moisture ingression.

Resistance of the joint shall not be more than the resistance of the equivalent length of the conductor.

All ground connections shall be made by thermo welding. All welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load on it. Artificial cooling shall not be allowed. Bending of earthing rod shall be done preferably by gas heating.

12.4.3 Power Cable Earthing

Metallic sheaths and armour of all multi core power cables shall be earthed at both equipment and switchgear end. Sheath and armour of single core power cables shall be earthed at switchgear end only.

12.4.4 Specific Requirement for Earthing Systems

Each earthing lead from the neutral of the transformer shall be directly connected to two pipe electrodes in treated earth pit (as per IS) which in turn, shall be buried in Cement Concrete pit with a cast iron cover hinged to a cast iron frame to have an access to the joints. All accessories associated with transformer like cooling banks, radiators etc. shall be connected to the earthing grid at minimum two points.

Earthing terminal of each lightning arrester & capacitor voltage transformer shall be directly connected to rod earth electrode which in turn, shall be connected to station earthing grid.

Auxiliary earthing mat comprising of 16 mm dia copper clad steel closely spaced (200 mm x 200 mm) conductors shall be provided at depth of 300mm from ground level below the operating handles of the M.O.M. Box of the disconnecting switches. M.O.M. boxes shall be directly connected to the auxiliary earthing mat.

12.5 Lightning Protection

The outdoor equipment of the substation and the buildings shall be protected against direct stroke lightning.

Direct stroke lightning protection (DSLP) shall be provided by lightning masts of adequate number and height. If required separate direct stroke lightning protection system shall be provided for the buildings.

The lightning protection may also 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.

The design of the lightning protection system shall be subject to the approval of the Employer.

The lightning protection system shall not be in direct contact with underground metallic service ducts and cables etc. Conductors of the lightning protection system shall not be connected with the conductors of the safety earthing system above ground level.

Down conductors shall be cleated on the structures at 2000 mm interval.

Connection between each down conductor and rod electrodes shall be made via test joint (pad type compression clamp) located approximately 1500 mm above ground level. The rod electrode shall be further joined with the main earthmat.

Lightning conductors shall not pass through or run inside G.I. conduits.

12.6 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.

12.7 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.

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SECTION - 13

ILLUMINATION SYSTEM

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13 ILLUMINATION SYSTEM

13.1 General

This chapter covers the scope and general description of the design, supply, installation, testing and commissioning of illumination system, which shall be incorporated and coordinated during the substation construction works. Illumination system design shall be submitted for approval of the Employer.

The explanations and listings hereinafter are intended to give a general requirement of the illumination design and installation and shall not be construed to be an itemized listing of each element of works required. The Bidder shall be responsible for design and installation of complete facilities, conforming in all respects to the relevant standards and to the details and requirements of the specifications.

13.2 System Description

The lighting system shall comprise of the following:

A. 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.

B. DC Emergency Lighting

A few DC emergency lighting fixtures operated on the 110 V DC system will be provided in the strategic locations including, outdoor substation, Battery charger room, control room, 11 kV switchgear room, communication room 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 lighting panel. Down light fixtures in false ceiling area and Bulkhead fixtures in non false ceiling area shall be used. Control board shall be equipped with necessary contactors and timers to control number of lighting fixtures in gang. Details shall be worked out to the satisfactory to the employer.

C. Portable Emergency Lighting

Three (3) numbers of self contained battery operated, portable emergency lights will be provided in the Control Building. These fixtures will be provided at important locations after approval by the Employer.

13.2.1 Illumination Level

Following illumination (lux) levels shall be maintained at different areas:

Sr. No.	Area	Average Lux Level (lx)
1.	11 kV Switchgear Room	200
2.	Control Room / Communication Room / Office Room	300
3.	Battery Room	100
4.	Street Lighting	20
5.	Outdoor Substation & Transformer Area	50
6.	Staff Quarters/Guard House	100

The minimum lux level to average lux level ratio should not be less than 0.6 times of average lux level specified (i.e $E_{min}/E_{av} > 0.6$). The maintenance factor for indoor illumination design shall be considered as 0.8 and 0.62 shall be considered for outdoor lighting. The surface reflectance for ceiling/wall/floor shall be 50/30/10.

Lighting in all indoor areas shall be done by CFL & fluorescent energy efficient based low power consumption luminaries and HPSV type for outdoor areas to achieve desired lux level specified.

13.2.2 Receptacles

All receptacles shall be suitable for fixing on wall or column and complete with individual switch
Appropriate socket-outlet shall be installed near each Power and Distribution transformers for connecting mobile oil treatment equipment.

General purpose and welding sockets outlets for maintenance shall be distributed in the whole Substation area. The distance between two sockets shall not be greater than 30 meters.

Type Of Receptacle	Description	Detail Of Outgoing Feeders
RO	Outdoor	15A, 240V, Receptacle 2 pole, 3- pin type
RP	Outdoor for oil filtration of transformer	63A, 415V, Interlocked switch socket, receptacle
RI	Indoor	5/15A, 240V, Receptacle 3-pin type (Modular)

All switches and receptacles shall be flush type and shall be capable to carry a continuous current to the rated capacity. Corresponding plug shall be furnished for every installed receptacle plus 10 pieces for spares.

13.3 Description of Works

The illumination works shall consist of outdoor substation lighting, control building lighting and roads lighting, lighting for staff quarters, existing store, gate post etc. All lighting fixtures shall be energy efficient type.

13.3.1 Outdoor Substation Lighting

The outdoor substation lighting shall consist of lighting of the area covered by substation equipment, access road, and substation compound lighting.

Substation outdoor equipment and area lighting

Lighting fixture shall be of outdoor, flood light type, symmetrical beam spread of not less than 2x30° with built-in ballast. The housing shall be die cast aluminium and the reflector shall be high-grade aluminium. A cast aluminium doorframe shall be designed for easy replacement of lamp. The front glass shall be heat & shock resistance with the gasket for jet proof and dust proof sealing.

The lamps shall be of sodium vapour, 400/250 watts, 230 volts and shall have minimum luminous flux of 20,000 lumens with 16,000 hour service life.

The ballast shall be high efficiency electronic type and shall be used with 400/250 watts lamp, 230 volts, 50 hertz. The ballast shall be electrically designed to ensure very low operating temperature and low wattage losses.

The wiring cable shall be of armoured single core, directly burial and shall be installed underground or laid in the cable trench except those rising along the steel structures shall be run in conduits.

Access Road Lighting

Street lighting of sub-station shall be done by “solar photovoltaic street lighting system (SLS)” to achieve the desired lux level specified. Solar lighting system consists of solar photovoltaic (SPV) module, a luminaire, storage battery, control electronics inter-connecting wires/ cables, module mounted pole including hardware and battery box.
The luminaire is based on CFL or HPSV.
In addition to Solar lighting, all street lighting shall also be connected with normal lighting power supply system. A suitable changeover arrangement shall be provided in each street pole to switchover to normal lighting in case of prolonged outage of solar grid.

The diffuser shall be vandal-proof and shall be ultra violet radiation and heat resistance. The fixture shall be rainproof and insect tight. All metal parts shall be made of non corrosive material.

The lamp shall be of sodium vapour, 250 watts, 230 volts and shall have minimum luminous flux of 11,000 lumens with 16,000 hour service life.

The ballast shall be of high efficiency electronic type and shall be used with 250 watts lamp, 230 volts, 50 hertz. The ballast shall be electrically designed to ensure very low operating temperature and low wattage losses.

The wiring cable shall be of armoured single core, directly buried and shall be installed underground or laid in the cable trench except those rising along the steel structures shall be run in conduits.

Building (Indoor) Lighting

Unless described herein, the control building lighting design shall conform to Illuminating Engineering Society, National Electrical Code and National Electrical Manufactures Association Standard.

All normal lighting fixtures of control building shall be of CFL type with granulated acrylic diffuser complete with all accessories. All lighting fixtures installed on the ceiling covered by false ceiling shall be recessed. Lighting fixtures shall conform to the Standard for Electric Lighting Fixtures or other internationally accepted standards.
All lighting fixtures for store shall be fluorescent type, whereas lighting fixtures for staff quarters and gate post shall be CFL type.

All lighting fixtures for store building shall be fluorescent type, whereas lighting fixtures for staff quarters and gate post shall be CFL of LED type.

13.4 Lighting Panels

The lighting panel shall conform to NEMA Standard requirements. All over-current protective devices shall be Moulded Case Circuit Breaker (MCCB) or Miniature Circuit Breakers (MCB).
The outdoor control panel shall be galvanised or enamel painted steel cabinet, outdoor type. The over current protective devices shall be of MCCB or MCB. The ON-OFF operation of outdoor lighting shall be both manual and automatic control (with photo-switch). The arrangement of lighting branch circuits shall be reliable and easy maintenance.

13.5 Cable and Raceway

All wiring cable shall be of single core and shall run in conduits.

13.6 Grounding

All lighting panels, junction boxes, fixtures conduits etc. shall be grounded in compliance with the provision of relevant standard or local statutory requirements.
All electrical equipment shall be effectively grounded. The ground wire shall not be less than 1.5 mm^2 copper for fixtures and 4 mm^2 copper for Panel.

13.7 Information to be Furnished

After award of the contract the contractor shall submit detail design of the illumination system. The fixtures shall be satisfactory to the Employer and shall be energy efficient.

The contractor shall submit detailed indoor and outdoor lighting calculation for reaching the above Lux level including surface illumination diagram at varying equipment surface levels, detailed drawing showing the lighting layout and lighting distribution wiring diagram, receptacles, switches and lighting panels for Employer's approval during detailed engineering.

Bidder shall confirm the Lux levels at different locations by measurement.
Bidder shall provide all necessary foundations and / or supporting structures for all outdoor and indoor areas.

All rectification, repairs or adjustment work found necessary during inspection, testing and commissioning shall be carried out by the bidder, without any extra cost to the Employer.
The Bidder along with the Employer shall measure the actual lux level in all the areas of the substations to prove compliance to the specification.

13.8 Tests

The entire illumination system operation shall be tested on completion of the works in presence of the Employer. The tests shall include but not limited to measurement of intensity of light.
During Test, if it is observed that illumination level in any area is lower than the specified value, the contractor will rectify the same at his own cost.

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SECTION - 14

CABLING SYSTEM

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14 CABLING SYSTEM

14.1 General

This specification covers the design, manufacture, factory test, supply, delivery, installation, field-testing and commissioning of all Power, Control, Communication and Instrumentation cables required for the entire project.

14.2 Codes and Standards

HV Cables shall comply as a minimum with the below mentioned standards.

IEC : 60059	:	Recommended current ratings for Cables
IEC : 60332	:	Tests on Electric Cables under fire conditions.
IEC-754 (Part-I)	:	Test on gases evolved during combustion of Electric Cables.
IEEE-383	:	Standard for type test of Class IE Electric Cables.
ASTM-D -2843	:	Standard test method for density of smoke from the burning or decomposition of plastics.
ASTM-D-2863	:	Standard method for measuring the minimum oxygen concentration to support candle like combustion of plastics.

14.3 132 kV Cables

a) General

The 132 kV power cable shall be of single-core, cross-linked polyethylene (XLPE) insulated, aluminium or lead sheathed, copper conductor type and shall have a conductor size of not less than 800 sq mm. The conductor shall be provided with a shielding of semi-conducting tape and/or extruded semi-conducting material. The aluminium or lead sheath shall be covered with an oversheath for anti-corrosion protection, which shall be of continuous extrusion of insulating grade general purpose semi-harden black polyvinyl chloride (PVC).

The power cables shall be rated as follows:

The rated voltage	132 kV
Highest voltage of three-phase system	145 kV
Rated lightning impulse withstand voltage	650 kV (crest)
Rated power-frequency short duration withstand Voltage for one minute	275 kV
Maximum short-circuit current	25 kA
Maximum time for short-circuit current	2 seconds

The aluminium sheath or lead sheath with copper wire screen of the cable shall be capable of carrying the line-to-ground fault current of 25 kA for two seconds.

b) Conductor / sheath

Conductor shall consist of stranded annealed copper wires. They shall comply with IEC Publication. The maximum temperature for the power cable shall be less than the following value:

S.N		Continuous Rating	Short-Time rating	Short-Circuit rating
a)	Conductor	90° C	105° C	250° C
b)	Sheath	-	-	150° C

c) Sealing ends

The following number of the sealing-ends shall be supplied and installed for termination of the 132 kV XLPE power cables at respective ends:

1) Three (3) bushing type for each circuit 132 kV bus connection at the switchyard.

2) Three (3) bushing type for each circuit for dead-end tower side of the transmission line.

The outdoor sealing end at switchyard as well as at the dead-end tower side shall be mounted on steel structures, which shall be supplied under the Contract.

The Tenderer shall offer the state-of-the-art type sealing-ends.

Each sealing-ends shall be complete with porcelain or epoxy insulator, leading conductor, condenser cone, stress relief cone, insulating substances, shielding cover, protective case, grounding terminal, lower metal with rigid flange and other necessary materials to properly seal the cable terminals.

Thermal expansion and contraction of the cable due to temperature changes shall be considered for designing the joint insulation of the sealing-end.

The minimum creepage distance of outdoor sealing-ends shall be as required for heavily polluted atmospheres in line with the IEC 137 standard.

The current rating of the cable terminal shall match the relevant feeder bay rating.

Terminations for cable shall be provided in sufficient quantities for complete installations of all works under the scope.

d) Anti-Termite Covering

Anti-termite protection shall be applied to the cable and shall be black PVC suitable for the operating temperature of cable and shall meet the requirements of IEC standards.

e) Outer Covering

The outer covering of the cable shall be extruded, continuous black PVC suitable for the operating temperature of cable and shall meet the requirements of IEC standards.

f) Cable Drum

Cable drum shall be non- returnable and shall be made of timber, pressure impregnated against fungal and insect attack. Alternatively, cable drum may be made of steel, suitably protected against corrosion.

g) Jointing Accessories

Cables shall be installed in maximum possible lengths and straight-through jointing between shorter lengths will not permitted without the prior written approval of the Employer.

h) Accessories

The following accessories shall be provided with the 132 kV power cable for each end.

i) Name plates
ii) Phase Identification

Phase identification for conductor cables shall be in accordance with the following:

Phase A (R): Red
Phase B (Y): Yellow
Phase C (B): Blue

iii) Voltage Identification

The plastic covering shall be embossed with the name of the manufacturer, number of conductors, the cross sections, and type of insulation followed by:

Electric cable - (Corresponding) volts

iv) Connecting terminals with bolts
v) Fuse boxes
vi) Grounding terminals (95 sq.mm x 2)

i) Spare parts

a) Two (2) set of complete outdoor sealing-ends with bushing and terminals.

b) One (1) lot of necessary materials for repair for four times.

c) One (1) set of spares as recommended by the manufacturer, excluding those mentioned above.

j) Test

The following tests shall be carried out at manufacturer's plant before shipment:

a) <u>132 kV XLPE power cable</u>

i) Appearance check

ii) Conductor resistance

iii) Capacitance

iv) Insulation resistance, Insulation

v) – do.- , Over-sheath

vi) A.C. withstand voltage, Insulation

vii) – do.- , Over-sheath

viii) A.C. long duration withstand voltage, Insulation

ix) Impulse withstand voltage, Insulation

x) – do.- , Over-sheath

xi) A.C. long duration breakdown voltage, Insulation

xii) Impulse breakdown voltage, Insulation

xiii) – do.- , Over-sheath

xiv) Dielectric loss tangent

xv) – do.- , temperature-voltage characteristic

xvi) Dimension

- Core inside diameter
- Core thickness
- Insulation thickness
- Sheath thickness
- Over-sheath thickness
- Thickness of each tape
- Interval of tape lapping
- Total diameter

xvii) Bending withstand characteristic

xviii) Over-sheath, tensile strength

xix) – do.- , terminal aging

xx) – do.- , oil-proof

xxi) – do.- , non-inflammability

xxii) – do.- , thermal deformation

xxiii) – do.- , hardness

b) Sealing ends

i) Conductor resistance

ii) A.C. long duration withstand voltage

iii) Impulse withstand voltage

iv) A.C. long duration breakdown voltage

v) Impulse breakdown voltage

vi) Porcelain or epoxy insulator, construction

vii) – do - , power frequency flash-over voltage(dry)

viii) – do - , power frequency flash-over voltage(wet)

ix) – do - , 50% impulse flash-over voltage

x) – do - , cantilever strength

xi) – do - , thermal mechanical performance.

14.4 33 kV Cables

(a) General

The rated voltage of the power cables shall be 36 kV.

The power cable shall be cross-linked polyethylene insulated, screened and steel tape armoured.

The scope of works shall include the supply and connection of 33 kV power cables from power transformer secondary to the 33 kV new incomer at Pangtan substation. The cables shall be supplied with necessary terminations and accessories for both connecting ends.

b) Conductor

Conductor for power cable shall consist of stranded annealed copper wires. They shall comply with IEC Publication.

c) Cable Rating

The minimum current rating for the cable and conditions of installation shall be as follows:

i) For transformer incomer, the continuous current rating of the cable shall not be less than 240 Sq.mm, single Core cable.

ii) The fault current for 1 sec. shall not be less than 25 kA.

d) Anti-Termite Covering

Anti-termite protection shall be applied to the cable and shall be black PVC suitable for the operating temperature of cable and shall meet the requirements of IEC standard.

e) Outer Covering

The outer covering of the cable shall be extruded, continuous black PVC suitable for the operating temperature of cable and shall meet the requirements of IEC standard.

f) Cable Drum

Cable drum shall be non- returnable and made of steel suitably protected against corrosion.

g) Outdoor and Indoor Termination

33 kV cable terminations shall be of the heat-shrinkable type / pre-moulded push on type. Terminations for cable shall be provided in sufficient quantities for complete installations of all works under the scope. The cost of all necessary termination kits shall be included in the price of the cables.

h) Jointing Accessories

Cables shall be installed in maximum possible lengths and straight-through jointing shall not be permitted without the prior written approval of the Employer.

i) Voltage Identification

The plastic covering shall be embossed with the name of the manufacturer, number of conductors, the cross sections, type of insulation followed by:

Electric cable - (Corresponding) volts

j) Phase Identification

Phase identification for either triplex or multi-core conductor cable shall be in accordance with the following:

Phase A (R) : Red

Phase B (Y) : Yellow

Phase C (B) : Blue

14.5 11 kV Cables

14.5.1 Design Requirement

11 kV cable shall be used for connection between 33/11 kV distribution transformer & 11 kV Switchgear and between 11 kV switchgear and 11 kV pole foe connection with 11 kV distribution line.

The main characteristics of the 11 kV cables shall be as follows:

- Rated Voltage : 17/10kV
- Conductors : Multi stranded annealed copper
- Conductor Screen : Extruded Semi-conducting
- Insulation : Cross-linked polyethylene (XLPE)
- Insulation Screen : Extruded Semi-conducting + Copper tape
- Inner sheath : PVC
- Armour : hard drawn aluminium round wire
- Outer sheath : PVC, black colour, FRLS, rodent protected

- Fire behavior : Flame retardant category according to IEC 60332.

The cables shall be suitable for laying on racks, in ducts, trenches, conduits.

Cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses develop under steady state and transient operating conditions.

XLPE insulation shall be suitable for continuous conductor temperature of 90 deg. C and short circuit conductor temperature of 250 deg C.

Outer sheath shall be of PVC black in colour and shall have the following FRLS properties.

- Oxygen index of min. 29 (to ASTMD 2863)
- Acid gas emission of max. 20% (to IEC-754-I).
- Smoke density rating shall not be more than 60% during Smoke Density Test as per ASTMD-2843.

All cables shall meet the fire resistance requirement with cable installations made in accordance with 'Flammability Test' and as per Category-B of IEC 332 Part -3.

For 11 kV Cables, the cross-sectional area of the metallic screen strip/tape shall be considered in design calculations. Metallic screen along with the armour shall be able to carry ground fault current.

Following sizes of 11 kV cables shall be used.

a) For connection between distribution transformer & 11 kV switchgear - single core 400 mm^2 copper,
b) For connection between 11 kV switchgear & 11 kV poles - three core 240 mm^2 copper.

Cable lengths shall be considered to ensure that straight through cable joints are avoided.

14.5.2 General Technical Requirements

The conductor having a semi conducting screen shall ensure perfectly smooth profile and avoid stress concentration. The conductor screen shall be extruded in the same operation as the insulation; the semi-conducting polymer shall be cross linked for XLPE cables.

The insulation of the cable shall be extruded type and shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method should give a very smooth interface between semi conducting screen and insulation.

In XLPE cables, to confine electrical field to the insulation, a non-magnetic semi-conducting shield shall be put over the insulation. The insulation shield shall be extruded in the same operation as the conductor shield and the insulation by triple extrusion/process. The XLPE cable insulation shield shall be strippable. Over semi conducting screen a metallic screening (copper tape) shall be provided.

The inner sheath shall be suitable to withstand the site conditions and the desired temperature. It shall be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects. PVC sheath shall be extruded.

Hard drawn aluminum wire armouring shall be used for single core cable.

The hard drawn aluminium wire for armour shall be of H4 grade, as per IS 8130 (having tensile strength above 150 N/mm2). The diameter of the aluminium wire shall be as per the table for the dimensions of the galvanized steel wire armour given in the relevant standard.
Extruded PVC serving as per IS: 5831 or as specified otherwise shall be applied over the armouring with suitable additives to prevent attach by rodent and termites. All serving must be given anti-termite protection.

Anti-termite protection shall be applied to the cable and shall consist of either a non-magnetic metallic barrier or layer of nylon sheathing.

Each cable shall have a printed legend on the overall jacket with the manufacturer's name, voltage class, the number and size of conductors, type of insulation etc.

14.6 Low Voltage Power Cables

14.6.1 General

Low voltage AC power systems will be solidly grounded neutral with phase to phase voltage level of 400 V and phase to neutral voltage of 230V AC and the DC system with 110V, ungrounded and 48 V DC .

The main characteristics of the low-voltage cables shall be as follows:

- Rated voltage : 0.6/1 kV
- Conductors : Multi stranded annealed copper
- Insulation : Cross-linked polyethylene (XLPE)
- Inner sheath : PVC
- Armour : Galvanized steel
- Outer sheath : PVC, black colour, FRLS, , rodent protected
- Fire behavior : flame retardant category according to IEC 60332.

Power cables will have a minimum cross section of 2.5 mm² for lighting and 4 mm² for power. The main (incomer) cable to AC distribution panel shall be three & half (3.5) core and not less than 150 mm^2.

14.6.2 Design Requirement

The cables shall be suitable for laying on racks, in ducts, trenches, conduits.

Conductor shall consist of stranded annealed copper wires. They shall comply with relevant IEC publication. XLPE insulation shall be suitable for continuous conductor temperature of 90 deg. C and short circuit conductor temperature of 250 deg C.

Cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses develop under steady state and transient operating conditions.

Outer sheath shall be of PVC black in colour. Outer sheath of all the cables shall have the following FRLS properties.

- Oxygen index of min. 29 (to ASTMD 2863)
- Acid gas emission of max. 20% (to IEC-754-I).
- Smoke density rating shall not be more than 60% during Smoke Density Test as per ASTMD-2843.

All cables shall meet the fire resistance requirement with cable installations made in accordance with ‘Flammability Test’ and as per Category-B of IEC 332 Part -3.

Selection & sizing of power cables shall be based on the following considerations.

- Rated current of the connected equipment
- The voltage drop in the cable, during motor starting condition, shall be limited to 10% and during full load running condition, shall be limited to 3% of the rated voltage
- Short circuit withstand capability
- De-rating Factors : De-rating factors for various conditions of installations including the following shall be considered while selecting the cable sizes:

a) Variation in ambient temperature for cables laid in air
b) Grouping of cables
c) Variation in ground temperature and soil resistivity for buried cables.

Cable lengths shall be considered to ensure that straight through cable joints are avoided.

14.6.3 General Technical Requirements

a) Conductor

Conductor shall consist of stranded annealed copper wires. They shall comply with IEC publication. The cable is intended for use at normal conductor operating temperatures not exceeding 75 degree C.

b) Insulation

The electrically and thermally stable XLPE insulation shall be extruded onto the conductor so as to prevent contamination and voids in the insulation.

c) Current Rating

The Contractor shall state the maximum continuous current rating and conditions of installation for low voltage power cables.

d) Jacket

The cable core assembly shall be covered with a flame-retardative and moisture resistant PVC jacket, which is free stripping from the insulation. The overall jacket shall be clean, dry, and free of grease and shall be suitable for ink or paint application.

Anti-termite protection shall be applied to the cable and shall consist of either a non-magnetic metallic barrier or layer of nylon sheathing.

e) Identification

Each cable shall have a printed legend on the overall jacket with the manufacturer's name, voltage class, the number and size of conductors, type of insulation etc.

The colors for core identification and color sequence shall be in accordance with follows.

- Single core : Black
- Twin core : Red and black
- Three core : Red, yellow and blue
- Three & half / Four core : Red, yellow, blue and black

14.7 Control and Instrumentation Cable

a) General

All control and instrumentation cable shall be 0.1 kV grade as per IEC standard, multi conductor, color-coded, PVC insulated armored cable. Each multicore cable shall have not less than 20 percent or 2 spare cores, whichever is the greater.

b) Conductor

Copper conductor shall be stranded circular non compacted cross section of minimum 2.5 sq.mm. The Contractor shall calculate the load of CT core considering all connected loads and submit to the employer for approval. In case of CT burden constrain, CT circuit cable cross sectional area shall be increased. In this case

the Contractor shall supply and install the cable required cross section area without any additional cost to the Employer.

c) Insulation

The electrically and thermally stable PVC insulation shall be extruded onto the conductor so as to prevent contamination and voids in the insulation.

d) Assembly

Multi core conductor cables shall be assembled in accordance with applicable IEC standards.

A flame-retardant binder tape may be used underneath the overall jacket of multi conductor cables, if required, to achieve the desired flame retardant characteristics. Tapes, if used, shall be non-hygroscopic.

e) Jacket

The cable core assembly shall be covered with a flame retardant and resistant jacket, which is free stripping from the insulation.

The overall jacket shall be clean, dry, and free of grease and shall be suitable for ink or paint application.
Cable jacketing and the interstices within the jacket shall be free of water. Evidence of water shall be the ground for rejection of the cable.

Anti Termite Covering: Anti termite protection shall be applied to the cable and shall consist of either a non magnetic metallic barrier or layer of nylon sheathing.

f) Identification

Each cable shall have a printed legend on the overall jacket, with the manufacturer's name, voltage class, the number and size of conductors, and a unique number or code indicating the production run or batch. The identification shall remain legible for the life of the cable.

14.8 Communication Cable

All cables and wiring shall have copper conductors and PVC insulation and shall comply with IEC standards.
Each communication cable shall have not less than 20 percent or 4 spare twisted pairs whichever is the greater. Cabling and wiring installations shall be arranged to minimize the risk of fire and damages, which might be caused in the event of fire.

For telephone type cables, 2 conductor wires of not less than 0.6 mm dia shall be used. Where twin or quad make up is required in any cable, the cores shall be uniformly twisted and the lays arranged such that cross talk is reduced to a minimum.

No conductor smaller than 32/0.2 mm (1 mm2), or having less than three strands, shall be used for interconnecting the cables except in the case of telephone extensions. All cables shall have insulation, which will withstand the highest temperature to be experienced in service.

Each conductor of a multicore cable shall be readily identified by a numbered marker tape or, in the case of telephone type cables, color coded insulation.

14.9 Cable Tags & Marker

Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.
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 Gl wire.

Conforming to IS: 280. Cable tags shall be of rectangular shape for power cables and of circular shape for control cables.

Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanized iron plate. Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable joints". 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.
Cable tags shall be provided on all cables at each end Gust 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.

14.10 Cable Termination and Connections

The termination and connection of cables shall be done strictly in accordance with cable and termination kit manufacturer's instructions, drawing and or as per instruction of the Employer.

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.

The Contractor shall tag/ferrule control cable cores at all terminations, as instructed by the Employer. 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.

Spare cores shall be similarly tagged with cable numbers and coiled up.

Double compression type nickel plated (coating thickness not less than 10 microns) brass cable glands shall be provided by the Bidder for all power and control cables to provide dust and weather proof terminations.

The cable glands shall conform to BIS: 6121. They shall comprise of heavy duty brass casting, machine finished and nickel plated, to avoid corrosion and oxidation.

Cable lugs shall be tined copper solder less crimping type conforming to IS-8309 & 8394. Bimetallic lugs shall be used depending upon type of cables used.

14.11 Installation of Cables

In general all power and control cables shall be in the cable trenches. In addition to the above, for lighting purpose also, cable trench can be used in outdoor area as far as possible.

Cabling in the Switchgear/control room shall also be done on ladder type cable trays.

For cables laid in conduits in out door area, conduits of 50 mm nominal outside diameter of class 4 as per IS 4985 shall be used, 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.

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.

- Power cables on top tiers.
- Control instrumentation and other service cables in bottom tiers.

Single core cables in trefoil formation shall be laid with a distance of three times the diameter of cable between trefoil centre lines. Power cables from station transformer to main ACDB shall be laid with a minimum centre to centre distance equal to twice the diameter of the cable.

Power and control cables shall be securely fixed to the trays/supports with self locking type nylon ties with the interlocking facility at every 5 meter interval for horizontal run. Vertical and inclined cable runs shall be secured with 25 mm wide and 2 mm thick aluminium strip clamp at every 2m.

Cables shall not be bent below the minimum permissible limit.

Where cables cross roads, drains, these shall be laid in reinforced spun concrete or steel pipes buried at not less than one meter depth.

14.12 Cable Trays

Cable trays shall be used in control building and other areas within substation and within cable trenches outside substation area. The cable trays shall be of GS sheet and minimum thickness of sheet shall be2 mm. cable trays shall have 2.5 meter straight section and 150, 300 mm and 600 mm wide

14.13 Conduits, Pipes and Duct Installation

Bidder 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. The size of the conduit/pipe shall be selected on the basis of 40% fill criterion.
Embedded conduits shall have a minimum concrete cover of 50 mm.

Size of conduit for lighting shall be selected by the Bidder during detailed engineering.

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.

Conduit shall be installed in such a way as to ensure against trouble from trapped condensation.

FO cables shall be laid in galvanised steel (GS) conduits within cable trenches keeping proper clearance with HV cables

14.14 Special Requirements

The Contractor shall be responsible for estimating and supplying the quantity of various types and sizes of the cables. In course of actual execution, if it is found that additional cross sections, types or quantities of cables are required for the completion of the specified works the same shall be supplied without any additional charge to the employer.

Small cut piece lengths of cables will not be accepted. Cables up to 500 meters in length or as approved by Employer shall be of one length shipped in a drum of adequate size. For higher quantities, multiple lengths/drums may be shipped subject to the approval of Employer.

14.15 Drawings, Data & Manuals

The following information shall be furnished along with the bid.

a) Manufacturer's leaflets giving constructional details, dimensions and characteristics of different cables.
b) Current rating of cables including de-rating factor due to grouping, ambient temperature and type of various installation.

14.16 Tests

14.16.1 Routine and Design Tests

Power cable shall be subjected to following routine tests. As far as practical, the procedure of IEC shall be followed:

a) Measurement of the electrical resistance of conductor
b) Partial discharge test
c) Voltage test

14.16.2 Design Test

The power cable design tests shall include following:

a) Partial discharge test
b) Bending test, followed by a partial discharge test
c) Tan delta measurement
d) Heating cycle test, followed by a partial discharge test
e) Impulse test, followed by voltage test
f) Voltage test for 4 hours.

The Bidder shall submit type test report as specified in section-2 of this specification for the offered power cable along with the bid.

14.16.3 Field Tests

After installation at Site, cables shall be subjected but not limited to the following tests:

a) Continuity test
b) Measurement of insulation resistance
c) DC dielectric test

14.17 Performance Guarantee

The performance figures quoted on schedule of Technical Data shall be guaranteed within the tolerance permitted by relevant standards and shall become part of the Contract. In case of failure of the cables to meet the guarantees, the Employer reserves the right to reject the item. The Contractor shall have to rectify/replace the defect/defective part at no extra cost to the Employer and without delaying the commissioning schedule.

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SUBSTATION AUTOMATION SYSTEM

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CHAPTER 15: SUBSTATION AUTOMATION SYSTEM

1.0 GENERAL

1.1. The substation automation system shall be offered from a manufacturer who must have designed, manufactured, tested, installed and commissioned substation automation system.

1.2. The Substation Automation System (SAS) shall be installed to control and monitor all the sub-station equipment from remote control centre (RCC) as well as from local control centre.

The SAS shall contain the following main functional parts:

- Bay control Intelligence Electronic Devices (IEDs) for control and monitoring.
- IEC 61850 compatible Bay control and protective relays (IEDs)
- Redundant Human Machine Interface (HMI) and DR work Station
- Redundant managed switched Ethernet Local Area Network communication infrastructure with hot standby.
- Gateway for remote control via industrial grade hardware through (MCC) on IEC60870-5-104 protocol
- Gateway for remote supervisory control (to RLDC), the gateway should be able to communicate with LDC on IEC 60870-5-101 protocol. Protocol converter should be used wherever required to match to existing communication system installed at MCC to be located at Baneshwor Substation.
  The specific protocol to be implemented is enclosed as Appendix-I.. It shall be the bidder's responsibility to integrate his offered system with existing system for exchange of desired data. The requirement of IO point shall be worked out by the bidder as per criterion enclosed as Appendix-II for data exchange with LDCs.
- Remote HMI.
- Industrial grade peripheral equipment like printers, display units, key boards, Mouse, terminal equipment for communication link etc. with necessary furniture.

1.3. It shall enable local station control via a PC by means of human machine interface (HMI) and control software package, which shall contain an extensive range of supervisory control and data acquisition (SCADA) functions. It shall include communication gateway, intelligent electronic devices (IED) for bay control and inter IED communication infrastructure. An architecture drawing for SAS is enclosed.

1.4. The communication gateway shall facilitate the information flow with Master control center. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions.

1.5. The point to point testing of all signals from switchyard equipment terminal to substation controller shall be in the scope of bidder.

2. **System design**

The SAS shall be designed as a common integrated system enabling local substation control and monitoring, protection relay management and remote control from the Main/Backup Control Centre.

The SAS shall provide complete control and monitoring system of the electrical substation by means of modern HMI facilities, replacing fully conventional station level and voltage level control boards/panels.
The SAS from the Control / Monitoring Structure point of view shall be designed as multilevel control system including:

1. Bay Control Level from local Bay Computer or Protection HMI
2. Station Control Level from Operator HMI (Level 2)
3. SCADA/Supervisory Control Level from SCC or ECC (Level 3)

2.1 General system design

The Substation Automation System (SAS) shall be suitable for operation and monitoring of the complete substation including future extensions as given in Chapter 1 - GTS.

The systems shall be of the state-of-the art suitable for operation under electrical environment present in substations, follow the latest engineering practice, ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

The offered SAS shall support remote control and monitoring from Remote Control centres (MCC) via gateways.

The system shall be designed such that personnel without any background knowledge in Microprocessor-based technology are able to operate the system. The operator interface shall be intuitive such that operating personnel shall be able to operate the system easily after having received some basic training.

The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signalling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records.

Maintenance, modification or extension of components may not cause a shutdown of the whole substation automation system. Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

Bidder shall offer the Bay level unit (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer), bay mimic along with relay and protection panels and PLCC panels (described in other sections of technical specifications) housed in air-conditioned *Panel Room* suitably located and Station HMI in Control Room building for overall optimisation in respect of cabling and control room building..

2.2 System architecture

The SAS shall be based on a decentralized architecture and on a concept of bay-oriented, distributed intelligence.

Functions shall be decentralized, object-oriented and located as close as possible to the process.

The main process information of the station shall be stored in distributed databases. The typical SAS architecture shall be structured in two levels, i.e. in a station and a bay level.

At bay level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The IEDs should be directly connected to the switchgear without any need for additional interposition or transducers.

Each bay control IED shall be independent from each other and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station.

The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fibre-optic cables, thereby

guaranteeing disturbance free communication. The fibre optic cables shall be run in GI / HDPE conduit pipes. Data exchange is to be realised using IEC 61850 protocol with a redundant managed switched Ethernet communication infrastructure

The communication shall be made in fault tolerant ring in redundant mode, excluding the links between individual bay IEDs to switch wherein the redundant connections are not envisaged, such that failure of one set of fiber shall not affect the normal operation of the SAS. However failure of fiber shall be alarmed in SAS. Each fiber optic cable shall have four (4) spare fibers

At station level, the entire station shall be controlled and supervised from the station HMI. It shall also be possible to control and monitor the bay from the bay level equipment at all times.

Clear control priorities shall prevent operation of a single switch at the same time from more than one of the various control levels, i.e. RCC, station HMI, bay level or apparatus level. The priority shall always be on the lowest enabled control level.

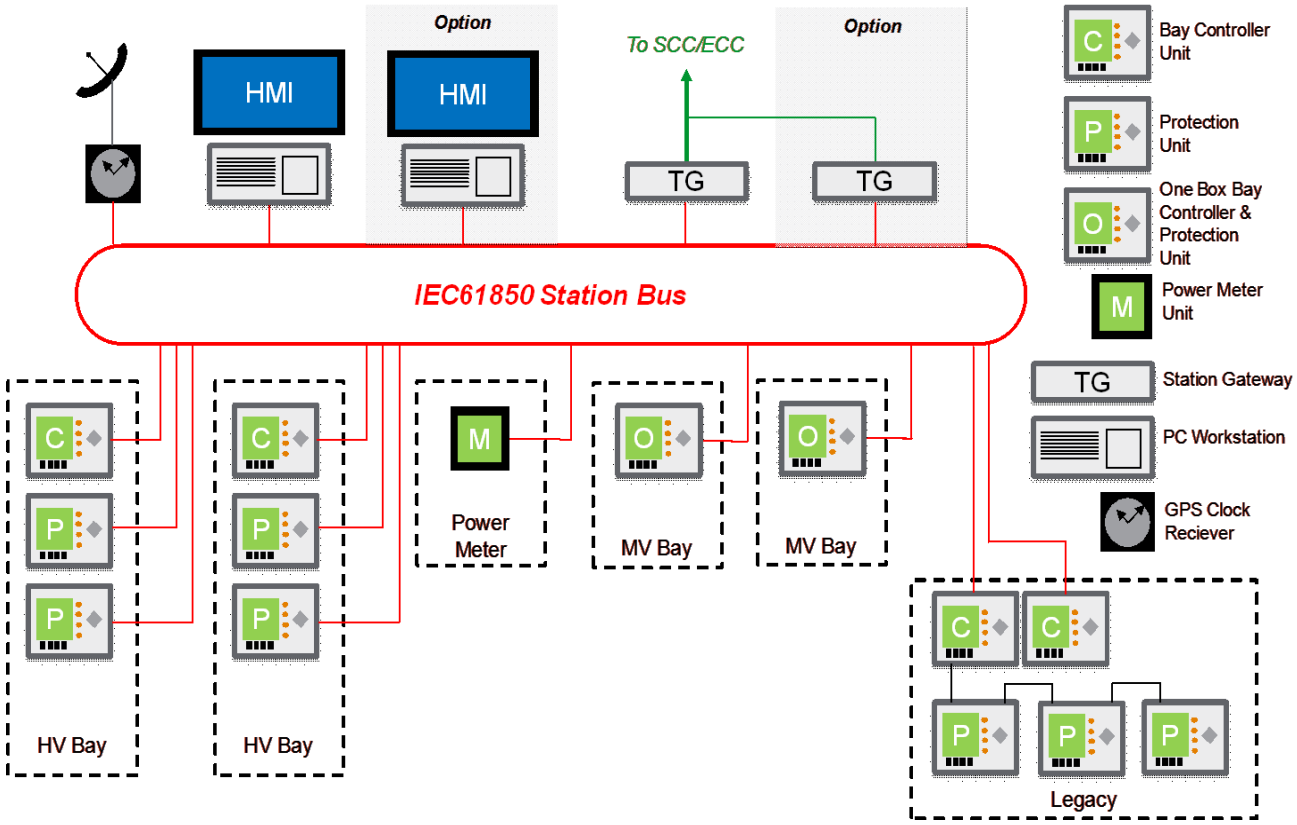
The station level contains the station-oriented functions, which cannot be realised at bay level, e.g. alarm list or event list related to the entire substation, gateway for the communication with remote control centres.

The GPS time synchronising signal (as specified in the section relay & protection) for the synchronization of the entire system shall be provided.

The SAS shall contain the functional parts as described in para 1.2 above.

In addition of above the SAS shall also include but not limited to following:

- A series of standard bays panels interconnected by an open protocol. A standard bay panel contains all the IEDs needed for the local control and protection of the bay. A bay is a feeder, a transformer, a coupler, a capacitor bank, a diameter or a Common Services Bay. Each bay has a local/remote switch enabling or disabling the local control.
- A Telecontrol Gateway even redundant, providing the interface between the substation and the remote control centre. It is active when the substation is in remote mode. The protocol is IEC 60870-5-101 or IEC 608670-5-104.
- An Operator interfaces (HMI), providing the local supervision and control of the substation, sequence of events, archiving, printing, engineering, SAS maintenance and data analysis. It is active when the substation is in local. This operator interface can be duplicated locally or remotely. Remotely it may be accessed from an Internet browser.
- Optional data concentrators, even redundant, providing the interface between legacy field bus communicating IED's and the IEC61850 substation bus. The protocols are serial or TCP/IP versions for IEC 60870-5, DNP3.0 and Modbus.
- A Local Area Network infrastructure so-called, interconnecting all station equipment, enabling their communication using the IEC61850-8-1 protocol.



The SAS shall be bay oriented, i.e.:

- Addition of a new feeder or transformer shall be an easy operation from a configuration and manufacturing point of view (copy of an existing model). The system interlocking shall be done by the mean of a topological interlocking, using the topology and expert rules to authorise or inhibit the switchgear operation. All these data will be exchanged between involved IED using the standard IEC61850 GOOSE or equivalent procedures.
- Each bay has an autonomous behaviour, i.e. local control and interlocking, sequence of events, etc. It is connected to other bays by logical means for system wide functions, such as interlocking or Busbar protection, but can have a downgraded mode with complete protection and control of the local bay.
- Each IED shall have its own integrated Ethernet switch.

i) FUNCTIONAL REQUIREMENTS

The high-voltage apparatus within the station shall be operated from different places:

- Remote control centres
- Station HMI.
- Local Bay controller IED (in the bays)

Operation shall be possible by only one operator at a time.

The operation shall depend on the conditions of other functions, such as interlocking, synchro-check, etc. (see description in"Bay level control functions").

2.3.1 Select-before-execute

For security reasons the command is always to be given in two stages: selection of the object and command for operation under all mode of operation except emergency operation. Final execution shall take place only when selection and command are actuated.

2.3.2 Command supervision

Bay/station interlocking and blocking

Software Interlocking is to be provided to ensure that inadvertent incorrect operation of switchgear causing damage and accidents in case of false operation does not take place.

In addition to software interlocking hardwired interlocking are to be provided for:

(a) Bus Earth switch Interlocking

(b) Transfer Bus interlocking (if applicable)

It shall be a simple layout, easy to test and simple to handle when upgrading the station with future bays. For software interlocking the bidder shall describe the scenario while an IED of another bay is switched off or fails.

A software interlock override function shall be provided which can be enabled to bypass the interlocking function.

2.3.3 Run Time Command cancellation

Command execution timer (configurable) must be available for each control level connection. If the control action is not completed within a specified time, the command should get cancelled.

2.3.4 Self-supervision

Continuous self-supervision function with self-diagnostic feature shall be included.

2.3.5 User configuration

The monitoring, controlling and configuration of all input and output logical signals and binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely.

It shall also be possible to interconnect and derive input and output signals, logic functions, using built-In functions, complex voltage and currents, additional logics (AND-gates, OR gates and timers). (Multi-activation of these additional functions should be possible).

The Functional requirement shall be divided into following levels:

a. Bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer) Level Functions

b. System Level Functions

3.1. Bay level functions

In a decentralized architecture the functionality shall be as close to the process as possible. In this respect, the following functions can be allocated at bay level:

- Bay control functions including data collection functionality in bay control/protection unit.
- Bay protection functions

Separate IEDs shall be provided for bay control function and bay protection function.

3.1.1. Bay control functions

3.1.1.1. Overview

Functions

- Control mode selection
- Select-before-execute principle
- Command supervision:
  - Interlocking and blocking
  - Double command
- Synchrocheck, voltage selection
- Run Time Command cancellation
- Transformer tap changer control (Raise and lower of tap) (for power transformer bays)
- Operation counters for circuit breakers and pumps
- Hydraulic pump/ Air compressor runtime supervision
- Operating pressure supervision through digital contacts only
- Breaker position indication per phase
- Alarm annunciation
- Measurement display
- Local HMI (local guided, emergency mode)
- Interface to the station HMI.
- Data storage for at least 200 events
- Extension possibilities with additional I/O's inside the unit or via fibre-optic communication and process bus

3.1.1.2. Control mode selection

Bay level Operation:

As soon as the operator receives the operation access at bay level the operation is normally performed via bay control IED. During normal operation bay control unit allows the safe operation of all switching devices via the bay control IED.

EMERGENCY Operation

It shall be possible to close or open the selected Circuit Breaker with ON or OFF push buttons even during the outage of bay IED**.**

REMOTE mode

Control authority in this mode is given to a higher level (Remote Control Centre) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

3.1.1.3. Synchronism and energizing check

The synchronism and energizing check functions shall be bay-oriented and distributed to the bay control and/or protection devices. These features are:

- Settable voltage, phase angle, and frequency difference.
- Energizing for dead line - live bus, live line - dead bus or dead line – dead bus with no synchro-check function.

- Synchronising between live line and live bus with synchro-check function

Voltage selection

The voltages relevant for the Synchro check functions are dependent on the station topology, i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronizing and energizing is derived from the auxiliary switches of the circuit breakers, the isolator, and earthing switch and shall be selected automatically by the bay control and protection IEDs.

3.1.1.4. Transformer tap changer control

Raise and lower operation of OLTC taps of transformer shall be facilitated through Bay controller IED.

3.1.2. Bay protection functions

3.1.2.1. General

The protection functions are independent of bay control function. The protection shall be provided by separate protection IEDs (numerical relays) and other protection devices as per section Relay & Protection.

IEDs, shall be connected to the communication infrastructure for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.

Event and disturbance recording function

Each IED should contain an event recorder capable of storing at least 200 time-tagged events. The disturbance recorder function shall be as per detailed in Chapter 15 – Control, Relay & Protection Panels.

3.1.2.2. **Bay Monitoring Function:**

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated in the Bay control/protection unit.

3.2. System level functions

3.2.1. Status supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, transformer tap changer etc., shall be supervised continuously. Every detected change of position shall be immediately displayed in the single-line diagram on the station HMI screen, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in the case of spontaneous position changes.

The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.

The SAS shall also monitor the status of sub-station auxiliaries. The status and control of auxiliaries shall be done through separate one or more IED and all alarm and analogue values shall be monitored and recoded through this IED.

3.2.2. Measurements

The analogue values acquired/calculated in bay control/protection unit shall be displayed locally on the station HMI and in the control centre. The abnormal values must be discarded. The analogue values shall be updated every 2 seconds.

Threshold limit values shall be selectable for alarm indications.

3.2.3. Event and alarm handling

Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All, or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time-tagged with a time resolution of 1 ms. The tentative list for various feeders and systems are enclosed as Annexure-I

3.2.4. Station HMI

3.2.4.1. Substation HMI Operation:

On the HMI the object has to be selected first. In case of a blocking or interlocking conditions are not met, the selection shall not be possible and an appropriate alarm annunciation shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object.

Control operation from other places (e.g. REMOTE) shall not be possible in this operating mode.

3.2.4.2. Presentation and dialogues

General

The operator station HMI shall be a redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear on the screen via mouse clicks.

The HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log.

An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from any screen selected by the operator.

The following standard pictures shall be available from the HMI:

- Single-line diagram showing the switchgear status and measured values
- Control dialogues with interlocking or blocking information details. This control dialogue shall tell the operator whether the device operation is permitted or blocked**.**
- Measurement dialogues
- Alarm list, station / bay-oriented
- Event list, station / bay-oriented
- System status

3.2.4.3. HMI design principles

Consistent design principles shall be adopted with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

The object status shall be indicated using different status colours for:

- Selected object under command

- Selected on the screen
- Not updated, obsolete values, not in use or not sampled
- Alarm or faulty state
- Warning or blocked
- Update blocked or manually updated
- Control blocked
- Normal state

3.2.4.4. Process status displays and command procedures

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap-changers shall be displayed in the station single-line diagram.

In order to ensure a high degree of security against undesired operation, a "select-before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen, and all other switchgear shall be blocked. As communication between control centre and device to be controlled is established, the operator shall be prompted to confirm the control action and only then final execute command shall be accepted**.** After the "execution" of the command the operated switching symbol shall flash until the switch has reached its new position.

The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level.

After command execution the operator shall receive a confirmation that the new switching position has been reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

3.2.4.5. System supervision & display

The SAS system shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are recorded as a faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication infrastructure and remote communication links, and printers at the station level, etc.

3.2.4.6. Event list

The event list shall contain events that are important for the control and monitoring of the substation.

The event and associated time (with1 ms resolution) of its occurrence has to be displayed for each event.

The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.

A printout of each display shall be possible on the hard copy printer.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer for at least one month. The information shall be obtainable also from a printed event log.

The chronological event list shall contain:

- Position changes of circuit breakers, isolators and earthing devices

- Indication of protective relay operations
- Fault signals from the switchgear
- Indication when analogue measured values exceed upper and lower limits. Suitable provision shall be made in the system to define two level of alarm on either side of the value or which shall be user defined for each measurands.
- Loss of communication.

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

- Date and time
- Bay
- Device
- Function e.g. trips, protection operations etc.
- Alarm class

3.2.4.7. Alarm list

Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control center. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated.

The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

- The date and time of the alarm
- The name of the alarming object
- A descriptive text
- The acknowledgement state.

Whenever an alarm condition occurs, the alarm condition must be shown on the alarm list and must be displayed in a flashing state along with an audible alarm. After acknowledgement of the alarm, it should appear in a steady (i.e. not flashing) state and the audible alarm shall stop. The alarm should disappear only if the alarm condition has physically cleared and the operator has reset the alarm with a reset command. The state of the alarms shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent).

Filters for selection of a certain type or group of alarms shall be available as for events.

3.2.4.8. Object picture

When selecting an object such as a circuit breaker or isolator in the single-line diagram, the associated bay picture shall be presented first. In the selected object picture, all attributes like

- Type of blocking
- Authority
- Local / remote control
- RSCC / SAS control
- Errors
- etc.,

shall be displayed.

3.2.4.9. Control dialogues

The operator shall give commands to the system by means of mouse click located on the single-line diagram. Data entry is performed with the keyboard. Dedicated control dialogues for controlling at least the following devices shall be available:

- Breaker and disconnector
- Transformer tap-changer

3.2.5. User-authority levels

It shall be possible to restrict activation of the process pictures of each object (bays, apparatus...) within a certain user authorisation group. Each user shall then be given access rights to each group of objects, e.g.:

- Display only
- Normal operation (e.g. open/close of switchgear)
- Restricted operation (e.g. by-passed interlocking)
- System administrator

For maintenance and engineering purposes of the station HMI, the following authorisation levels shall be available:

- No engineering allowed
- Engineering/configuration allowed
- Entire system management allowed

The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

3.2.6. Reports

The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise:

- Trend reports:
    - Day (mean, peak)
    - Month (mean, peak)
    - Semi-annual (mean, peak)
    - Year (mean, peak)
- Historical reports of selected analogue Values:
    - Day (at 15 minutes interval)
    - Week
    - Month
    - Year

It shall be possible to select displayed values from the database in the process display on-line. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.

Following printouts shall be available from the printer and shall be printed on demand:

i. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.

ii. Weekly trend curves for real and derived analogue values.

iii. Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.

iv. Provision shall be made for logging information about breaker status like number of operation with date and time indications along with the current value it interrupts (in both condition i.e. manual opening and fault tripping)

v. Equipment operation details shift wise and during 24 hours.

vi. Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each feeder and transformer as well as Tap Positions, temperature and status of pumps and fans for transformers.

vii. Printout on adjustable time period as well as on demand system frequency and average frequency.

viii. Reports in specified formats which shall be handed over to successful bidder. The bidder has to develop these reports. The reports are limited to the formats for which data is available in the SAS database.

3.2.7. Trend display (historical data)

It shall be possible to illustrate all types of process data as trends - input and output data, binary and analogue data. The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen. Adjustable time span and scaling ranges must be provided.

It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

3.2.8. Automatic disturbance file transfer

All recorded data from the IEDs with integrated disturbance recorder as well as dedicated disturbance recording systems shall be automatically uploaded (event triggered or once per day) to a dedicated computer and be stored on the hard disc.

3.2.9. Disturbance analysis

The PC-based work station shall have necessary software to evaluate all the required information for proper fault analysis.

3.2.10. IED parameter setting

It shall be possible to access all protection and control IEDs for reading the parameters (settings) from the station HMI or from a dedicated monitoring computer. The setting of parameters or the activation of parameter sets shall only be allowed after entering a password.

3.2.11. Automatic sequences

The available automatic sequences in the system should be listed and described, (e.g. sequences related to the bus transfer). It must be possible to initiate pre-defined automatic sequences by the operator and also define new automatic sequences.

3.3. Gateway

Gateway offered shall be of reputed make with modular structure & high availability. The Gateway provided for the above system shall be rack mounted. LED indications should be provided on the front of the cards to know the status of communication by looking at the front of the communication card. The Gateway shall also support PLC programming for future controls at complied are stipulated hereunder.

Technical Parameters of Gateway

1.	Power supply	: 230V+/-10V,50 HzAC
2.	Processor Type	: Intel Pentium D 820 Processor, 2.8 GHz or Higher Standard L2 2MB, 800 MHz front side bus
3.	Chipset	: INTEL 945 GC chipset :. :
4.	Memory Type	: DDR2-Synch DRAM PC2-5300 @ 667 MHz
5.	Standard memory	4GB
6.	Memory slots	2 DIMM
7.	Hardware monitoring	: System Monitor (fan, temp., Voltage)
8.	Memory upgrade	: Expandable
9.	Internal hard disk drive	: 160 GB
10.	Hard disk drive speed	: 7200 rpm
11.	Protocols capabilities	: IEC 61850, IEC 69870-5-101/104, Modbus
13.	Chassis type	: Industrial Rack mount BP chassis
14.	Video adapter, bus	: PCI Express ™X16
16.	Audio	: Integrated Audio with External speakers & Microphone
17.	Network Interface	: Integrated 10/100/1000 Gigabit Fast Ethernet-WOL, Dual RJ-45 with Two LED indicators
25.	Antivirus s/w	: Registered standard latest Anti-virus software

3.3.1 Communication Interface

The Substation Automation System shall have the capability to support simultaneous communications with multiple independent remote master stations,

The Substation Automation System shall have communication ports as follows:
(a) Two ports for Remote Control Centre
(b) Two ports for Regional System Coordination Centre (RSCC)

The communication interface to the SAS shall allow scanning and control of defined points within the substation automation system independently for each control centre. The substation automation system shall simultaneously respond to independent scans and commands from employer's control centres (MCC & RLDC). The substation automation system shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to each remote control centre. Also, each control centre's data scan and control commands may be different for different data points within the substation automation system's database.

The SAS shall also allow all necessary S/S data (which are very important to monitor by RLDC for whole system study) transfer to LDC main communication system. There may require

typical protocol converter depending upon LDC RTU system.

i. Remote Control Centre (MCC) Communication Interface

Employer will supply communication channels between the Substation Automation System and the remote control centre. The communication channels provided by Employer will consist either of power line carrier, microwave, optical fibre, VSAT or leased line, the details of which shall be provided during detailed Engineering.

ii. **Interface equipment:**

The Contractor shall provide interface equipment for communicating between Substation Automation system and Remote control centre and between Substation Automation system and Regional System Coordination Centre (RSCC). However, the communication channels available for this purpose are specified in Chapter 1 - GTS.

In case of PLCC communication any modem supplied shall not require manual equalization and shall include self-test features such as manual mark/space keying, analogue loop-back, and digital loop-back. The modems shall provide for convenient adjustment of output level and receive sensitivity. The modem should be stand alone complete in all respects including power supply to interface the SAS with communication channel. The configuration of tones and speed shall be programmable and maintained in non-volatile memory in the modem. All necessary hardware and software shall also be in the scope of bidder.

iii. Communication Protocol

The communication protocol for gateway to control centre must be open protocol and shall support IEC 60870-5-101 and IEC 61850 for all levels of communication for sub-station automation such as Bay to station HMI, gateway to remote station etc.

The telecontrol gateway shall interface up to 5 telecontrol centres, each with a possible link redundancy. It maintains a database per control centre.

The gateway shall be able to send to the remote control centre, but not limited to:

- Single point indication with time.
- Double point indication with time.
- Transformer tap position with time.
- Measurement value with time.
- Integrated total (counters).
- Disturbance record files.

The gateway shall be able to receive from the control centre:

- Single control, either direct or as a select/execute sequence.
- Double control, either direct or as a select/execute sequence.
- Interrogation command on a group of data.
- Clock synchronisation.
- Counter freeze.

- Taking control. This facility allows a remote control point to force the mode of the substation from LOCAL to REMOTE and to define on which port the SCADA controls must be accepted.

TG shall comply with Cyber Security function as described in specification.

4.0 System hardware:

4.1 Redundant Station HMI, Remote HMI and Disturbance Recorder Work station:

The contractor shall provide redundant station HMI in hot standby mode. The servers used in these work stations shall be of industrial grade**.**

It shall be capable to perform all functions for entire substation including future requirements as indicated in the SLD. It shall use industrial grade components. Processor and RAM shall be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used. Supplier shall demonstrate these features.

The capacity of hard disk shall be selected such that the following requirement should occupy less than 50% of disk space:

1. Storage of all analogue data (at 15 Minutes interval)and digital data including alarm , event and trend data for thirty(30) days,
2. Storage of all necessary software,
3. 40GB space for OWNER'S use.

Supplier shall demonstrate that the capacity of hard disk is sufficient to meet the above requirement.

4.1.1 HMI (Human Machine Interface)

The VDU shall show overview diagrams (Single Line Diagrams) and complete details of the switchgear with a colour display. All event and alarm annunciation shall be selectable in the form of lists. Operation shall be by a user friendly function keyboard and a cursor positioning device. The user interface shall be based on WINDOWS concepts with graphics & facility for panning, scrolling, zooming, decluttering etc.

4.1.2 Visual Display Units/TFT's (Thin Film Technology)

ii) The display units shall have high resolution and reflection protected picture screen. High stability of the picture geometry shall be ensured. The screen shall be at least 21" diagonally in size and capable of colour graphic displays.

iii) The display shall accommodate resolution of 1280 X 1024 pixels.

4.1.3 Printer

It shall be robust & suitable for operation with a minimum of 132 characters per line. The printing operation shall be quiet with a noise level of less than 45 dB suitable for location in the control room. Printer shall accept and print all ASCII characters via master control computer unit interface.

The printer shall have in built testing facility. Failure of the printer shall be indicated in the Station HMI. The printer shall have an off line mode selector switch to enable safe maintenance. The maintenance should be simple with provisions for ease of change of print

head, ribbon changing, paper insertion etc.

All reports and graphics prints shall be printed on laser printer. One dot matrix printer shall be exclusively used for hourly log printing.

All printers shall be continuously online.

4.1.4 Mass Storage Unit

The mass storage unit shall be built-in to the Station HMI. All operational measured values, and indications shall be stored in a mass-storage unit **in form** of **DVD RW** The unit should support at least Read (48X), Write(24X), and Re-Write (10X) operations, with Multi-Session capability. It should support ISO9660, Rockridge and Joliet Filesystems. It should support formatting and use under the operating system provided for Station HMI. The monthly back up of data shall be taken on disc. The facility of back up of data shall be inherent in the software**.**

4.1.5 Switched Ethernet Communication Infrastructure:

The bidder shall provide the redundant switched optical Ethernet communication infrastructure for SAS. One switch shall be provided to connect all IEDs for two bays of 220kV yard to communication infrastructure. Each switch shall have at least two spare ports for connecting bay level IEDs and one spare port for connecting station bus.

4.2 Bay level unit

The bay unit shall use industrial grade components. The bay level unit, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select-before-operate control principles as safety measures for operation via the HMI. They shall perform all bay related functions, such as control commands, bay interlocking, data acquisition, data storage, event recording and shall provide inputs for status indication and outputs for commands. They shall be directly connected to the switchgear. The bay unit shall acquire and process all data for the bay (Equipment status, fault indications, measured values, alarms etc.) and transmit these to the other devices in sub-station automation system. In addition, this shall receive the operation commands from station HMI and control centre. The bay unit shall have the capability to store all the data for at least 24 hours.

One number Bay level unit shall be provided for supervision and control of each 220 kV bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer). The Bay level unit shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All bay level interlocks are to be incorporated in the Bay level unit so as to permit control from the Bay level unit/ local bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out of service.

The bay control unit to be provided for the bays shall be preferably installed in the CB relay panel/feeder protection panel for respective bay.

The bay control unit for future bay (if required as per Chapter 1 – Project Specification Requirement) shall be installed in a separate panel.

The Bay level unit shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 61850. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.

4.2.1 Input/Output (I/O) modules

iv) The I/O modules shall form a part of the bay level unit and shall provide coupling to the substation equipment. The I/O modules shall acquire all switchgear information (i.e. data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear. The measured values of voltage and current shall be from the secondaries of instrument transformers. The digital inputs shall be acquired by exception with 1 ms resolution. Contact bouncing in digital inputs shall not be assumed as change of state

Technical Parameters of BCU: It is a minimum requirement, the contractor shall demonstrate the adequacy of the capacity provided.

1. Power supply:	110 VDC, + 15%, Power consumption: < 15W Ripple (peak to peak): < 12%
2. Protocol Capabilities:	Ethernet based communication: Dual on ¬Board with dual I.P. addresses on IEC-61850 & upgradeable in future.
3. Binary Input processing	: Hardwired Digital Input should be acquired via digital boards or IED connected by a serial link. Software Digital Input coming from configurable relays & other devices with 1 ms time tagging. Support GOOSE mode digital boards or IED connected by a serial link. Software Digital Input coming from configurable relays & other devices with 1 ms time tagging. Support GOOSE mode.
4. Analogue Input processing	: 110V for Voltage inputs, 1A & 5A for Current inputs and transducer (4-20 mA) inputs for station auxiliaries should process measurements received through the communication network with 16-bit resolution.
5. Measured value acquisition	: Monitoring of calculated four CT & four PT/CVT direct primary measures.
6. Derived values	: From the direct primary measures: RMS currents & voltages, network frequency active power, reactive power, apparent power, Power factor, Phase angles,
7. Digital Outputs	: DO used for switching device in field or inside C/R via digital boards, should also configurable & contain security, interlocks etc.
8. Sub-station/bay	: Should use logical equation and pre defined Inter-locking rules & sub-station topology for operation.
9. Trip Circuit Supervision	: Supervise trip circuits for both the conditions of Breaker.
10. Event Logging	: Storage of events up to 2000 in ROM.
11. Disturbance files & record of wave forms	: Five records of waveforms and disturbance files stored and accessible by HMI/DR work Station.
12. Gateway support	: Should interface with Gateway for Remote Control facility.
13. Local control, Operation	: Local control & Operation should be possible and Display using backlit LCD Display and keypad of BCU.
14. Self-monitoring	: Power ON and continuous cyclic self-monitoring tests. Abnormality result should be displayed.
15. I/O processing	: As per our required I/O list with 20% extra for Capacities each bay.
16. Internal Ethernet	: 4 X 10/100 Base T (RJ-45) ports+2X10/100 Base Switches Fx (optical) ports for redundant Ethernet network.
17. Additional ports	: 1 X RS232 and 3 X RS485 can support IEC 103 Modbus, should be s/w configurable.
19. Mounting & design	: Rack fitting with modular design.

4.3 Switchyard Panel Room:

The switchyard panel room shall be constructed to house Bay level units, bay mimic, relay and

protection panels, PLCC panels etc.. The layout of equipment/panel shall be subject to Owner's approval. The switchyard panel room shall be provided with necessray illuminations, fire alarm system with at least two detectors with necessary power supply if required and it shall be wired to SAS. The detailed constructional requirement of switchyard panel room is detailed in chapter 14 civil of technical specification and air conditioning requirement of switchyard panel room shall be as detailed in chapter 10 Air conditioning system of technical specification. The air conditioner provided in switchyard panel room shall be monitored from substation automation system.

4.4 Extendibility in future

Offered substation automation system shall be suitable for extension in future for additional bays. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the employer. During such event, normal operation of the existing substation shall be unaffected and system shall not require a shutdown. The contractor shall provide all necessary software tools along with source codes to perform addition of bays in future and complete integration with SAS by the user. These software tools shall be able to configure IED, add additional analogue variable, alarm list, event list, modify interlocking logics etc. for additional bays/equipment which shall be added in future.

- The SAS must be able to have a 30% expansion in term of bays and 20% configurable I/O s within the bays. This reserved capacity shall be used without any additional hardware such as CPU, I/O Cards and Terminal Blocks etc.
- The SAS components (HMI, TG, Bays) must have the capability to manage at least two configuration databases, in order to enable fast and secure system extension. At a given instant only one database shall be active on each component. The dual database shall be activate from the HMI when changing the system configuration.
- The SAS must be able to integrate in the future new IEDs on IEC 61850.The SAS must be able to support future SCL standard (IEC61850-6) for its configuration.

5.0 Software structure

The software package shall be structured according to the SAS architecture and strictly divided in various levels. Necessary firewall shall be provided at suitable points in software to protect the system. An extension of the station shall be possible with lowest possible efforts. Maintenance, modification or an extension of components of any feeder may not force a shut-down of the parts of the system which are not affected by the system adaptation.

5.1.1 Station level software

1. Human-machine interface (HMI)

The base HMI software package for the operator station shall include the main SAS functions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. Systems shall contain a library with standard functions and applications.

5.1.2 Bay level software

5.1.1.1 System software

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. The lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance engineer for

modifications. The system shall support the generation of typical control macros and a process database for user specific data storage. In case of restoration of links after failure, the software along with hardware shall be capable of automatically synchronising with the remaining system without any manual interface. This shall be demonstrated by contractor during integrated system test.

2. Application software

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They form part of a library.

The application software within the control/protection devices shall be programmed in a functional block language.

3. Network Management System (NMS):

The contractor shall provide a network management system software for following management functions:

a. Configuration Management
b. Fault Management
c. Performance Monitoring

This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in DR work-station and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any fault in the monitored devices. The NMS shall

(a) Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports.
(b) Maintain a graphical display of SAS connectivity and device status.
(c) Issue alarms when error conditions occurs
(d) Provide facility to add and delete addresses and links

4. The contractor shall provide each software in two copies in CD to load into the system in case of any problem related with Hardware/Communication etc.

Cyber-security

The cyber security features shall improve the overall quality of the system and improve the reliability and the availability of operations by securing the access of each device and providing an audit capability. The solution should be based on IEC62351, IEC62443-3-3, and NERC-CIP Vendors shall be certified for Bronze Level Practice Certification (IEC62443-2-4).

6.0 TESTS

The substation automation system offered by the bidder shall be subjected to following tests to establish compliance with IEC 61850 for EHV sub-station equipment installed in sheltered area in the outdoor switchyard and specified ambient conditions:

6.1 Type Tests:

6.1.1 Control IEDs and Communication Equipment:

a. Power Input:
- i. Auxiliary Voltage
- ii. Current Circuits
- iii. Voltage Circuits
- iv. Indications

b. Accuracy Tests:
- i. Operational Measurd Values
- ii. Currents
- iii. Voltages
- iv. Time resolution

c. Insulation Tests:
- i. Dielectric Tests
- ii. Impulse Voltage withstand Test

d. Influencing Quantities
- i. Limits of operation
- ii. Permissible ripples
- iii. Interruption of input voltage

e. Electromagnetic Compatibility Test:
- i. 1 MHZ. burst disturbance test
- ii. Electrostatic Discharge Test
- iii. Radiated Electromagnetic Field Disturbance Test
- iv. Electrical Fast transient Disturbance Test
- v. Conducted Disturbances Tests induced by Radio Frequency Field
- vi. Magnetic Field Test
- vii. Emission (Radio interference level) Test.
- viii. Conducted Interference Test

f. Function Tests:
- i. Indication
- ii. Commands
- iii. Measured value Acquisition
- iv. Display Indications

g. Environmental tests:
- i. Cold Temperature
- ii. Dry Heat
- iii. Wet heat
- iv. Humidity (Damp heat Cycle)
- v. Vibration
- vi. Bump
- vii. Shock

6.2 Factory Acceptance Tests:

v) The supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual bay level IED's applicable type test certificates shall be submitted**.**

The manufacturing and configuration phase of the SAS shall be concluded by the factory acceptance test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the user. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated

in a test lab. During FAT the entire Sub-station Automation System including complete control and protection system to be supplied under present scope shall be tested for complete functionality and configuration in factory itself. The extensive testing shall be carried out during FAT. The purpose of Factory Acceptance Testing is to ensure trouble free installation at site. No major configuration setting of system is envisaged at site.

If the complete system consists of parts from various suppliers or some parts are already installed on site, the FAT shall be limited to sub-system tests. In such a case, the complete system test shall be performed on site together with the site acceptance test (SAT).

6.2.1 Hardware Integration Tests:

vi) The hardware integration test shall be performed on the specified systems to be used for Factory tests when the hardware has been installed in the factory. The operation of each item shall be verified as an integral part of system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software integration and factory testing of the system. The equipment expansion capability shall also be verified during the hardware integration tests. The vendor specifically demonstrates how to add a device in future in SAS during FAT. The device shall be from a different manufacturer than the SAS supplier.

6.2.2 Integrated System Tests:

Integrated system tests shall verify the stability of the hardware and the software. During the tests all functions shall run concurrently and all equipment shall operate a continuous 100 Hours period. The integrated system test shall ensure the SAS is free of improper interactions between software and hardware while the system is operating as a whole.

6.3 Site Acceptance Tests:

The site acceptance tests (SAT) shall completely verify all the features of SAS hardware and software. The bidder shall submit the detailed SAT procedure and SAT procedure shall be read in conjunction with the specification.

7.0 SYSTEM OPERATION

7.1 Substation Operation

7.1.1 NORMAL OPERATION

Operation of the system by the operator from the remote RCC or at the substation shall take place via industry standard HMI(Human Machine interface) subsystem consisting of graphic colour VDU , a standard keyboard and a cursor positioning device (mouse).

The coloured screen shall be divided into 3 fields :

i) Message field with display of present time and date
ii) Display field for single line diagrams
iii) Navigation bar with alarm/condition indication

For display of alarm annunciation, lists of events etc a separate HMI View node shall be provided.

All operations shall be performed with mouse and/or a minimum number of function keys and cursor keys. The function keys shall have different meanings depending on the operation. The operator shall see the relevant meanings as function tests displayed in the command field (i.e. operator prompting). For control actions, the switchgear (i.e. circuit breaker etc.) requested shall be selectable on the display by means of the cursor keys. The switching element selected shall then appear on the background that shall be flashing in a different color. The operator prompting shall distinguish between:-

- Prompting of indications e.g. fault indications in the switchgear, and

- prompting of operational sequences e.g. execution of switching operations

The summary information displayed in the message field shall give a rapid display of alarm/message of the system in which a fault has occurred and alarm annunciation lists in which the fault is described more fully.

Each operational sequence shall be divided into single operation steps which are initiated by means of the function keys/WINDOW command by mouse. Operator prompting shall be designed in such a manner that only the permissible keys are available in the command field related to the specific operation step. Only those switching elements shall be accessed for which control actions are possible. If the operation step is rejected by the system, the operator prompting shall be supported by additional comments in the message field. The operation status shall be reset to the corresponding preceding step in the operation sequence by pressing one of the function keys. All operations shall be verified. Incorrect operations shall be indicated by comments in the message field and must not be executed.

The offer shall include a comprehensive description of the system. The above operation shall also be possible via WINDOWS based system by mouse.

8.0 POWER SUPPLY

Power for the substation automation system shall be derived from substation 220V DC system. 2No.s of Inverter of minimum 2KVA capacity shall be provided for servers, gateways station HMI disturbance recorder evaluation unit and its peripheral devices e.g. printer etc. In the event of Power failure, necessary safeguard software shall be built for proper shutdown. Inverter shall be connected to 220V DC independent source and should be used to drive 1No. each server/HMI/Gateway so that in case any failure of DC power supply system is not affected.

9.0 DOCUMENTATION

The following documents shall be submitted for employer's approval during detailed engineering:

(a) System Architecture Drawing
(b) Hardware Specification
(c) Functional Design Document
(d) Clear procedure describing how to add an IED/bay/diameter in future covering all major supplier

The following documentation to be provided for the system in the course of the project shall be consistent, CAD supported, and of similar look/feel. All CAD drawings to be provide in "dxf" format.

- List of Drawings
- Substation automation system architecture

- Block Diagram
- Guaranteed technical parameters, Functional Design Specification and Guaranteed availability and reliability
- Calculation for power supply dimensioning
- I/O Signal lists
- Schematic diagrams
- List of Apparatus
- List of Labels
- Logic Diagram (hardware & software)
- **Switchyard Panel Room** layout drawing
- Control Room Lay-out
- Test Specification for Factory Acceptance Test (FAT)
- Product Manuals
- Assembly Drawing
- Operator's Manual
- Complete documentation of implemented protocols between various elements
- Listing of software and loadable in CD ROM
- Other documents as may be required during detailed engineering

Two sets of hard copy and Four sets of CD ROM containing all the as built documents/drawings shall be provided.

10.0 TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES

10.1 Training

Contractor personnel who are experienced instructors and who speak understandable English shall conduct training. The contractor shall arrange on its own cost all hardware training platform required for successful training and understanding in Nepal. The Contractor shall provide all necessary training material. Each trainee shall receive individual copies of all technical manuals and all other documents used for training. These materials shall be sent to Employer at least two months before the scheduled commencement of the particular training course. Class materials, including the documents sent before the training courses as well as class handouts, shall become the property of Employer. Employer reserves the right to copy such materials, but for in-house training and use only. Hands-on training shall utilize equipment identical to that being supplied to Employer.

The Contractor shall quote training prices as indicated in BPS.

The schedule, location, and detailed contents of each course will be finalized during Employer and Contractor discussions.

10.2 Computer System Hardware Course

A computer system hardware course shall be offered, but at the system level only. The training course shall be designed to give Employer hardware personnel sufficient knowledge of the overall design and operation of the system so that they can correct obvious problems, configure the hardware, perform preventive maintenance, run diagnostic programs, and communicate with contract maintenance personnel. The following subjects shall be covered:

(a) System Hardware Overview: Configuration of the system hardware.
(b) Equipment Maintenance: Basic theory of operation, maintenance techniques and diagnostic procedures for each element of the computer system, e.g., processors,

auxiliary memories, LANs, routers and printers. Configuration of all the hardware equipments.

(c) System Expansion: Techniques and procedures to expand and add equipment such as loggers, monitors, and communication channels.

(d) System Maintenance: Theory of operation and maintenance of the redundant hardware configuration, failover hardware, configuration control panels, and failover switches. Maintenance of protective devices and power supplies.

(e) Subsystem Maintenance: Theory of design and operation, maintenance techniques and practices, diagnostic procedures, and (where applicable) expansion techniques and procedures. Classes shall include hands-on training for the specific subsystems that are part of Employer's equipment or part of similarly designed and configured subsystems. All interfaces to the computing equipment shall be taught in detail.

(f) Operational Training: Practical training on preventive and corrective maintenance of all equipment, including use of special tools and instruments. This training shall be provided on Employer equipment, or on similarly configured systems.

10.3 Computer System Software Course

The Contractor shall provide a computer system software course that covers the following subjects:

(a) System Programming: Including all applicable programming languages and all stand-alone service and utility packages provided with the system. An introduction to software architecture, Effect of tuning parameters (OS software, Network software, database software etc.) on the performance of the system.

(b) Operating System: Including the user aspects of the operating system, such as program loading and integrating procedures; scheduling, management, service, and utility functions; and system expansion techniques and procedures

(c) System Initialization and Failover: Including design, theory of operation, and practice

(d) Diagnostics: Including the execution of diagnostic procedures and the interpretation of diagnostic outputs,

(e) Software Documentation: Orientation in the organization and use of system software documentation.

(f) Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

10.4 Application Software Course

The Contractor shall provide a comprehensive application software courses covering all applications including the database and display building course. The training shall include:

(a) Overview: Block diagrams of the application software and data flows. Programming standards and program interface conventions.

(b) Application Functions: Functional capabilities, design, and major algorithms. Associated maintenance and expansion techniques.

(c) Software Development: Techniques and conventions to be used for the preparation and integration of new software functions.

(d) Software Generation: Generation of application software from source code and associated software configuration control procedures.

(e) Software Documentation: Orientation in the organization and use of functional and detailed design documentation and of programmer and user manuals.

(f) Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

10.5 Requirement of training:

The contractor shall provide training for OWNER'S personnel comprehensively covering following courses.

S. No.	Name of Course
1	Computer System Hardware
2	Computer System Software
3	Application Software

11.0 Maintenance

11.1 Maintenance Responsibility during the Guaranteed Availability Period.

During Guaranteed Availability Period, the Contractor shall take continual actions to ensure the guaranteed availability and shall make available all the necessary resources such as specialist personnel, spare parts, tools, test devices etc. for replacement or repair of all defective parts and shall have prime responsibility for keeping the system operational. **During guarantee period as specified in tender document, contractor shall arrange bi-monthly visit of their representative to site to review the performance of system and in case any defect/shortcoming etc. is observed during the period, the same shall be set right by the contractor within 15 days.**

12.0 RELIABILITY AND AVAILABILITY

The SAS shall be designed so that the failure of any single component, processor, or device shall not render the system unavailable. The SAS shall be designed to satisfy the very high demands for reliability and availability concerning:

- Mechanical and electrical design
- Security against electromagnetic interference (EMI)
- High quality components and boards
- Modular, well-tested hardware
- Thoroughly developed and tested modular software
- Easy-to-understand programming language for application programming
- Detailed graphical documentation and application software
- Built-in supervision and diagnostic functions
- Security
  - Experience of security requirements
  - Process know-how
  - Select before execute at operation
  - Process status representation as double indications
- Distributed solution
- Independent units connected to the local area network
- Back-up functions
- Panel design appropriate to the harsh electrical environment and ambient conditions
- Panel grounding immune against transient ground potential rise

vii) Outage terms

1) Outage

The state in which substation automation system or a unit of SAS is unavailable for Normal Operation as defined in the clause 7.1 due to an event directly related to the SAS or unit of SAS. In the event, the owner has taken any equipment/ system other than Sub-station

Automation System for schedule/forced maintenance, the consequent outage to SAS shall not be considered as outage for the purpose of availability.

2) Actual outage duration (AOD)

The time elapsed in hours between the start and the end of an outage. The time shall be counted to the nearest $1/4^{th}$ of an hour. Time less than $1/4^{th}$ of an hour shall be counted as having duration of $1/4^{th}$ of an hour.

3) Period Hours (PH)

The number of hours in the reporting period. In a full year the period hour are 8760h (8784h for a leap year).

4) Actual Outage hours (AOH)

The sum of actual outage duration within the reporting period

$$AOH = \sum AOD$$

5) Availability:

Each SAS shall have a total availability of 99.98 % i.e. the ratio of total time duration minus the actual outage duration to total time duration.

12.1 Guarantees Required

The availability for the complete SAS shall be guaranteed by the Contractor. Bidder shall include in their offer the detailed calculation for the availability. The contractor shall demonstrate their availability guaranteed by conducting the availability test on the total sub-station automation system as a whole after commissioning of total Sub-station Automation system. The test shall verify the reliability and integrity of all sub-systems. Under these conditions the test shall establish an overall availability of 99.98%. After the lapse of 1000 Hours of cumulative test time, test records shall be examined to determine the conformance with availability criterion. In case of any outage during the availability test, the contractor shall rectify the problem and after rectification, the 1000 Hours period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.

The contractor has to establish the availability in a maximum period of three months from the date of commencement of the availability test.

After the satisfactory conclusion of test both contractor and employer shall mutually agree to the test results and if these results satisfy the availability criterion, the test is considered to be completed successfully. After that the system shall be taken over by the employer and then the guarantee period shall start.

13.0 Spares

13.1 Consumables:

All consumables such as paper, cartridges shall be supplied by the contractor till the SAS is taken over by the owner.

13.2 Availability Spares:

In addition to mandatory spares as listed in section project for SAS, the bidder is required to list the spares, which may be required for ensuring the guaranteed availability during the guaranteed availability period. The final list of spares shall form part of scope of supply and

accordingly the price thereof shall be quoted by the bidder and shall be considered in the evaluation of the bids. During the guaranteed availability period, the spare parts supplied by the Contractor shall be made available to the Contractor for usage subject to replenishment at the earliest. Thus, at the end of availability period the inventory of spares with the Employer shall be fully replenished by the Contractor. However, any additional spares required to meet the availability of the system (which are not a part of the above spares supplied by the Contractor) would have to be supplied immediately by the Contractor free of cost to the Employer.

14.0 LIST OF EQUIPMENTS

Quantity of equipments shall be decided by bidder in order to achieve guaranteed reliability and availability as declared by bidder.

i) Station HMI
ii) Redundant Station HMI (in Hot-stand by mode)
iii) Bay level units along with bay mimic as detailed in Chapter 1 – Project Specification Requirement.
iv) Bay Level Unit for Auxiliary system (as per requirement)
v) Disturbance Recorder Work Station(Maintenance HMI)
vi) Colour Laser Printer – 1 No. (For Reports & Disturbance records)
vii) Dot matrix printers - (one each for Alarms and log sheets)
viii) All interface equipment for gateway to RCC and RSCC
ix) Communication infrastructure between Bay level units, Station HMI, Printers, gateways, redundant LAN etc. as required
x) Remote workstation including HMI and along with one printer
xi) Modems as per requirement.
xii) Any other equipment as necessary.

List of Analogue and Digital Inputs

Basic Monitoring requirements are:

- Switchgear status indication
- Measurements (U, I, P, Q, f)
- Event
- Alarm
- Winding temperature of transformers & reactors
- ambient temperature
- Status and display of 400V LT system, 220V & 48V DC system
- Status of display of Fire protection system and Air conditioning system.
- Acquisition of all counters in PLCC panels through potential free contacts from PLCC or independently by counting the receive/send commands.
- Acquisition of alarm and fault record from protection relays
- Disturbance records
- Monitoring the state of batteries by displaying DC voltage, charging current and load current etc.
- Tap-position of Transformer

List of Inputs

The list of input for typical bays is as below:-

Analogue inputs

i) For line
Current R phase
Y phase
B phase
Voltage R-Y phase
Y-B phase
B-R phase

ii) For transformer/reactor
Current R phase
Y phase
B phase
WTI (for transformer and reactor)
Tap position (for transformer only)

iii) For TBC and bus coupler

Current R phase
Y phase
B phase

iv) Common

a) Voltage for Bus-I, Bus-II and Transfer bus wherever applicable

Voltage R-Y phase
Y-B phase

B-R phase

b) Frequency for Bus-I and Bus-II

c) Ambient temperature (switchyard)

d) Switchyard Panel Room Temperature.

e) LT system

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

Digital Inputs

The list of input for various bays/SYSTEM is as follows:

1. Line bays

i) Status of each pole of CB.
ii) Status of Isolator, Earth switch
iii) CB trouble
iv) CB operation/closing lockout
v) Pole discrepancy optd
vi) Trip coil faulty
vii) LBB optd
viii) Bus bar protn trip relay optd
ix) Main bkr auto recloser operated
x) Tie/transfer auto recloser operated
xi) A/r lockout
xii) Tie/transfer bkr a/r lockout
xiii) Direct trip-I/II sent
xiv) Direct trip-I/II received
xv) Main I/II blocking
xvi) Main I/II-Inter trip send
xvii) Main I/II-Inter trip received
xviii) O/V STAGE – I operated
xix) O/V STAGE – II operated
xx) FAULT LOCATOR FAULTY
xxi) MAIN-I/II CVT FUSE FAIL
xxii) MAIN-I PROTN TRIP
xxiii) MAIN-II PROTN TRIP
xxiv) MAIN-I PSB ALARM
xxv) MAIN-I SOTF TRIP

xxvi) MAIN-I R-PH TRIP
xxvii) MAIN-I Y-PH TRIP
xxviii) MAIN-I B-PH TRIP
xxix) MAIN-I START
xxx) MAIN-I/II Carrier aided trip
xxxi) MAIN-I/II fault in reverse direction
xxxii) MAIN-I/II ZONE-2 TRIP
xxxiii) MAIN-I/II ZONE-3 TRIP
xxxiv) MAIN-I/II weak end infeed optd
xxxv) MAIN-II PSB alarm
xxxvi) MAIN-II SOTF TRIP
xxxvii) MAIN-II R-PH TRIP
xxxviii) MAIN-II Y-PH TRIP
xxxix) MAIN-II B-PH TRIP
xl) MAIN-II start
xli) MAIN-II aided trip
xlii) MAIN-I/II fault in reverse direction
xliii) Back-up o/c optd
xliv) Back-up e/f optd
xlv) 220V DC-I/II source fail
xlvi) SPEECH CHANNEL FAIL
xlvii) PLCC Protection Channel-I FAIL
xlviii) PLCC Protection Channel-II FAIL

2. **Transformer bays**

viii) Status of each pole of CB, Isolator, Earth switch
ix) CB trouble
x) CB operation/closing lockout
xi) Pole discrepancy optd
xii) Trip coil faulty
xiii) LBB optd
xiv) Bus bar protn trip relay optd
xv) REF OPTD
xvi) DIF OPTD
xvii) OVERFLUX ALARM (MV)
xviii) OVERFLUX TRIP (MV)
xix) OVERFLUX ALARM (HV)
xx) OVERFLUX TRIP (HV)
xxi) HV BUS CVT ½ FUSE FAIL
xxii) MV BUS CVT ½ FUSE FAIL
xxiii) OTI ALARM/TRIP
xxiv) PRD OPTD
xxv) OVERLOAD ALARM
xxvi) BUCHOLZ TRIP
xxvii) BUCHOLZ ALARM
xxviii) OLTC BUCHOLZ ALARM
xxix) OLTC BUCHOLZ TRIP
xxx) OIL LOW ALARM
xxxi) back-up o/c (HV) optd
xxxii) back-up e/f (HV)optd
xxxiii) 220v DC-I/II source fail
xxxiv) TAP MISMATCH
xxxv) GR-A PROTN OPTD

xxxvi) GR-B PROTN OPTD
xxxvii) back-up o/c (MV) optd
xxxviii) back-up e/f (MV)optd

3. **Transformer bays**

i) Status of each pole of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty
vi) LBB optd
vii) Bus bar protn trip relay optd
viii) REF OPTD
ix) DIF OPTD
x) HV BUS CVT ½ FUSE FAIL
xi) OTI ALARM/TRIP
xii) PRD OPTD
xiii) BUCHOLZ TRIP
xiv) BUCHOLZ ALARM
xv) OIL LOW ALARM
xvi) Back-up impedance relay
xvii) 220v DC-I/II source fail
xviii) GR-A PROTN OPTD
xix) GR-B PROTN OPTD

4. Line/Bus Reactor bays (as applicable):

i) Status of each pole of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty
vi) LBB optd
vii) Bus bar protn trip relay optd
viii) REF OPTD
ix) DIF OPTD
x) Line/ BUS CVT ½ FUSE FAIL
xi) OTI ALARM/TRIP
xii) PRD OPTD
xiii) BUCHOLZ TRIP
xiv) BUCHOLZ ALARM
xv) OIL LOW ALARM
xvi) Back-up impedance relay
xvii) 220V DC-I/II source fail
xviii) GR-A PROTN OPTD
xix) GR-B PROTN OPTD

5 **Bus bar Protection**

i) Bus bar main-I trip
ii) Bus bar main-II trip
iii) Bus bar zone-I CT open
iv) Bus bar zone-II CT open

v) Bus transfer CT sup. Optd
vi) Bus transfer bus bar protn optd
vii) Bus protection relay fail

6. **Auxiliary system**

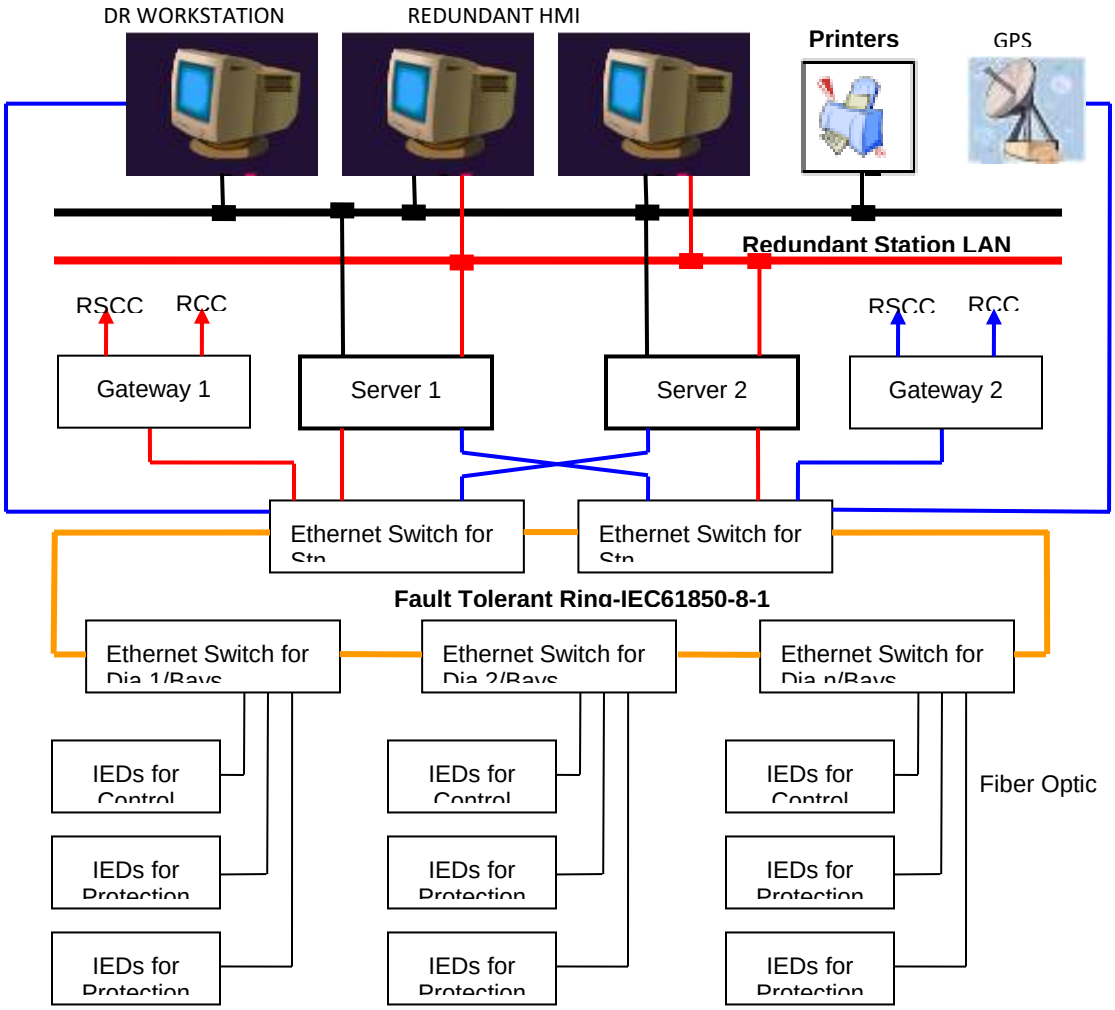
i) Incomer-I On/Off
ii) Incomer-II On/Off
iii) 400V Bus-I/II U/V
iv) 400V bus coupler breaker on/off
v) DG set bkr on/off
vi) Alarm/trip signals as listed in Section: DG set
vii) LT transformer-I Bunchholz Alarm & trip
viii) LT transformer-II Buchloz Alarm & trip
ix) LT transformer-I WTI Alarm & trip
x) LT transformer-II WTI Alarm & trip
xi) LT transformer-I OTI Alarm & trip
xii) LT transformer-II OTI Alarm & trip
xiii) PLCC exchange fail
xiv) Time sync. Signal absent
xv) Alarm/trip signals as listed in Section: Battery and Battery charger
xvi) 220V DC-I earth fault
xvii) 220V DC-II earth fault
xviii) Alarm/trip signals as listed in Section: Fire protection system

7. Switchyard Panel Room:

i) AC Compressor 1 ON/OFF
ii) AC Compressor 2 ON/OFF
iii) Fire Detection 1 ON/OFF
iv) Fire Detection 2 On/OFF
v) Switchyard Panel Room Temperature High Alarm

The exact number and description of digital inputs shall be as per detailed engineering requirement Apart from the above mentioned digital inputs, minimum of 200 inputs shall be kept for future use.

TYPICAL ARCHITECTURAL DRAWING OF SUBSTATION AUTOMATION SYSTEM



Note:

1. The redundant managed bus shall be realized by high speed optical bus using industrial grade components and shall be as per IEC 61850.
2. Inside the sub-station, all connections shall be realized as per IEC 61850 protocol.
3. For gateway, it shall communicate with Remote Supervisory Control Centre (RSCC) on IEC 60870-5-101 protocol.
4. The printer as required shall be connected to station bus directly and can be managed either from station HMI, HMI view node or disturbance recorder work station.
5. The above layout is typical. However if any contractor offers slightly modified architecture based on their standard practice without compromising the working, the same shall be subject to approval during detailed engineering.

(A) Applicable Standards

(B) Environment standard

All these standards are applicable to any PCMD elements (HMI, Ethernet network and elements, RTUs, IEDs).

Type Test Name	Type Test Standard	Conditions
Insulation Resistance	IEC 60255-5	100 MΩ at 500 Vdc (CM & DM)
Dielectric Withstand	IEC60255-5 IEEE C37.90	50 Hz, 1mn, 2kV (CM), 1kV (DM)
		50 Hz, 1mn, 1kV (CM)
		G 1.4 & 1.5 500V CM G 6 :1,5 kV CM
High Voltage Impulse Test	IEC 60255-5	5kV (CM), 3kV (DM)
		2kV (CM)
		Groups 1 to 6 :5 kV CM & 3 kV DM(1)
		Not on 1.4 & 1.5 : 5 kV CM & 3 kV DM(1)
Free Fall Test Free Fall Packaging Test	IEC 60068-2-31 IEC 60068-2-32	Test Ec : 2 falls from 5cm Test Ed : 2 falls from 0,5m
		2 falls of 5 cm (Computer not powered)
		25 falls of 50 cm (1) (2) (Packaging computer)
Vibration Response – Powered On	IEC 60255-21-1	Class 2 : 1g from 2 to 150Hz
		Class 2 : Acceleration : 1g from 10 (1) to 150Hz
Vibration Response – Not Powered On	IEC 60255-21-1	Class 2 : 2g from 2 to 500Hz
		Class 2 : Acceleration : 2g from 10 (1) to 500Hz
Vibration Endurance – Not Powered On	IEC 80068-2-6	Class 2 : 1g from 10 to 150Hz
		Class 2 : Acceleration : 1g from 10 (1) to 500Hz
Shocks – Not Powered On	IEC 60255-21-2	Class 1 : 15g, 11 ms
Shocks – Powered On	IEC 60255-21-2	Class 2 : 10g, 11 ms
Bump Test – Not Powered On	IEC 60255-21-2	Class 1 : 10g, 16ms, 2000/axis
Seismic Test – Powered On	IEC 60255-21-3	Class 1 : Axis H : 3,5mm – 2g Axis V : 3,5mm – 1g

Type Test Name	Type Test Standard	Conditions
		Class 2 : Acceleration : 2g Displacement : 7,5mm axis H Acceleration : 1g Displacement : 3,5mm axis V
Damp Heat Test - Operating	IEC 60068-2-3	Test Ca : +40°C / 10 days / 93% RH
Cold Test - Operating	IEC 60068-2-1	Test Ab : -10°C / 96h
		Test Ab : - 25°c / 96 H
Cold Test - Storage	IEC60068-2-1	Test Ad : -40°C / 96h Powered On at –25°C (for information) Powered On at –40°C (for information)
Dry Heat Test – Operating	IEC 60068-2-2	Test Bd : 55°C / 96h
		70°C / 2h
		70°c / 24 H
Dry Heat Test – Storage	IEC 60068-2-1	Test Bd : +70°C / 96h Powered On at +70°C
Enclosure Protection	IEC 60529	Front : IP=52 Rear : IP=30
Inrush current (start-up)		T < 1,5 ms / I < 20 A T < 150 ms / I < 10 A T > 500 ms / I < 1,2 In
Supply variation	IEC 60255-6	Vn ± 20% Vn+30% & Vn-25% for information
Overvoltage (peak withstand)	IEC 60255-6	1,32 Vn max 2 Vn during 10 ms (for information)
Supply interruption	IEC 60255-11	From 2,5 ms to 1 s at 0,8 Vn 50 ms at Vn, no malfunction (for information)
40 s interruption	IEC 60255-11	
Ripple (frequency fluctuations)	IEC 60255-11	12% Vn at f=100Hz or 120Hz 12% Vn at f=200Hz for information
Supply variations	IEC 60255-6	Vn ± 20%
AC Voltage dips & short interruptions	EN 61000-4-11	2ms to 20ms & 50ms to 1s 50 ms at Vn, no malfunction (for information
Frequency fluctuations	IEC 60255-6	50 Hz : from 47 to 54 Hz 60 Hz : from 57 to 63 Hz
Voltage withstand		2 Vn during 10 ms (for information)

Type Test Name	Type Test Standard	Conditions
High Frequency Disturbance	IEC 60255-22-1 IEC 61000-4-12 IEEE C37.90.1	Class 3 : 2.5kV (CM) / 1kV (DM)
		Class 2 : 1kV (CM)
Electrostatic discharge	IEC 60255-22-2 IEC 61000-4-2	Class 4 : 8kV contact / 15 kV air
Radiated Immunity	IEC 60255-22-3 IEC 61000-4-3	Class 3 : 10 V/m – 80 to 1000 MHz & spot tests
	IEEE C37.90.2	35 V/m – 25 to 1000 MHz
Fast Transient Burst	IEC 60255-22-4 IEC 61000-4-4 IEEE C37.90.1	Class 4 : 4kV – 2.5kHz (CM & DM)
		Class 3 2 kV - 2,5 kHz MC
		Class 3 : 2kV – 5kHz (CM)
Surge immunity	IEC 61000-4-5	Class 4 : 4kV (CM) – 2kV (DM)
		Class 3 : 2kV (CM) on shield Class 4 : 4kV (CM) for information
		Class 3 : 1 kV MC
High frequency conducted immunity	IEC 61000-4-6	Class 3 : 10 V, 0.15 – 80 MHz
Harmonics Immunity	IEC 61000-4-7	5% & 10% de H2 à H17
Power Frequency Magnetic Field Immunity	IEC 61000-4-8	Class 4 : 50 Hz – 30 A/m permanent – 300 A/m short time
		Class 5 : 100A/m for 1mn 1000A/m for 3s
Power Frequency	IEC 61000-4-16	CM 500 V / DM 250 V via 0.1 μF
Conducted emission	EN 55022	Gr. I, class A and B : from 0.15 to 30 MHz
Radiated emission	EN 55022	Gr. I, class A and B : from 30 to 1000 MHz, 10m

(C) Communication Standard

IEC 61850:

- IEC 61850-8-1: *Communication networks and systems in substations – Part 8-1: Specific communication service mapping (SCSM) – Mapping to MMS(ISO/IEC 9506 Part 1 and Part 2*

- IEC 61850 shall be used as reference standard to model substation switchyard and associated protection and automation functions. As a consequence, IEC 61850 protocols are mandatory for the communications between the SAS bays, Gateways, the Bay IEDs and HMI. Within a bay this permits to suppress wiring between IEDs such as start of the disturbance recorder, initiation of the circuit breaker failure protection, Re-closer coordination, etc.
- IEC61850 shall be used for the time synchronisation, control, reports, peer-to-peer exchanges and disturbance records file transfers. No private protocol is allowed for such exchanges. IED setting may use a private tunnelling mechanism since this part is not part of the IEC61850 standard. The supplier shall state the exact profile intended to be used.
- The SAS shall offer 99.8% network availability based on redundancy principles.

- IEC 61850 is based on Ethernet 100 Mbps. The communication between bays shall use fibre optic. The architecture shall be a redundant loop so that the damage on one fibre will not affect the SAS. The switching time from one loop to the other shall be less than 1 ms in order to keep the peer-to-peer exchanges performances in case of a network failure. There shall be one switch per bay so that the failure of one switch will not affect more than one bay. The switch shall preferably be a board integrated within the protection and control devices. The switch must have at least 1 spare port reserve for future enhancement at the bay level and temporary HMI connection.

Tele-Control Protocol:

- IEC 608670-5-101
- IEC 608670-5-104

(D) Automation standard

- IEC 61131-3

(E) Communication Interfaces

- The communication with the remote control centre is using a duplicated IEC 60870-5-101 or IEC 60870-5-104 link.
- The communication with the remote HMI is using a standard telecom arrangement. Connection.
- The SAS must be able to interface third party IEDs and integrate them into the standard bay. The communication is done through IEC 61850 or IEC -60870-5-103 (profile defined in a later section).
- The time synchronization is acquired from a GPS receiver.
- The Tele-protection interfaces are project specific. Sufficient Ethernet ports shall be required to communicate with the following:
    a) Main/Backup Smart Grid Control Centres
    b) Main/Backup SLDC/ALDC
    c)

List of IO Points to be transmitted to RSCC

a) MW and MVAR for all lines , transformers, reactors and Capacitors
b) Voltage of all buses
c) Frequency of 220kV Bus
d) All Breakers
e) All isolators
f) Tap Position for all transformers
g) Master protection signal for all feeders, transformers Units and Bus Bar

h) Loss of Voltage signal for Bus bar
i) All the points identified in point (e), (h) and (i) above as GPS Time stamped.
j) Temperature value per substation.
k) Any other point decided during detailed engineering

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SECTION - 16

GAS INSULATED SWITCHGEAR (GIS) FOR BAHRABISE SS

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16.1 GENERAL CHARACTERISTICS

16.1.1 The SF6 gas insulated metal enclosed switchgear shall be totally safe against inadvertent touch of any of it's constituent parts. It should be designed for indoor application with meteorological conditions at site as per Section Project.

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

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

16.1.4 The required overall parameters of GIS are as follows:-

Sl.No	Technical particulars	
1.	Rated Voltage (RMS)	145 kV
2.	Rated frequency	50 HZ
	Grounding	Effectively earthed
3.	Rated power frequency withstand Voltage (1 min) line to earth (rms)	275 kV
4.	Impulse withstand BIL (1.2/50/mic. Sec) Line to earth	±650 kVp
5.	Rated short time withstand current (1 sec) (As applicable)	31.5kA (rms)
6.	Rated peak withstand current (as applicable)	78.75kA (peak)
7.	Rated current (at 50 degree C design ambient temperature)	As per BPS

16.2 REFERENCE STANDARDS

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

IEC 62271-203 Gas Insulated metal-enclosed switchgear for rated voltages above 52 KV

IEC 62271-207 Seismic qualification for gas-insulated switchgear assemblies for rated voltages above 52 kV

IEC 60376 New sulphur hexafluoride

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

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

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

16.3 DEFINITIONS

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

16.3.2 **Bay:** Bay refers to the area occupied by one Circuit Breaker and associated equipment.

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

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

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

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

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

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

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

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

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

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

16.3.13 The bus enclosure should be sectionalized in a manner that maintenance work on any bus disconnector (when bus and bus disconnector are enclosed in a single enclosure) can be carried out by isolating and evacuating the small effected section and not the entire bus.. The design of 220/132 kV GIS shall be such that in case a circuit breaker module of a feeder is removed for maintenance, both bus bars shall remain in service. For achieving the above requirements, adequate Mechanical support and number of

intermediate gas tight compartments as required, shall be provided to ensure equipment and operating personnel's safety.

16.3.14 Typical drawings indicating gas tight compartments are enclosed at **Annexure-A**.

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

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

16.3.17 The material used for manufacturing the switchgear equipment shall be of the type, composition and have physical properties best suited to their particular purposes and in accordance with the latest engineering practices. All the conductors shall be fabricated of aluminum/ copper tubes of cross sectional area suitable to meet the normal and short circuit current rating requirements. The finish of the conductors shall be smooth so as to prevent any electrical discharge. The conductor ends shall be silver plated and fitted into finger contacts or tulip contacts. The contacts shall be of sliding type to allow the conductors to expand or contract axially due to temperature variation without imposing any mechanical stress on supporting insulators.

16.3.18 Each pressure filled enclosure shall be designed and fabricated to comply with the requirements of the applicable pressure vessel codes and based on the design temperature and design pressures as defined in IEC-62271-203.

16.3.19 The maximum SF6 gas leakage shall not exceed 0.5% (half percent) per year for the whole equipment and for any individual gas compartment separately. The SF6 gas leakage should not exceed 0.5% per year and the leakage rate shall be guaranteed for at least 10 years. In case the leakage under the specified conditions is found to be greater than 0.5% after one year of commissioning, the manufacturer will have to supply free of cost, the total gas requirement for subsequent ten (10) years, based on actual leakage observed during the first year of operation after commissioning

16.3.20 Each gas-filled compartment shall be equipped with static filters, density switches, filling valve and safety diaphragm. The filters shall be capable of absorbing any water vapour which may penetrate into the enclosures as well as the by-products of SF6 during interruption. Each gas compartment shall be fitted with non-return valve connectors for evacuating & filling the gas and checking the gas pressure etc.

16.3.21 The switchgear line-up when installed and operating under the ambient conditions shall perform satisfactorily and safely under all normal and fault conditions. Even repeated operations up to the permissible servicing intervals under 100% rated and fault conditions shall not diminish the

performance or significantly shorten the useful life of the switchgear. Any fault caused by external reasons shall be positively confined to the originating compartment and shall not spread to other parts of the switchgear.

16.3.22 The thermal rating of all current carrying parts shall be minimum for one sec. for the rated symmetrical short-circuit current.

16.3.23 The switchgear shall be of the free standing, self-supporting with easy accessibility to all the parts during installation & maintenance with all high-voltage equipment installed inside gas-insulated metallic and earthed enclosures, suitably sub-divided into individual arc and gas-proof compartments preferably for:

1) Bus bars
2) Intermediate compartment
3) Circuit breakers
4) Line Disconnectors
5) Voltage Transformers
6) Gas Insulated bus duct section between GIS and XLPE cable/Overhead Conductor.
7) Gas Insulated bus section between GIS & Oil filled Transformer (if applicable)

16.3.24 The arrangement of the individual switchgear bays shall be such so as to achieve optimum space-saving, neat and logical arrangement and adequate accessibility to all external components.

16.3.25 The layout of the substation equipment, bus bars and switchgear bays shall preferably be based on the principle of "phase grouping". Switchgear layout based on the "mixed phases" principle shall not be accepted without mutual agreement between supplier and employer/consultant. The arrangement of the equipment offered must provide adequate access for operation, testing and maintenance.

16.3.26 All the elements shall be accessible without removing support structures for routine inspections. The removal of individual enclosure parts or entire breaker bays shall be possible without disturbing the enclosures of neighbouring bays.

16.3.27 It should be impossible to unwillingly touch live parts of the switchgear or to perform operations that lead to arcing faults without the use of tools or brute force. All interlocks that prevent potentially dangerous mal-operations, shall be constructed such that they cannot be operated easily, i.e. the operator must use tools or brute force to over-ride them.

16.3.28 In general the contours of energized metal parts of the GIS and any other accessory shall be such, so as to eliminate areas or points of high electrostatic flux concentrations. The surfaces shall be smooth with no projection or irregularities which may cause visible corona. No corona shall be visible in complete darkness which the equipment is subjected to specified test voltage. There shall be no radio interference from the energized switchgear at rated voltage.

16.3.29 The GIS shall be designed, so as to take care of the VFT over voltages generated as a result of pre-strikes and re-strikes during isolator operation. Maximum VFT over voltages peak shall not be higher

than rated lightning impulse withstand voltage (LIWV) of the equipment. Necessary measures shall be under taken by GIS manufacture to restrict maximum VFT over voltages lower than the LIWV. Manufacturer shall submit the study report of VFTO generated for GIS installation.

16.3.30 The enclosure shall be of continuous design and shall meet the requirement as specified in clause no. 10 (special considerations for GIS) of IEEE- 80, Year- 2000.

16.3.31 The enclosure shall be sized for carrying induced current equal to the rated current of the Bus. The conductor and the enclosure shall form the concentric pair with effective shielding of the field internal to the enclosure.

16.3.32 The fabricated metal enclosures shall be of Aluminum alloy having high resistance to corrosion, low electrical loses and negligible magnetic losses. All joint surfaces shall be machined and all castings shall be spot faced for all bolt heads or nuts and washers. All screws, bolts, studs and nuts shall conform to metric system.

16.3.33 The elbows, bends, cross and T-sections of interconnections shall include the insulators bearing the conductor when the direction changes take place in order to ensure that live parts remain perfectly centered and the electrical field is not increased at such points.

16.3.34 The enclosure shall be designed to practically eliminate the external electromagnetic field and thereby electro-dynamic stresses even under short circuit conditions. The average intensity of electromagnetic field shall not be more than 50 micro –Tesla on the surface of the enclosure. The contractor shall furnish all calculations and documents in support of the above during detailed engineering.

16.3.35 The switchgear shall have provision for connection with ground mat risers. This provision shall consist of grounding pads to be connected to the ground mat riser in the vicinity of the equipment.

16.3.36 The ladders and walkways shall be provided wherever necessary for access to the equipment.

16.3.37 Wherever required, the heaters shall be provided for the equipment in order to ensure the proper functioning of the switchgear at specified ambient temperatures. The heaters shall be rated for 230V AC supply and shall be complete with thermostat, control switches and fuses, connected as a balanced 3-phase. 4-wire load. The heaters shall be so arranged and protected as to create no hazard to adjacent equipment from the heat produced.

16.3.38 The enclosure & support structure shall be designed that person of 1780 mm in height and 80 Kg in weight is able to climb on the equipment for maintenance.

16.3.39 The sealing provided between flanges of two modules / enclosures shall be such that long term tightness is achieved.

16.3.40 Alarm circuit shall not respond to faults for momentary conditions. The following indications including those required elsewhere in the specifications shall be generally provided in the alarm and indication circuits.

Gas Insulating System:

i) Loss of Gas Density.
ii) Loss of Heater power(if required)
iii) Any other alarm necessary to indicate deterioration of the gas insulating system.

Operating System:

i) Low operating pressure.
ii) Loss of Heater power.
iii) Loss of operating power.
iv) Loss of control supply.
v) Pole Discordance.

16.3.41 The equipment will be operated under the following ambient conditions(or as defined in the section project):

a) The ambient temperature varies between 0 degree-C and 50 degree-C. However, for design purposes, ambient temperature should be considered as 50 degree-C.
b) The humidity will be about 95% (indoors)
c) The elevation as per section project.

16.3.42 Temperature rise of current carrying parts shall be limited to the values stipulated in IEC-62271-1, under rated current and the climatic conditions at site. The temperature rise for all enclosures shall not exceed 20 degree C above the ambient temperature of 50 degree C. These conditions shall be taken into account by the supplier in the design of the equipment

16.3.43 **Bellows or Compensating Units:-** Adequate provision shall be made to allow for the thermal expansion of the conductors & enclosures and of differential thermal expansion between the conductors and the enclosures. The bellows metallic(preferably stainless steel) with suitable provision for permitting the movement during expansion and contraction may be provided and shall be of following types:.

1. Lateral / Vertical mounting units: These shall be inserted, as required, between sections of busbars, on transformer and XLPE cable etc. Lateral mounting shall be made possible by a sliding section of enclosure and tubular conductors.

2. Axial compensators: These shall be provided to accommodate changes in length of busbars due to temperature variations.

3. Parallel compensators: These shall be provided to accommodate large linear expansions and angle tolerances.

4. Tolerance compensators: These shall be provided for taking up manufacturing, site assembly and foundation tolerances.

5. Vibration compensators: These bellow compensators shall be provided for absorbing vibrations caused by the transformers when connected to SF6 switchgear by oil- SF6 bushings.

The electrical connections across the bellows or compensating units shall be made by means of suitable connectors. For sliding type compensators, markers/pointers shall be provided to observe expansion or contraction during climatic conditions.

16.3.44 **Indication and verification of switch positions**: Indicators shall be provided on all circuit breakers, isolators and earth-switches, which shall clearly show whether the switches are open or closed. The indicators shall be mechanically coupled directly to the main contact operating drive rod or linkages

and shall be mounted in a position where they are clearly visible from the floor or the platform in the vicinity of the equipment.

16.3.45 Inspection windows shall also be provided with all isolators and earth switches so that the switch contact positions can be verified by direct visual inspection.

16.3.46 **Pressure relief device** : Pressure relief devices shall be provided in the gas sections to protect the gas enclosures from damage or distortion during the occurrence of abnormal pressure increase or shock waves generated by internal electrical fault arcs (preferably in downward direction).

16.3.47 Pressure relief shall be achieved either by means of diaphragms or plugs venting directly into the atmosphere in a controlled direction.

16.3.48 If the pressure relief devices vent directly into the atmosphere, suitable guards and deflectors shall be provided. Contractor shall submit to the owner the detailed criteria/ design regarding location of pressure relief devices/rupture diaphragms.

16.3.49 **Pressure vessel requirements**: The enclosure shall be designed for the mechanical and thermal loads to which it is subjected in service. The enclosure shall be manufactured and tested according to the pressure vessel code (ASME/CENELEC code for pressure Vessel.)

16.3.50 The bursting strength of Aluminum castings has to be at least 5 times the design pressure. A bursting pressure test shall be carried out at 5 times the design pressure as a type test on each type of enclosure.

16.3.51 Each enclosure has to be tested as a routine test at 1.5 times the design pressure for one minute.

16.3.52 Grounding:

i. The grounding system shall be designed and provided as per IEEE-80-2000 and CIGRE-44 to protect operating staff against any hazardous touch voltages and electro-magnetic interferences.

ii. The GIS supplier shall define clearly what constitutes the main grounding bus of the GIS. The contractor shall supply the entire material for grounding bus of GIS viz conductor, clamps, joints, operating and safety platforms etc. The contractor is also required to supply all the earthing conductors and associated hardware material for connecting all GIS equipment, bus ducts, enclosures, control cabinets, supporting structure, GIS surge arrestor etc. to the ground bus of GIS.

iii. The enclosure of the GIS may be grounded at several points so that there shall be grounded cage around all the live parts. A minimum of two nos. of grounding connections should be provided for each of circuit breaker, cable terminals, surge arrestors, earth switches and at each end of the bus bars. The grounding continuity between each enclosure shall be effectively interconnected externally with Copper /Aluminum bonds of suitable size to bridge the flanges. Subassembly to subassembly bonding shall be provided to bridge the gap & safe voltage gradients between all intentionally grounded parts of the GIS assembly & between those parts and the main grounding bus of the GIS.

iv. Each marshaling box, local control panel, power and control cable sheaths and other non- current carrying metallic structures shall be connected to the grounding system of GIS via connections that are separated from GIS enclosures.

v. The grounding connector shall be of sufficient mechanical strength to withstand electromagnetic forces as well as capable of carrying the anticipated maximum fault current without overheating. At least two grounding paths shall be provided to connect each point to the main grounding bus.

Necessary precautions should be under taken to prevent excessive currents from being induced into adjacent frames, structures of reinforcing steel and to avoid establishment of current loops via other station equipment.

vi. All flexible bonding leads shall be tinned copper. All connectors, for attaching flexible bonding leads to grounding conductors and grounding conductors to support structures shall be tinned bronze with stainless steel or tinned bronze hardware.

vii. The contractor shall provide suitable measure to mitigate transient enclosure voltage caused by high frequency currents caused by lightning strikes, operation of surge arrestor, phase to earth fault and discharges between contacts during switching operation. The grounding system shall ensure safe touch & step voltages in all the enclosures.

16.3.53 **UHF sensors for PD detection**: Contractor shall provide adequate number of UHF sensors in the offered GIS for detection of Partial discharge (of 5 pC and above) as per IEC 60270 through Partial Discharge (PD) monitoring system and the number and location of these sensors shall be subject to approval of the employer/consultant. Further UHF sensors shall necessarily be provided in close proximity to VT compartments

However adequacy of number of sensors and their location shall be verified at site by the contractor as per recommendations of CIGRE task force TF 15/33.03.05 (**Task force on *Partial discharge detection system for GIS: Sensitivity verification for the UHF method and the acoustic method***). In case during site testing additional UHF sensors are required, the same shall also be supplied& installed to complete the technical requirement.

16.3.54 Gas Insulated Bus (GIB) layout:

GIB shall be designed based on the following criteria

(1) Maximum weight of gas in a gas tight section of GIB shall not exceed 250 Kg for 132 kV.

(2) GIS bus ducts of each circuit shall be arranged in preferably horizontal formation and the clearance (outer to outer) between nearest bus ducts of two adjacent circuits shall be minimum one (1) meter.

(3) GIB shall be generally in only one horizontal layer. However in exceptional circumstance two horizontal GIB layers can be provided with the approval of Owner/consultant and the vertical clearance between layers shall be minimum one (1) meter in such case.

(4) The minimum outer to outer horizontal clearance between each GIS bus duct shall 0.5 meter for 132 kV voltage level.

(5) The minimum vertical ground clearance of GIB at road crossing shall be 5.5 meters

(6) The horizontal clearance between GIB and GIS building /any other building wall shall be minimum three (3) meters.

(7) The GIB route inside the GIS Hall shall not obstruct easy access to GIS and control room buildings and shall not obstruct movement of crane, equipment including HV test equipment for maintenance works.

(8) The GIB height outside the GIS hall in switchyard area shall not obstruct easy access to GIB, movement of crane for maintenance work.

(9) Optimization of outdoor GIB length using overhead AIS connection with Bus Post Insulator of respective voltage class is generally acceptable subject to meeting the electrical clearances as stipulated.

(10) For the maintenance of GIB of one circuit, only that circuit shall be isolated

16.3.55 A portable ladder with adjustable height shall be supplied to access the GIS equipment for O&M purpose.

16.3.56 Extension of GIS

i. The arrangement of gas sections or compartments shall be such as to facilitate future extension of any make without any drilling, cutting or welding on the existing equipment. To add equipment, it shall not be necessary to move or dislocate the existing switchgear bays.

ii. As the GIS is likely to be extended in future, the contractor shall make available during detailed engineering stage, the complete design detail of interface module such as cross section, enclosure material, enclosure dimensions (inner & outer), Flange diameter (inner & outer), conductor connection arrangement, bolt spacing & dimension, rated gas pressure etc. Further GIS manufacturer supplying GIS under present scope shall furnish all the required details in addition to mentioned above necessary for design and successful implementation of an interface module during later stage while extending GIS by any other GIS manufacturer, without any help of GIS manufacturer who has supplied the GIS equipment in present scope.

iii. The Interface module (extension module) shall be designed to provide Isolating link with access hole on enclosure. The Isolating link shall be provided in such a way so that HV test can be performed on either side of the interface module separately, keeping other side of GIS remain isolated.

iv. Further the contractor who is extending the existing GIS installation shall optimally utilize the space inside the GIS hall (including the extension portion) for accommodating the interface module being supplied under the contract and the space (along the length of the hall) inside the GIS hall for interface module shall preferably be limited to 1 meter for 220/132kV

16.3.57 SF6 GAS

The SF6 gas insulated metal-clad switchgear shall be designed for use with SF6 gas complying with the **recommendations** of IEC 376, 376A & 376B, at the time of the first charging with gas. All SF6 gas supplied as part of the contract shall comply with the requirements of IEC as above as a minimum & should be suitable in all respects for use in the switchgear under all operating conditions.

The high pressure cylinders in which SF6 gas is supplied & stored at site shall comply with the requirements of following standards & regulations:

IS : 4379 Identification of the contents of industrial gas cylinders.

IS : 7311 Seamless high carbon steel cylinders for permanent & high pressure liquefiable gases. The cylinders shall also meet Indian Boilers Regulations. (Mandatory)

SF6 gas shall be tested for purity, dew point, air, hydrolysable fluorides and water contents as per IEC: 376, 376A & 376B and test certificates shall be furnished to the owner indicating all test results as per IEC standards for each lot of SF6 gas. Further site tests for moisture, air content, flash point and dielectric strength to be done during commissioning of GIS. Gas bottles should be tested for leakage during receipt at site.

The contractor shall indicate diagnostic test methods for checking the quality of gas in the various sections during service. The method proposed shall, as a minimum check the moisture content & the percentage of purity of the gas on annual basis.

The contractor shall also indicate clearly the precise procedure to be adopted by maintenance personnel for handling equipment that are exposed to the products of arcing in SF6 Gas so as to ensure that they are not affected by possible irritants of the skin and respiratory system. Recommendations shall be submitted for suitable protective clothing, method of disposal of cleaning utensils and other relevant matters.

The contractor shall also indicate the details and type of filters used in various gas sections, and should also submit the operating experience with such filters.

i. **SF6 gas monitoring devices and alarm circuits:** Dial type temperature compensated gas density monitoring devices with associated pressure gauge will be provided. The devices shall provide continuous & automatic monitoring of gas density & a separate device shall be provided for each gas compartment so that each compartment can be monitored simultaneously as follows:-

Compartment/ Sl no	Compartments except CB	Circuit Breaker compartments
1	**"Gas Refill level:** This will be used to annunciate the need for the gas refilling. The contractor shall provide a contact for remote indication.	**'Gas Refill' level: This** will be used to annunciate the need for gas refilling. The contractor shall provide a contact for remote indication.
2	**"SF6 low level":** This will be used to annunciate the need for urgent gas filling. A contact shall be provided for remote indication	**"SF6 low level":** This will be used to annunciate the need for urgent gas filling. A contact shall be provided for remote indication
3	**'Zone Trip' level:** This is the minimum level at which the manufacturer will guarantee the insulation rating of the assembly.	**Breaker Block' level :** This is the minimum gas density at which the manufacturer will guarantee the rated fault interrupting capability of the breaker .At this level the breaker block contact shall operate and the closing & tripping circuit shall be blocked
4	**Not Applicable**	**'Zone Trip' level:** This is the minimum level at which the manufacturer will guarantee the insulation rating of the assembly.

The density monitor/pressure switch contacts shall be in accordance with the above requirement.

ii. The contractor should furnish temperature v/s pressure curves for each setting of density monitor along with details of the monitoring device.

It shall be possible to test all gas monitoring relays/devices without de-energizing the primary equipment & without reducing pressure in the main section. Plugs & sockets shall be used for test purposes. It shall also damp the pressure pulsation while filling the gas in service, so that flickering of the pressure switch contacts does not take place.

iii. Gas Supply: The contractor shall include the supply of all SF6 gas necessary for filling & putting into operation the complete switchgear installation being supplied. The empty gas cylinders shall be returnable to the contractor.

16.4 CIRCUIT BREAKERS

16.4.1 General

SF6 gas insulated metal enclosed circuit breakers shall comply with the latest revisions of IEC- 62271-100 & relevant IEC except to the extent explicitly modified in the specification and shall meet with requirements specified

Circuit breakers shall be equipped with the operating mechanism. Circuit breakers shall be of single pressure type. Complete circuit breaker with all necessary items for successful operation shall be

supplied. The circuit breakers shall be designed for high speed single and three phase reclosing with an operating sequence and timing as specified.

16.4.2 Duty Requirements**:**

Circuit breaker shall be C2 - M2 class as per IEC 62271-100.

Circuit breaker shall meet the duty requirements for any type of fault or fault location also for line charging and dropping when used on effectively grounded system and perform make and break operations as per the stipulated duty cycles satisfactorily.

16.4.3 The circuit breaker shall be capable of:

1. Interrupting line/cable charging current as per IEC without re-strikes and without use of opening resistors. The breaker shall be able to interrupt the rated line charging current as per IEC-62271-100 with test voltage immediately before opening equal to the product of $U/\sqrt{3}$ and 1.4

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

3. Breaking 25% the rated fault current at twice the rated voltage under phase opposition condition.

4. The breaker shall satisfactorily withstand the high stresses imposed on them during fault clearing, load rejection and re-energisation of shunt reactor and/or series capacitor compensated lines with trapped charges.

5. Withstanding all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. shall be designed for 2 p.u. across the breaker continuously, for validation of which a power frequency withstand test conducted for a duration of at least 15 minutes is acceptable).

16.4.4 **Total Break Time: The** total break time shall not be exceeded under any of the following duties:

a) Test duties T10,T30,T60,T100 (with TRV as per IEC- 62271-100)

b) Short line fault L90, L75 (with TRV as per IEC-62271-100)

The Contractor may please note that total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage (70-110%), pneumatic/hydraulic pressure and SF6 gas pressure etc. While furnishing the proof for the total break time of complete circuit breaker, the contractor may specifically bring out the effect of non-simultaneity between poles and show how it is covered in the total break time.

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

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

i. **Contacts:** All making and breaking contacts shall be sealed and free from atmospheric effects. Contacts shall be designed to have adequate thermal and current carrying capacity for the duty specified and to have a life expectancy so that frequent replacement due to excessive burning will not be necessary. Provision shall be made for rapid dissipation of heat generated by the arc on opening.

ii. Any device provided for voltage grading to damp oscillations or, to prevent re-strike prior to the complete interruption of the circuit or to limit over voltage on closing, shall have a life expectancy comparable of that of the breaker as a whole.

iii. Breakers shall be so designed that when operated within their specified rating, the temperature of each part will be limited to values consistent with a long life for the material used. The temperature rise shall not exceed that indicated in IEC-62271-100 under specified ambient conditions.

iv. The gap between the open contacts shall be such that it can withstand at least the rated phase to ground voltage for eight hours at zero pressure above atmospheric level of SF6 gas due to its leakage. The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lockout pressure continuously (i.e. 2 pu. power frequency voltage across the breaker continuously)

v. In the interrupter assembly there shall be an adsorbing product box to minimize the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be such as to be fully compatible with SF6 gas decomposition products.

vi. Provisions shall be made for attaching an operational analyzer to record travel, speed and making measurement of operating timings etc. after installation at site. The contractor shall supply three set of transducer for each substation covered under the scope.

vii. Circuit Breaker shall be supplied with auxiliary switch having additional 8 NO (normally open) and 8 NC (normally closed) contacts for future use over and above those required for switchgear interlocking and other control and protection function. These spare NO and NC contacts shall be wired upto the local control cubicle.

16.4.6 Operating mechanism

1. General Requirements :

a) Circuit breaker shall be operated by spring charged mechanism or electro hydraulic mechanism or a combination of these. The mechanism shall be housed in a dust proof cabinet and shall have IP: 42 degree of protection.

b) The operating mechanism shall be strong, rigid, not subject to rebound or to critical adjustments at site and shall be readily accessible for maintenance.

c) The operating mechanism shall be suitable for high speed reclosing and other duties specified. During reclosing the breaker contacts shall close fully and then open. The mechanism shall be anti-pumping and trip free (as per IEC definition) under every method of closing.

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

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

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

g) The contractor shall furnish detailed operation and maintenance manual of the mechanism along with the operation manual for the circuit breaker.

2. Control

a) The close and trip circuits shall be designed to permit use of momentary-contact switches and push buttons.

b) Each breaker pole shall be provided with two (2) independent tripping circuits and trip coils which may be connected to a different set of protective relays.

c) The breaker shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. However, provisions shall be made for local electrical control. For this purpose a local/remote selector switch and close and trip control switch/push buttons shall be provided in the breaker control cabinet.

d) The trip coil shall be suitable for trip circuit supervision during both open and close position of breaker.

e) Closing coil and associated circuits shall operate correctly at all values of voltage between 85% and 110% of the rated voltage. Shunt trip and associated circuits shall operate correctly under all operating conditions of the circuit breaker upto the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage.

f) Densimeter contacts and pressure switch contacts shall be suitable for direct use as permissive in closing and tripping circuits. Separate contacts have to be used for each of tripping and closing circuits. If contacts are not suitably rated and multiplying relays are used then fail safe logic/schemes are to be employed. DC supplies shall be monitored for remote annunciations and operation lockout in case of dc failures.

g) The auxiliary switch of the breaker shall be positively driven by the breaker operating rod.

3. Spring operated Mechanism

a) Spring operated mechanism shall be complete with motor in accordance with Section GTR. Opening spring and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit shall also be provided.

b) As long as power is available to the motor, a continuous sequence of the closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty.

c) After failure of power supply to the motor one close open operation shall be possible with the energy contained in the operating mechanism.

d) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring shall also be provided. The motor rating shall be such that it required preferably not more than 90 seconds for full charging of the closing spring.

e) Closing action of circuit breaker shall compress the opening spring ready for tripping.

f) When closing springs are discharged after closing a breaker, closing springs shall automatically be charged for the next operation and an indication of this shall be provided in the local control cabinet & SAS.

g) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition.

h) Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is in the closed position.

i) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

4. Hydraulically Operated Mechanism :

a) Hydraulically operated mechanism shall comprise of operating unit with power cylinder, control valves, high and low pressure reservoir, motor etc.

b) The hydraulic oil used shall be fully compatible for the temperature range to be encountered during operation.

c) The oil pressure switch controlling the oil pump and pressure in the high pressure reservoir shall have adequate no. of spare contacts, for continuous monitoring of low pressure, high pressure etc. at switchyard control room.

d) The mechanism shall be suitable for at-least two close open operations after failure of AC supply to the motor starting at pressure equal to the lowest pressure of auto reclose duty plus pressure drop for one close open operation.

e) The mechanism shall be capable of operating the circuit breaker correctly and performing the duty cycle specified under all conditions with the pressure of hydraulic operated fluid in the operating mechanism at the lowest permissible pressure before make up.

f) Trip lockout shall be provided to prevent operations of the circuit breaker below the minimum specified hydraulic pressure. Alarm contacts for loss of Nitrogen shall also be provided.

g) All hydraulic joints shall have no oil leakage under the site conditions and joints shall be tested at factory against oil leakage.

16.4.7 The technical parameters of Circuit breakers are as per Annexure -1

16.4.8 Additional data to be furnished during detailed engineering:

a) Drawing showing contacts in close, arc initiation, full arcing, arc extinction and open position.
b) Data on capabilities of circuit breakers in terms of time and number of operations at duties ranging from 100 fault currents to load currents of the lowest possible value without requiring any maintenance or checks.
c) Curves supported by test data indicating the opening time under close open operation with combined variation of trip coil voltage and hydraulic pressure.

16.4.9 Tests :

1. **Type Tests**:

i. In accordance with the requirements stipulated under Section GTR the circuit breaker along with its operating mechanism shall conform to the type tests as per IEC-62271-100.

ii. The type test report of Electromagnetic Compatibility Test (EMC) of CSD shall be submitted for approval

2. Routine Tests:

Routine tests as per IEC: 62271-100 shall be performed on all circuit breakers.
In addition to the mechanical and electrical tests specified by IEC, the following shall also be performed.

i. Speed curves for each breaker shall be obtained with the help of a suitable operation analyzer to determine the breaker contact movement during opening, closing, auto-reclosing and trip free operation under normal as well as limiting operating conditions (control voltage, pneumatic pressure etc.). The tests shall show the speed of contacts directly at various stages of operation, travel of contacts, opening time, closing time, shortest time between separation and meeting of contacts at break make operation etc. This test shall also be performed at site for which the necessary operation analyzer along with necessary transducers, cables, console etc. shall be provided.

ii. Functional tests are to be carried out on circuit breaker along with Control Switching device (CSD).

iii. DCRM (Dynamic Contact Resistance Measurement) to be carried out for all CBs during routine test.

16.5 DISCONNECTORS (ISOLATORS)

16.5.1 Disconnectors shall be three-pole group operated or Single-pole individual operated (as per single line diagram of the substation/section project) and shall be installed in the switchgear to provide electrical isolation. The disconnectors shall conform to IEC- 62271-102 and shall have the ratings as specified in BPS.

16.5.2 Construction & Design.

1. The disconnectors shall be operated by electric motor suitable for use on DC system and shall be equipped with a manual operating mechanism for emergency use. The motor shall be protected against over current and short circuit.

2. Disconnectors shall be suitable to switch the bus charging currents during their opening and closing and shall confirm to all three test duties viz TD1, TD2 and TD3 as per Annexure –F of IEC: 62271- 102.They shall also be able to make and break rated bus transfer current at rated bus

transfer voltage which appears during transfer between bus bars in accordance with Annexure –B of IEC: 62271-102. The contact shielding shall also be designed to prevent restrikes and high local stresses caused by transient recovery voltages when these currents are interrupted.

3. The disconnecting switches shall be arranged in such a way that all the three phases operate simultaneously. All the parts of the operating mechanism shall be able to withstand starting torque of the motor mechanism without damage until the motor overload protection operates.
4. It shall be possible to operate the disconnecting switches manually by cranks or hand wheels. The contacts shall be both mechanically and electrically disconnected during the manual operation.
5. The operating mechanisms shall be complete with all necessary linkages, clamps, couplings, operating rods, support brackets and grounding devices. All the bearings shall be permanently lubricated or shall be of such a type that no lubrication or maintenance is required.
6. The opening and closing of the disconnectors shall be achieved by either local or remote control. The local operation shall be by means of a two-position control switch located in the Local Control Cabinet (LCC).
7. Remote control of the disconnectors from the control room/SAS shall be made by means of remote/ local transfer switch.
8. The disconnector operations shall be inter-locked electrically with the associated circuit breakers in such a way that the disconnector control is inoperative if the circuit breaker is closed.
9. Each disconnector shall be supplied with auxiliary switch having additional 4 NO (Normally Open) and 4 NC (Normally Closed) contacts for future use over and above those required for switchgear interlocking and automation purposes. These spare NO and NC contacts shall be wired up to the local control cabinet.
10. The signaling of the closed position of the disconnector shall not take place unless it is certain that the movable contacts will reach a position in which the rated normal current, peak withstand current and short-time withstand current can be carried safely.
11. The signaling of the open position of the disconnector shall not take place unless the movable contacts have reached such a position that the clearance between the contacts is at least 80 percent of the rated isolating distance.
12. The disconnectors and safety grounding switches shall have a mechanical and electrical inter-locks to prevent closing of the grounding switches when isolator switches are in the closed position and to prevent closing of the disconnectors when the grounding switch is in the closed position. Integrally mounted lock when provided shall be equipped with a unique key for such three phase group. Master key is not permitted.
13. The local control of the Isolator and high-speed grounding switches from the Local Control Cabinet (LCC) should be achieved from the individual control switches with the remote/local transfer switch set to local.
14. All electrical sequence interlocks will apply in both remote and local control modes.
15. Each disconnector shall have a clearly identifiable local, positively driven mechanical position indicator, together with position indicator on the local control cubicle (LCC) and provisions for taking the signals to the control room. The details of the inscriptions and colouring for the indicator are given as under :

	INSCRIPTION	COLOUR
Open position	OPEN	GREEN
Closed position	CLOSED	RED

16. All the disconnecting switches shall have arrangement allowing easy visual inspection of the travel of the switch contacts in both open and close positions, from the outside of the enclosure.
17. The disconnecting switches shall be provided with rating plates and shall be easily accessible.

18. The mechanical endurance class shall be M2 as per IEC for 765kV, 400kV and 220kV and it shall be M1 class for 132kV disconnectors

19. Mechanical position indication shall be provided locally at each disconnector and Electrical indication at each Local Control Cabinet (LCC) / SAS.

16.5.3 The technical parameters of disconnectors are as per **Annexure-2**

16.6 SAFETY GROUNDING SWITCHES

16.6.1 Safety grounding switches shall be three-pole group operated or single-pole individual operated (as per single line diagram of the substation/section project). It shall be operated by DC electric motor and shall be equipped with a manual operating mechanism for emergency use. The motor shall be protected against over-current and short circuit.

16.6.2 Each safety grounding switch shall be electrically interlocked with its associated disconnectors and circuit breaker such that it can only be closed if both the circuit breaker and disconnectors are in open position. Safety grounding switch shall also be mechanically key interlocked with its associated disconnectors.

16.6.3 Each safety grounding switch shall have clearly identifiable local positive driven mechanical indicator together with position indicator on the Local Control Cabinet (LCC) and provision for taking the signal to Control room.

16.6.4 The details of the inscription and coloring for the indicator are given as under :

	INSCRIPTION	COLOUR
Open position	OPEN	GREEN
Closed position	CLOSED	RED

16.6.5 Interlocks shall be provided so that manual operation of the switches or insertion of the manual operating device will disable the electrical control circuits.

16.6.6 Each ground switch shall be fitted with auxiliary switches having 4 NO (Normally Open) and 4 NC (Normally Closed) contacts for use by others over and above those required for local interlocking and position indication purposes.

16.6.7 Provision shall be made for padlocking / suitable locking arrangement for the ground switches in either the open or closed position.

16.6.8 All portions of the grounding switch and operating mechanism required for grounding shall be connected together utilizing flexible copper conductors having a minimum cross-sectional area of 100 sq. mm.

16.6.9 The main grounding connections on each grounding switch shall be rated to carry the full short circuit current for 1 sec. and shall be equipped with a silver- plated terminal connector suitable for steel strap of adequate rating for connection to the grounding grid.

16.6.10 The safety grounding switches shall conform to the requirements of IEC- 62271- 102 and shall have electrical endurance class: E0 & shall have mechanical endurance class M1 for 220/132 kV voltage level.

16.6.11 Combined Disconnectors & Safety grounding switch arrangement shall also be acceptable.

16.6.12 Mechanical position indication shall be provided locally at each switch and Electrical indication at each Local Control Cabinet (LCC) / SAS.

16.6.13 Continuous current rating of the grounding switches (not less than 100A) shall be specified by the manufacturer, which can be safely injected for Bay/ Bus equipment testing.

16.7 HIGH SPEED MAKE PROOF GROUNDING SWITCHES:

16.7.1 Grounding switches located at the beginning of the line feeder bay modules shall be of the high speed, make proof type and will be used to discharge the respective charging currents, trapped charge in addition to their safety grounding function. These grounding switches shall be capable of interrupting the inductive and capacitive currents and to withstand the associated TRV. These shall confirm to class B and electrical endurance class E1 as per annexure – C of IEC : 62271-102

16.7.2 High Speed Grounding switches shall be provided with individual/three pole operating mechanism suitable for operation from DC.

16.7.3 The switches shall be fitted with a stored energy closing system to provide fault making capacity.

16.7.4 The short circuit making current rating of each ground switch shall be at least equal to its peak withstand current rating as stated in clause 1.4 above. The switches shall have inductive/ capacitive current switching capacity as per IEC-62271-102.

16.7.5 Each high speed make proof grounding switch shall have clearly identifiable local positive driven mechanical indicator together with position indicator on the Local Control Cabinet (LCC) and provision for taking the signal to Control Room/SAS.

16.7.6 The details of the inscription and colouring for the indicator shall be as under:-

	INSCRIPTION	COLOUR
Open position	OPEN	GREEN
Closed position	CLOSED	RED

16.7.7 High speed ground switch operation should be possible locally from Local Control Cabinet (LCC)

16.7.8 These high speed grounding switches shall be electrically interlocked with their associated circuit breakers and disconnectors so that the grounding switches cannot be closed if disconnectors are closed. Interlocks shall be provided so that the insertion of the manual operating devices will disable the electrical control circuits.

16.7.9 Each high speed ground switch shall be fitted with auxiliary switches having 4 NO (Normally Open) and 4 NC (Normally Closed) contacts for use by others, over and above these required for local interlocking and position indication. All contacts shall be wired to terminal blocks in the Local Control Cabinet. Provision shall be made for padlocking the ground switches in their open or closed position.

16.7.10 All portion of the grounding switches and operating mechanism required for connection to ground shall be connected together utilizing copper conductor having minimum cross-sectional area of 100 sq. mm.

16.7.11 The main grounding connection on each grounding switch shall be rated to carry the peak withstand current rating of the switch for 1 sec. and shall be equipped with a silver plated terminal connector suitable for steel strap of adequate design for connection to the grounding grid.

16.7.12 The high speed make proof grounding switches shall confirm to the requirements of IEC-62271-102.

16.7.13 Continuous current rating of the High speed grounding switches (not less than 100A) shall be specified by the manufacturer, which can be safely injected for Bay/ Bus equipment testing.

16.8 INSTRUMENT TRANSFORMERS

16.8.1 Current Transformers

The current transformers and accessories shall conform to IEC: 60044-1 and other relevant standards except to the extent explicitly modified in the specification.

1. **Ratios and Characteristics: The** CT core distribution for various voltage levels shall be as per Table 3. Further the numbers of cores, rating, ratios, accuracy class, etc. for the individual current transformers secondary cores shall be in accordance with above table.

   Where multi-ratio current transformers are required the various ratios shall be obtained by changing the effective number of turns on the secondary winding.

2. **Rating and Diagram Plates:** Rating and diagram plates shall be as specified in the IEC specification incorporating the year of manufacture. The rated extended current rating voltage and rated thermal current shall also be marked on the name plate.

The diagram plates shall show the terminal markings and the relative physical arrangement of the current transformer cores with respect to the primary terminals (P1 & P2).

The position of each primary terminal in the current transformer SF6 gas section shall be clearly marked by two plates fixed to the enclosure at each end of the current transformer.

3. Constructional Details:

a) The current transformers incorporated into the GIS will be used for protective relaying and metering purposes and shall be of metal- enclosed type.

b) Each current transformer shall be equipped with a secondary terminal box with terminals for the secondary circuits, which are connected to the Local Control Cubicle. The star/ delta configuration and the inter connection to the line protection panels will be done at the CT terminal block located in the local control cubicle.

c) Current transformers guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

d) For 245/145 kV class CTs, the rated extended primary current shall be 120% (or 150% if applicable) on all cores of the CTs as specified in the Section – Project.

e) 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.

f) The instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably built in construction of the CTs.

g) The wiring diagram, for the interconnections of the three single phase CTs shall be provided inside the Secondary terminal box.

h) The current transformers shall be suitable for high speed auto-reclosing.

i) Provisions shall be made for primary injection testing either within CT or outside.

j) All the current transformers shall have effective electromagnetic shields to protect against high frequency transients. Electromagnetic shields to be provided against high frequency transients typically 1-30 MHz.

16.8.2 VOLTAGE TRANSFORMERS

The voltage transformers shall conform to IEC- 60044-2 and other relevant standards except to the extent explicitly modified in the specification.

Voltage transformers shall be of the electromagnetic type with SF6 gas insulation. The earth end of the high voltage winding and the ends of the secondary winding shall be brought out in the terminal box.

1. **Ratios and Characteristics:** The rating, ratio, accuracy class, connection etc. for the voltage transformers shall be in accordance with annexure -4 & Table 4
2. **Rating and diagram plates :**Rating and diagram plate shall be provided complying with the requirements of the IEC specification incorporating the year of manufacture and including turns ratio, voltage ratio, burden, connection diagram etc.

3. Secondary Terminals, Earthing

The beginning and end of each secondary winding shall be wired to suitable terminals accommodated in a terminal box mounted directly on the voltage transformer section of the SF6 switchgear.

All terminals shall be stamped or otherwise marked to correspond with the marking on the diagram plate. Provision shall be made for earthing of the secondary windings inside the terminal box.

4. The transformer shall be able to sustain full line to line voltage without saturation of transformer.
5. Constructional Details of Voltage Transformers :

a) The voltage transformers shall be located as a separate bay module and will be connected phase to ground and shall be used for protection, metering and synchronization.

b) The voltage transformers shall be of inductive type, nonresistant and shall be contained in their own-SF6 compartment, separated from other parts of installation. The voltage transformers shall be effectively shielded against high frequency electromagnetic transients. The supplier shall ensure that there is no risk of Ferro resonance due to the capacitance of the GIS.

c) The voltage transformers shall have three secondary windings.

d) Voltage transformers secondary shall be protected by Miniature Circuit breakers (MCBs) with monitoring contacts for all the windings. The secondary terminals of the VT's shall be terminated to preferably stud type non-disconnecting terminal blocks in the secondary boxes via the fuse.

e) The voltage transformer should be thermally and dielectrically safe when the secondary terminals are loaded with the guaranteed thermal burdens.

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

g) The diagram for the interconnection of the VTs shall be provided inside secondary terminal box.

16.8.3 Tests:

Current and voltage transformers shall conform to type tests and shall be subjected to routine test in accordance with IEC.

16.9 SURGE ARRESTORS

16.9.1 The surge arrestors shall confirm in general to latest IEC –60099-4.

16.9.2 Insulation co-ordination and selection of surge arrestor:

The contractor shall be fully responsible for complete insulation co-ordination of switchyard including GIS. Contractor shall carry out detailed studies and design calculations to evolve the required parameters locations, energy capability etc. of surge arrestors such that adequate protective margin is available between peak impulse, surge and power frequency discharge voltages and BIL of the protected requirement. The locations of surge arrestors shown in single line diagram is indicative only. If the contractor feels that at some more locations the surge arrestors are required to be provided the same should also be deemed included in the offer.

The contractor shall perform all necessary studies and the report shall detail the limits of all equipment parameters which could affect the insulation co-ordination. The report shall also detail the characteristics of the surge arrestor and shall demonstrate that the selected arrestor's protective and withstand levels, discharge and coordinating currents and arrestor ratings and comply with the requirement of this specification.

The contractor shall also consider in the studies the open circuit breaker condition, fast transients generated by slow operation of disconnecting switches. The study report and design calculations shall be submitted for Owner's approval.

16.9.3 Duty requirements of GIS Surge Arrestor

1. The surge arrester shall be of heavy duty station class and gapless (Metal oxide) type without any series or shunt gaps.
2. The surge arresters shall be capable of discharging over-voltages occurring during switching of unloaded transformers, reactors and long lines.
3. 245 & 145kV class arrester shall be capable of discharging energy equivalent to class 3 of IEC for 245 kV & 145 kV system respectively on two successive operations.\
4. The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

5. The surge arresters are being provided to protect the followings whose insulation levels are indicated in the table given below:-

Equipment to be protected	132 kV system
	Lightning impulse (kVp)
Power Transformer	± 550
Instrument Transformer	± 650
Reactor	-
CB/Isolator Phase to ground	± 650
CB/Isolator Across open contacts	± 750

6. Constructional Features

The nonlinear blocks shall be of sintered/inferred metal oxide material. These shall be provided in such a way as to obtain robust construction, with excellent mechanical and electrical properties even after repeated operations.

The arrestor enclosure shall be vertically or horizontally mounted to suit the layout of the switchgear as suggested by the supplier and each arrestor shall be fitted with a Online continuous resistive leakage current monitoring system. The system shall be provided with an interface to integrate with the substation automation system.

The main grounding connection from the surge arrestor to the earth shall be provided by the contractor. The size of the connecting conductor shall be such that all the energy is dissipated to the ground without getting overheated.

16.9.4 Tests

1. In accordance with the requirements stipulated, the surge arrestors shall conform to type tests and shall be subjected to routine and acceptance tests in accordance with IEC document.
2. Each metal oxide block shall be tested for the guaranteed specific energy capability in addition to the routine/acceptance test as per IEC-60099.
3. Test on Surge Monitors: The Surge monitors shall also be connected in series with the test specimens during residual voltage and current impulse withstand tests to verify efficacy of the same. Additional routine/functional tests with one 100A and 10 kA current impulse, (8/20 micro sec.) shall also be performed on the surge monitor.

16.9.5 Technical Parameters:

Technical parameters are as per annexure 5;

16.10 OUTDOOR BUSHINGS:

Outdoor bushings, for the connection of conventional external conductors to the SF6 metal enclosed switchgear, shall be provided where specified and shall conform to the requirements given in GTR.

The dimensional and clearance requirements for the metal enclosure will be the responsibility of the manufacturer and their dimensions must be coordinated with the switchgear.

Bushings shall generally be in accordance with the requirements of IEC -60137.

16.10.1 Insulation levels and Creepage distances: All bushings shall have an impulse and power frequency withstand level that is greater than or equal to the levels specified for GIS.

The creepage distance over the external surface of outdoor bushings shall not be less than 25 mm/kV and in highly polluted area it shall not be less than 31mm/kV (as per section- Project).

16.10.2 **Bushing types and fitting**: The details of bushing shall be as follows

SF6 to air Bushing shall be of Polymer / composite type and shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout. The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137. All details of the bushing shall be submitted for approval and design review.

Polymer / composite insulator shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution and humidity. The hollow silicone composite insulators shall comply with the requirements of the IEC publications IEC 61462 and the relevant parts of IEC 62217. The design of the composite insulators shall be tested and verified according to IEC 61462 (Type & Routine test)

16.10.3 **Mechanical forces on bushing terminals:** Outdoor bushings must be capable of withstanding cantilever forces due to weight of bus duct (GIB) on one side & AIS conductor/Al tube on the other side and short circuit forces. Design calculations in support of the cantilever strength chosen shall be submitted for owners review and approval.

16.10.4 Type test reports as per applicable IEC including radio interference voltage (RIV) test shall be submitted in line with the requirement as specified in section GTR for approval.

16.10.5 The technical parameters of Bushing are as per Annexure -6.

16.11 SF6 GIS TO XLPE CABLE TERMINATION (If Applicable)

16.11.1 The underground cables shall be connected to GIS by the interfacing of XLPE cable sealing end to GIS Cable termination enclosure.

16.11.2 The SF6 GIS to XLPE cable termination shall conform to IEC-62271-209.

16.11.3 The rating of XLPE cables for different voltages are specified in the Section project.

16.11.4 Cable termination kit shall be in the scope of the contract. The ducts and the casing shall be suitable for the requirements for which it is designed. This interface section shall be designed in a manner which will allow ease of operation and maintenance.

16.11.5 The provision shall be made for a removable link. The gap created when the link is removed should have sufficient electric strength to withstand the switchgear high voltage site tests. The contractor may suggest alternative arrangements to meet these requirements. The corona rings/stress shields for the control of electrical field in the vicinity of the isolation gap shall be provided by the GIS manufacturer.

16.11.6 All supporting structures for the SF6 bus-duct connections between the XLPE cable sealing ends and the GIS shall be the scope of the contract. The supplier may specify alternative connecting & supporting arrangements for approval of the purchaser.

16.11.7 The opening for access shall be provided in each phase terminal enclosures as necessary to permit removal of connectors to isolate the XLPE cables to allow carrying out the insulation tests. The general arrangement drawing of interconnecting bus-duct from GIS bay module to XLPE cable termination end shall also be submitted.

16.11.8 Type test reports of radio interference voltage (RIV) level shall be submitted for approval

16.12 TRANSFORMER TERMINATION MODULE (If applicable)

16.12.1 The transformer termination module enables a direct transition from the SF6 gas insulation to the bushing of an oil-insulated transformer / reactor. For this purpose, the transformer/reactor bushing must be oil-tight, gas-tight and pressure resistant. Any temperature related movement and irregular setting of the switchgear's or transformer's/reactor's foundations are absorbed by the expansion fitting.

16.12.2 The oil filled transformers and reactors are as shown in the substation SLD. The oil to air bushings of the transformers and reactors shall be supplied by the respective supplier's and the same shall be connected to the SF6 ducts thru air to SF6 bushings to be provided under present scope.

16.12.3 Terminal connection arrangement to connect GIS duct to bushing and duct mounting arrangement details shall be submitted during detailed engineering for Employer's/consultant approval and for co-ordination with transformer and reactor supplier. Any modification suggested by autotransformer and reactor supplier shall have to be carried out by the supplier to facilitate proper connection with the bushings of the autotransformer and reactors.

16.12.4 In case of single phase transformers are being installed in the substation, HV &LV auxiliary bus for the transformer bank for connecting spare unit shall be formed inside the GIS.

16.13 LOCAL CONTROL CUBICLE (LCC)

16.13.1 Functions

1. Each circuit-breaker bay shall be provided with a local control cubicle containing local control switches and a mimic diagram for the operation and semaphore for status indication of the circuit-breaker and all associated isolators and earth switches together with selector switches to prevent local and remote and supervisory controls being in operation simultaneously
2. Status indications in the LCC shall be semaphore type or LED type.
3. Closing of the circuit- breaker from the local control unit shall only be available when the breaker is isolated for maintenance purposes. Circuit-breaker control position selector, operating control switch and electrical emergency trip push button shall be installed in the Local Control Cubicle. Circuit-breaker control from this position will be used under maintenance and emergency conditions only. The emergency trip push buttons shall be properly shrouded.
4. If Disconnector or earth switch is not in the fully open or closed position a "Control Circuit Faulty" alarm shall be initiated, and electrical operation shall be blocked.
5. 20% spare terminals shall be provided in each LCC apart from terminals provided for the termination and interconnection of all cabling associated with remote and supervisory control, alarms, indications, protection and main power supply etc .
6. Where plugs and sockets connect control cabling between the local control cubicle and the switchgear these shall not be interchanged.
7. Hydraulic/pneumatic and SF6 auxiliary equipment necessary for the correct functioning of the circuit breaker, isolators and earth switches shall be located in a separate cubicle compartment.
8. LCC shall be suitable for remote operation from substation automation system (SAS) . Each gas tight compartment shall be monitored individually per phase basis through SAS

16.13.2 Constructional features

1. Local Control cubicle shall be either mounted on the GIS with front access or free standing, floor mounting type. It shall comprise structural frames completely enclosed with specially selected smooth finished, cold rolled sheet steel of thickness not less than 3 mm for weight bearing members of the panels such as base frame, front sheet and door frames, and 2.0mm for sides, door, top and bottom portions. There shall be sufficient reinforcement to provide level transportation and installation.
2. Access to all compartments shall be provided by doors. All fastenings shall be integral with the panel or door and provision made for locking. Cubicles shall be well ventilated through vermin-proof louvers having anti insect screen. All doors shall be gasketed all around with suitably profiled Neoprene/EPDM gaskets conforming with provision of IS 11149. However, XLPE gaskets can also be used for fixing protective glass doors.
3. Each LCC panel should have its own separate AC supply source feed from the ACDB. The DC supply shall be from respective relay & protection panel power, control, interlocking, signaling. Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with Fuses. All fuses shall be HRC cartridge type mounted on plug-in type fuse bases. The short time fuse rating of Fuses shall be not less than 9 KA. Fuse carrier base shall have imprints of the fuse 'rating' and 'voltage'.
4. Each LCC Panel shall be provided with the following

    i. **Plug Point**: 230V, Single phase 50Hz, AC socket with switch suitable to accept 5 Amps and 15 Amps pin round standard Indian plug, shall be provided in the interior of each cubicle with ON-OFF switch.

    ii. **Interior Lighting**: Each panel shall be provided with a fluorescent lighting fixture rated for 230 Volts, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch. Adequate lighting shall also be provided for the corridor in Duplex panels.

    iii. **Space Heater:** Each panel shall be provided with a thermostatically connected space heater rated for 230V, single phase, 50 Hz AC supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with switch unit
5. Operating mechanisms, auxiliary switches and associated relays, control switches, control cable terminations, and other ancillary equipment shall be accommodated in sheet steel vermin proof cubicles.
6. Local control cubicles shall be provided to be free standing and shall be equipped with anti-condensation heaters. A suitable humidity stat and thermostat shall be included in the heater circuit.
7. The interior of each cubicle shall be finished with a semi-gloss white surface. An interior lamp suitable for the local LVAC supply, controlled by a door-operating switch, shall be fitted at the top of each panel.

8. The arrangement of equipment within cubicles shall be such that access for maintenance or removal of any item shall be possible with the minimum disturbance of associated apparatus. All the control switches shall be internal i.e. installed behind a lockable glass door.

9. An interlocking scheme shall be provided that takes into account the following basic requirements.

    - To safeguard maintenance personnel who may be working on one section of the equipment with other sections live.
    - Prevent incorrect switching sequences that could lead to a hazardous situation to plant, equipment and personnel.

10. Electrical bolt interlocks shall be energized only when the operating handle of the mechanism is brought to the working position. Visible indication shall be provided to show whether the mechanism is locked or free. Means, normally padlocked, shall be provided whereby the bolt can be operated in the emergency of a failure of interlock supplies.

11. Where key interlocking is employed tripping of the circuit breaker shall not occur if any attempt is made to remove the trapped key from the mechanism. Any local emergency-tripping device shall be kept separate and distinct from the key interlocking.

12. Disconnecting switches shall be so interlocked that they cannot be operated unless the associated circuit-breaker is open except that where double bus bar arrangements are specified, on-load transfer of feeder circuits from one bus bar to another shall be made possible by interlocks which ensure that the associated bus coupler and its isolators are closed.

13. Bus coupler circuit breaker shall be interlocked so that it shall not be possible to open a bus coupler circuit breaker while on load change over on that side of the breaker is in progress.

14. All isolating devices shall be interlocked with associated circuit-breakers and isolators in the same station so that it shall not be possible to make or break current on an isolating device unless a parallel circuit in that station is already closed.

16.14 GIS BUILDING

16.14.1 The buildings shall house each voltage class Gas Insulated Switchgear (GIS) separately and other associated equipment inside in each of the GIS buildings. GIS building(s) shall be constructed for the specified number of bays/diameters as per section project

16.14.2 Wherever GIS hall of proposed voltage is already existing, then the existing GIS hall of respective class shall be suitably extended (wherever applicable) to accommodate the number of bays/diameters as specified in the Section Project.

16.14.3 The contractor shall submit the design & construction proposal of the building along with necessary information, data, and drawings during the detailed engineering according to the complete requirements.

16.14.4 The area for GIS hall(s) is indicated in the enclosed General Arrangement drawing. The area given is for reference only and may vary according to requirement of the equipment to be installed inside. The contractor shall finalize the dimensions according to the equipment offered by them providing enough space & access for erection, operation and maintenance.

16.14.5 The contractor shall place their panels i.e. Bay level units, bay mimic, relay and protection panels, RTCC panels, PLCC panels etc. in a separate room in the GIS building.. The size of the room shall be such that all the panels for the future bays/ diameters as per clause 15.1 shall be accommodated in the above room. The panel room shall be air-conditioned. Further, the temperature of the room shall be monitored through substation automation system by providing necessary temperature transducers. The Switchyard panel room as detailed in section Sub-station Automation System is not required for GIS station.

16.15 ELECTRIC OVERHEAD CRANE:

16.15.1 One EOT Crane each for GIS hall of suitable capacity shall be provided for erection & maintenance of largest GIS component/assembly. The crane shall consist of all special requirements for erection & maintenance of GIS equipment.

16.15.2 The capacity of the crane shall be sized to lift the heaviest GIS switchgear component crane.

16.15.3 The Crane shall be used for the erection and maintenance of the GIS switchgear component and all plant installed in the GIS switchgear room .On completion of erection of the switchgear, the Contractor shall completely service the crane before the Taking over Certificate is issued.

16.15.4 Crane hook approaches shall be of the minimum possible dimensions to ensure maximum coverage of the plant area.

16.15.5 The crane(s) shall be capable of lifting and accurately positioning all loads ranging from full crane rated capacity to at least 10% rated capacity.

16.15.6 The crane shall have minimum speeds under full load of:

Speed

(a) Hoisting 2 meters/minute

(b) Cross Travel 10 meters/minute

(c) Long Travel 20 meters/minute

(d) Creep speed shall be of 25% of operating speed

16.15.7 The electric overhead cranes shall be provided with walkways, platforms. Guard hand rails shall be provided along the bridge rails and on the crab of EOT crane to facilitate cleaning/maintenance of the crane and to give access to the GIS room high bay lighting and ventilation duct and grilles.

16.15.8 The platform and walkways shall be designed to support any weight to be imposed upon them during crane overhaul.

16.15.9 An access platform shall be provided together with a guarded ladder on the crane to allow access to the bridge rails.

16.15.10 The crane shall be possible to be operated through the cable, through the pendant control and which shall be easily accessible from the floor of GIS building and through remote control device.

16.15.11 Contractor shall submit the capacity calculation of crane for GIS hall considering a factor of safety of 5.

a) The crane for 132 kV GIS shall have capacity of minimum 5T safe working load & minimum height of crane have shall be 8.0 meters or as per actual requirement whichever is higher.

16.15.12 In case the GIS hall is to be extended, the scope of work also involves extension of EOT crane girders to facilitate movement of EOT crane in the extended portion of GIS hall.

16.15.13 The following tests may be EOT Crane

1. The crane shall be tested at manufacturer work under full load and 25 percent overload of hoisting and cross transverse motions as a routine test.
2. Further the following tests may be done at site after installation of the crane at site
    a. Check althea accessories for proper function
    b. No load test
    c. Load test as per site conditions

16.16 VENTILATION SYSTEM FOR GIS HALL

16.16.1 Construction of GIS Hall is already in the scope of another project, however extension works on the existing system is in the scope of this project. Each GIS Hall shall have an independent ventilation system. Each Ventilation system shall consist of two 100% capacity systems, one operating and one stand-by.

16.16.2 To ensure that the air being supplied to the GIS hall is free from dust particles, a minimum two stage dust filtration process shall be supplied. This shall consist of at least the following:

1. Pre Filters: To remove dust particles down to 10 micron in size with at least 95% efficiency.
2. Fine Filters: To remove dust particles down to 5 microns in size with at least 99% efficiency.

All the filters shall be panel type. Easy access should be available to the filters for replacement/cleaning.

The ventilation of the GIS hall shall be of a positive pressure type with minimum 4 air changes per hour. The pressure inside the GIS hall shall be maintained 5 mm of water above the atmospheric pressure. Fresh outdoor air shall be filtered before being blown into the GIS hall by the air fans to avoid dust accumulation on components present in the GIS hall. GIS hall shall be provided with motorized exhaust dampers with local control.

16.17 SEISMIC DESIGN CRITERIA:

16.17.1 The equipment shall be designed for operation in seismic zone for earthquake resistance. The seismic loads are due to the horizontal and vertical acceleration which may be assumed to act on concurrently. Seismic Qualification requirements shall be as per IEC 62271-207 for the design of equipment. The equipment along with its parts shall be strong enough and sufficiently well connected to resist total operating stresses resulting from the forces in normal operation, but in case of abnormal condition shall also resist with forces superimposed due to earthquakes. The copies of type test reports for similar rated equipment, if tested earlier, should be furnished. If the equipment has not been type tested earlier, Test Report/Analysis Report should be furnished.

16.17.2 To prevent the movement of GIS sub-assemblies i.e. various bay modules during the earthquake, suitable devices shall be provided for fixing the sub-assemblies to the foundation. The contractor shall supply necessary bolts for embedding in the concrete foundation. The fixing of GIS sub-assemblies to the foundation shall be designed to with-stand the seismic events. It will also be ensured that the special devices as well as bolts shall not be over stressed. The details of the devices used and the calculations for establishing the adequacy shall be furnished by the supplier and shall be subject to the employer's/consultant approval.

16.18 DESIGN REVIEW

16.18.1 Design reviews shall be conducted by Employer/consultant or an appointed consultant during the detailed Engineering of the GIS; however the entire responsibility of design shall be with the supplier.

16.18.2 Employer/consultant may also visit to the supplier's works to inspect design, manufacturing and test facilities.

16.18.3 The design review will commence after placement of award with the successful contractor and shall be finalized before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the GIS under the scope of this specification. Employer/consultant reserve the right to waive off the design review during detailed engineering.

16.18.4 The design review shall be conducted generally following the, "User Guide for the application of Gas Insulator Switchgear (GIS) rated voltage of 72.5kV and above" – CIGRE report No. 125 prepared by CIGRE Working Group 23.10.

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

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

1.	Dielectric Stress of Solid Insulation like Gas Barrier, support insulator etc.
2.	Dielectric stress of SF6 Gas Volume.
3.	Mechanical strength of enclosure, expansion joints etc.
4.	Criteria for providing expansion joint.
5.	Sealing system
6.	Insulation coordination
7.	Thermal stress and resulting increase in gas pressure during short circuit condition.
8.	Earthing of enclosure w.r.t circulating current.
9.	Seismic design, as per IEC 62271-207
10.	Circuit Breaker.
11.	Isolator and Earth switch.
12.	Voltage transformer.
13.	Current Transformer.
14.	Surge Arrester.
15.	Bushing.
16.	Ducting.
17.	Corrosion protection.
18.	Electrical and physical Interfaces with substation.
19.	Testing capabilities.
20.	Inspection and test plan.
21.	Transport and storage.
22.	Maintainability.
23.	Site Test.

16.18.7 Further, the manufacturer shall furnish the following information

a) Details regarding the loosely distributed metallic particles within the GIS encapsulation and calculations of critical field strength for specific particles of defined mass and geometry.

b) Study report of VFTO generated for GIS installation.

c) The methodology and all the equipment for electrical partial discharge (PD) detection, including that mentioned in the specification else-where.

d) The calculations and documents in support of the average intensity of electromagnetic field on the surface of the enclosure above during detailed engineering.

e) The detailed criteria/ design regarding location of pressure relief devices/rupture diaphragms

f) Calculations to show that there is no Ferro resonance due to capacitance of GIS for the voltage transformers

g) Design calculation for simulated parameters for Seismic level as applicable

h) Insulation Coordination studies including studies to recommend for additional surge arrestor

i) Calculation in support of touch & step voltages in all enclosures and earthing of complete GIS installation.

j) Measures to mitigate transient enclosure voltage by high frequency currents.

k) Calculation for providing bus duct supports.

16.19 TYPE TESTS

The offered GIS equipment shall conform to the type tests as per IEC-62271-203. Contractor shall submit type test reports for the following type tests & additional type tests.

Sl.	Description of the Type Test for GIS
1	Tests to verify the insulation level of the equipment and dielectric test on auxiliary circuits
2	Tests to prove the temperature rise of any part of the equipment and measurement of the resistance of the main circuit
3	Tests to prove the ability of the main and earthing circuits to carry the rated peak and rated short time withstand current
4	Tests to verify the making and breaking capacity of the included switching devices
5	Tests to prove the satisfactory operation of the included switching devices
6	Tests to prove the strength of the enclosures
7	Gas tightness tests
8	Tests on partitions
9	Tests to prove the satisfactory operation at limit temperatures
10	Tests to assess the effects of arcing due to internal fault
11	Verification of the degree of protection of the enclosure
12	Tests to prove performance under thermal cycling and gas tightness tests on insulators
13	Additional tests on auxiliary and control circuits
14	Reactor current switching test
15	Test to demonstrate the Power frequency withstand capability of breaker in open condition at lock out pressure.
16	Electromagnetic compatibility tests (if applicable)
17	Radio inference voltage tests (RIV) , if applicable

The test reports of the above type tests for GIS (including type test report on Circuit breaker, Disconnectors, Grounding switches, Current and Voltage transformers as per relevant IEC and type tests of SF6/Air & Oil bushing as per IEC 60137 shall be submitted for approval as per Section- GTR, Technical Specification.

16.20 GENERAL

16.20.1 **Painting of enclosure**: All enclosures shall be painted externally as per manufacturer's painting procedure. The painting procedures as followed shall be submitted during detailed engineering.

16.20.2 **Heaters:** Wherever required, heaters shall be provided to prevent moisture condensation. Heaters are not allowed inside the main circuit**.**

16.20.3 Identification & rating plate

Each bay shall have a nameplate showing

a) A listing of the basic equipment (such as a breaker, Disconnectors grounding switches, current transformers, voltage transformers, and bushings etc).

b) A schematic diagram indicating their relative locations.

c) NEA Contract Number.

d) Each module will have its own Identification & rating plate. The rating plate marking for each individual equipment like Circuit breaker, Disconnectors Grounding switches, Current transformer, Voltage transformers, Surge arrester etc shall be as per their relevant IEC.

16.21 TRANSPORT OF EQUIPMENT TO SITE

The contractor shall be responsible for the loading, transport, handling and offloading of all equipment and materials from the place of manufacture or supply to site. The contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities as well as determining any transport restrictions and regulations imposed by the government and other local authorities. All transport packages containing critical units viz Circuit breakers and Voltage transformers shall be provided with sufficient number of electronic impact recorders (on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. The acceptance criteria and limits of impact in all three directions which can be withstood by the equipment during transportation and handling shall be submitted by the contractor during detailed engineering. The recording shall commence in the factory and must continue till the units reach site. The data of electronic impact recorders shall be downloaded at site and a soft copy of it shall be handed over to Engineer – in –charge. Further, contractor shall communicate the interpretation of the data within three weeks.

16.22 PACKING, STORAGE AND UNPACKING

16.22.1 All the equipment shall be carefully packed for transport by sea, rail and road in such a manner that it is protected against the climatic conditions and the variations in such conditions that will be encountered enroute from the manufacturer's works to the site.

16.22.2 The SF6 metal clad equipment shall be shipped in the largest factory assembled units that the transport and loading limitations and handling facilities on site will allow to reduce the erection and installation work on site to a minimum.

16.22.3 Where possible all items of equipment or factory assembled units shall be boxed in substantial crates or containers to facilitate handling in a safe and secure manner. Should the units be considered too large for packing in crates, they shall be suitably lagged and protected to prevent damage to any part, particularly small projections, during transport and handling. Special lugs or protective supports shall be provided for lifting to prevent slings and other lifting equipment from causing damage. Each crate, container or shipping unit shall be marked clearly on the outside to show where the weight is bearing and the correct position for the slings.

16.22.4 Each individual piece to be shipped, whether crate, container or large unit, shall be marked with a notation of the part or parts contained therein.

16.22.5 Special precautions shall be taken to protect any parts containing electrical insulation against the ingress of moisture. This applies particularly to the metal clad equipment of which each gas section shall be sealed and pressurized prior to shipping. Either dry nitrogen/air or dry SF6 gas shall be used and the pressure shall be such as to ensure that, allowing for reasonable leakage, it will always be greater than the atmospheric pressure for all variations in ambient temperature and the atmospheric pressure encountered during shipment to site and calculating the pressure to which the sections shall be filled to ensure positive pressure at all times during shipment. The type of gas, the maximum pressure to which sections will be filled prior to shipment and the minimum allowable pressure during shipment shall be advised prior to dispatch.

16.22.6 All blanking plates, caps, seals, etc., necessary for sealing the gas sections during shipment to site shall be provided as part of the contract and shall remain the property of NEA. If considered necessary, blanking plates or other sealing devices shall be provided with facilities for measuring the gas pressure and recharging at any time during the transport period. Any seals, gaskets, 'O' rings, etc. that may be used as part of the arrangement for sealing off gas sections for shipment of site, shall not be used in the final installation of the equipment at site. Identification serial numbers shall be stamped into the blanking plates, etc., and on the switchgear equipment to which they are fitted so that they can easily be identified and refitted should it ever be necessary to ship sections of the switchgear back to the manufacturer's works for repair.

16.22.7 Valves and other gas couplings associated with the switchgear gas systems shall be adequately protected against damage from any bumps or physical blows. They shall also be capped to prevent ingress of dirt or moisture or damage to any coupling, pipes, threads or special fittings. Any explosion vents and other pressure relief devices, shall be suitably sealed and protected to prevent accidental exposure of the sealed sections during shipment to site.

16.22.8 For bus ducts involving male and female joints of the current carrying conductor, the same shall be transported in disassembled condition to avoid any damage during transit. All bright parts liable to rust shall receive a coat of anti-rusting composition and shall be suitably protected.

16.22.9 The contractor will be able to use the available storage areas at site. The contractor shall ensure that during the period between arrival at site and erection, all materials and parts of the contract works are suitably stored in such approved manner as to prevent damage by weather, corrosion, insects, vermin or fungoral growth. The scope of providing the necessary protection, storing off the ground, as required etc. is included in the works to be performed by the contractor.

16.22.10 The equipment shall only be unpacked or removed from the containers immediately prior to being installed. They shall not be left lying unnecessarily in open crates or containers. Special precautions shall be taken when gas sections which have been sealed and pressurized for shipping are opened up to reduce the ingress of dirt and atmospheric moisture to a minimum. Whenever possible this shall only be done immediately prior to installation and if any section is to be left outside for any length of time after being opened, it shall be resealed and pressurized with either dry nitrogen/air or SF6 gas until required.

16.23 INSTALLATION OF GIS

16.23.1 Civil works of GIS Hall shall be completed in all respects for taking up the installation and it shall be ensured that all dust and dirt in the hall are removed. All openings (including Bus Duct) except entry door should be closed and proper sealed

16.23.2 The installation area shall be secured against entry of unauthorized personnel. Only certified manufacturer's engineer and supervisor shall supervise critical & important erection works. The help of local technicians can be taken only for material handling and non-critical erection works. Engineers and supervisors of the manufacturer shall submit authorization and competency certificate.

16.23.3 Assembly drawing for GIS erection for the section under progress shall be available and displayed in GIS hall at the time of work.

16.23.4 Proper power supply shall be ensured by installing DG Set of proper rating and frequency if required prior to commencement of erection work so that assembly work is not interrupted in the middle which is critical for GIS installation.

16.23.5 Working personnel shall clean their shoes or apply covers on shoes before entering the immediate working area. The working clothes of authorized personnel shall be made of non-fluffy material.

16.23.6 GIS hall door shall have automatic close facility after entry of personnel to avoid dust and moisture entry. Walls and ceiling shall be in a condition so that neither dirt nor plaster might fall or rub off and formation of condensation water in ceiling shall be prevented under any circumstances.

16.23.7 Floor in the installation area shall have a firm surface and shall be kept dust free with a vacuum cleaner. Vacuum cleaning to be done at regular interval throughout the day with separate team of persons assigned for cleaning work only.

16.23.8 Only T&P and consumables required for GIS erection shall be kept in GIS during erection.

16.23.9 In case of outdoor installation of GIS or of GIS components open gas compartments shall be protected from dust and moisture ingress (by tarpaulin covers etc)

16.23.10 Bus duct exit in the GIS hall wall shall be kept covered by suitable means until permanent cover is provided after installation of bus ducts.

16.23.11 A separate room shall be identified in consultation with NEA/consultant for carrying out repair works/ small part assembly and the room shall be weather protected and lockable. All excess material (not required for immediate installation works) test equipment and tools and tackles to be stored separately from GIS hall in the separate room for rework.

16.23.12 All assembly work shall be done by qualified personnel only who are to be identified before starting of erection work.

16.23.13 Erection agency shall submit method statement and make available formats for checking during each stage of hall preparation, assembly process and final checks to be approved before start of erection. Method statement shall include record of shock/ impact recorder at the time of unpacking. Shock recorder down loaded data and analysis shall be submitted before commencement of erection work. In case of violation of shock limits, expert form manufacturer shall visit and do the internal inspection before giving clearance for erection.

16.23.14 Cleaning is of utmost importance and hence before assembly, all the loose metal parts, subassemblies and all contact& sealing surfaces shall be cleaned before installation. Cleaning shall be e carried out with specified cleaning agents of the manufacturer in no condition water is to be used except for external surfaces. Further, prior to opening, gas compartment shall be thoroughly cleaned and vacuum cleaning of the installation area shall also be done specially the immediate vicinity of the flanges to be connected. Dust disturbance in the area to be avoided

Also, before closing a flange connection clean the immediate vicinity and all accessible parts of the components shall be connected with a vacuum cleaner

16.23.15 Once the transport covers are removed installation of flanges shall be done without any interruptions, if interruptions cannot be avoided open flanges are to be covered with clean plastic foil. Transport covers, O-rings and other packing material shall be taken out of GIS after immediately after removal.

16.23.16 O Rings shall be properly stored and taken out only before installation. O Rings are also to be cleaned before use with manufacturer authorized cleaning agent.

16.23.17 At all points of time during installation authorized personnel shall use disposable gloves to avoid contamination.

16.23.18 Cable termination work shall commence only after completion of GIS equipment as during GIS installation period laying and termination of cables interferes with the GIS erection work and affects cleanliness.

16.23.19 Approved Field Quality Plan shall be followed strictly during site work.

16.24 ON SITE TESTING

After the switchgear has been completely installed on site and filled with SF6 gas, the complete assembly shall be subjected to the site tests as per IEC – 62271-203 and with the test voltages specified below :-

16.24.1 The adequacy of number of UHF sensors and their location shall be verified as per recommendations of CIGRE task force **TF 15/33.03.05** (Task force on **Partial discharge detection system for GIS: Sensitivity verification for the UHF method and the acoustic method**). In case during site testing additional UHF sensors are required, the same shall also be supplied and installed to complete the technical requirement.

16.24.2 Application of AC voltage equal to 1.2 times the service voltage in order to condition the GIS whilst at the same time permitting measurement of Partial discharge and detection of conductive particles by UHF method.

16.24.3 In case of a disruptive discharge in the gas as outlined in clause no: C.6.2.2 Procedure b) , annexure – C of IEC : 62271-203 , and a repeat test is performed due to failure during the AC voltage test , then the test shall be carried out at 1.2 times the service voltage .

The analysis of PD measured during High voltage test shall done very carefully and presence of PD measured by any sensor shall be attended and HV test shall be repeated after the rectification work. Calibration of PD sensors shall be completed before start of HV test to establish reference for detection of PD above 5 pc.

16.24.4 Method statement/ procedure of on-site high voltage testing and PD measurement shall be submitted by contractor in advance.

16.25 TESTING & MAINTENACE EQUIPMENT

All testing & maintenance equipment shall be offered, if specified as per relevant schedule of BPS.

16.25.1 SF6 Gas leakage detector.

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

16.25.2 Gas filling and evacuating plant:

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

   Vacuum Pump: 60 M^3/Hour (Nominal suction pressure)
   Compressor : 15 M3/Hour (Delivery)
4. The evacuation equipment shall be provided with all the necessary pipes, couplings, flexible tubes and valves for coupling up to the switchgear for filling or evacuating all the gases.
5. The gases compartments shall preferably be fitted with permanent non-return valves through which the gas is pumped into or evacuated form the compartments.

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

16.25.3 SF6 gas analyzer:

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

a. In-built calibration facility.
b. Sensitivity of the equipment shall not be affected by any atmospheric conditions like dust, humidity, heat, wind etc.
c. Equipment shall work on zero gas loss principle i.e. gas should be pumped back to the compartment after measurement without any exposure to the atmosphere.
d. Equipment shall be supplied with suitable regulator which can be used to connect SF6 cylinder if required.
e. Following acidic/impurities products should be detected as per IEC 60480 and IEC 60376
  i) SF6 purity – Range: 0-100 % & Accuracy: +/- 0.5 %
  ii) Dew point - Range : -60 to +20 deg C & Accuracy: +/- 0.5 deg C
  iii) SO2 - Range : 0-150 ppm & Accuracy : +/- 2 %
  iv) CF4 – Range : 0-60% vol & Accuracy : +/- 1 %
  v) HF - Range : 0-200ppm & Accuracy : +/- 5 %
f. Instrument should work on AC source as well as on rechargeable battery
g. Input pressure: upto 10 bar
h. It should be housed in a robust IP67 case with wheels

1. Portable Partial Discharge (PD) monitoring system

i. The equipment shall be used for detecting different types of defects in Gas Insulated Stations (GIS) such as Particles, Loose shields and Partial Discharges as well as for detection of Partial discharges in other types of equipment such as Cable Joints, CTs and PTs.

ii. It shall be capable for measuring PD in charged GIS environment as EHV which shall have bandwidth in order of 100 MHz–2GHz with possibility to select a wide range of intermediate bandwidths for best measurement results. The principle of operation shall be based on UHF principle of detection. The instrument should also be able to detect partial discharges in cable joints and terminations.

iii. Detection and measurement of PD and bouncing particles shall be displayed on built in large LCD display and the measurement shall be stored in the instrument and further downloadable to a PC for further analysis to locate actual source of PD such as free conducting particles, floating components, voids in spacers, particle on spacer surfaces etc. Software for display and diagnosis of PD signals and an expert software system for accurate interpretation of cause of PD shall also be supplied and installed by the contractor.

iv. The equipment shall meet the following requirements

  a. Measurement shall be possible in noisy environment.
  b. Stable reading shall be possible in presence of vibrations within complex GIS assemblies, which can produce signals similar to PD.
  c. Equipment should have necessary synchronizing circuits to obtain PD correlation with power cycle and power frequency.
  d. The equipment shall be battery operated with built-in-battery charger. It shall also be suitable for 230V AC/50 Hz input.
  e. Measurement shall be possible in the charged switchyard in the presence of EMI/EMC. Supplier should have supplied similar detector for GIS application to other utilities. Performance certificate and the list of users shall be supplied along with the offer.

f. Instrument shall be supplied with standard accessories i.e., re-locatable sensors with mounting arrangements, connecting cables (duly screened) to sensors, Lap-top PC, diagnostic and expert interpretation software, carrying case, rechargeable battery pack with charger suitable for 230V AC, 50Hz supply connecting cables (duly screened) to view in storage.

g. The function of software shall be covering the following:

a) Data recording, storage and retrieval in computer
b) Data base analysis
c) Template analysis for easy location of fault inside the GIS
d) Evaluation of PD measurement i.e., Amplitude, Phase Synchronization etc.
e) Evaluation of bouncing/loose particles with flight time and estimation on size of particle.
f) Expert software system for accurate interpretation of cause of PD.
g) Report generation.

h. To prove the suitability in charged switchyard condition, practical demonstration shall be conducted before acceptance.

i. Supplier shall have "Adequate after sales service" facility.

j. Necessary training may be accorded to personnel to make use of the kit for locating PD sources inside the GIS

k. Instrument shall be robust and conform to relevant standard.

v. Calibration: The UHF Couplers have to be first calibrated as per CIGRE procedure TF 15/330305 as part of factory acceptance tests to guarantee detection sensitivity of 5pC or better. The GIS of same design shall be used as test specimen during the coupler calibration. The pulse injection level determined through above factory calibration tests shall only be used as reference for site sensitivity checks during commissioning of PDM system. The data sheet/frequency response characteristics shall be submitted for reference.

vi. Pulse generator for UHF sensor sensitivity test shall also be supplied as a standard accessory.

16.26 ANNEXURE-1

TECHNICAL PARAMETERS FOR CIRCUIT BREAKER

S.N	Parameter	132 kV system
1.	Rated voltage kV (rms)	145
2.	Rated frequency (Hz)	50
3.	No. of poles	3
4.	Type of circuit breaker	SF6 insulated.
5.	Rated continuous current (A) at an ambient temperature of 50^0C	1250/2000 (as applicable)
6.	Rated short circuit capacity with percentage of DC component as per IEC-62271-100 corresponding to minimum opening conditions as specified.	31.5 kA (As applicable)
7.	Symmetrical interrupting capability kA (rms) (As applicable)	31.5
8.	Rated short circuit making current kAp (As applicable)	80
9.	Short time current carrying capability for one second kA (rms) (As applicable)	80
10.	Rated line charging interrupting current at 90 deg. Leading power factor angle (A rms) (The breaker shall be able to interrupt the rated line charging current with test voltage immediately before opening equal to the product of U/√3 and	As per IEC

	1.4 as per IEC-62271-100	
11.	First pole to clear factor	As pr IEC
12.	Rated break time as IEC (ms)	60
13.	Total break time (ms)	65
14.	Total closing time (ms)	Not more than 200
15.	Rated operating duty cycle	
16.	Reclosing	Single phase &Three phase auto reclosing.
17.	**Rated insulation levels**	
	Full wave impulse withstand (1.2 /50 µs) between line terminals and ground:	± 650 kVp
	Full wave impulse withstand (1.2 /50 µs) Between terminals with circuit breaker open:	± 750kVp
	Rated switching impulse withstand voltage (250/2500 µs) Dry & wet.	NA
	Rated switching impulse withstand voltage (250/2500 µs) Dry &wet Between terminals with circuit breaker open:	NA
	One minute power frequency withstand voltage between line terminals and ground	275 kV rms
	One minute power frequency withstand voltage between terminals with circuit breaker open	315 kV rms
18.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 266 kV (Micro volts)	500µV
19.	Max. difference in the instants of closing/opening of contacts (ms) between poles	As per IEC
20.	Trip coil and closing coil voltage with variation as specified in Sec. GTR	220 V DC
21.	Rating of Auxiliary contacts	10A at 220 V DC
22.	Breaking capacity of Aux. Contacts less than 20 ms.	10A at 220 V DC
23.	System neutral earthing	Solidly Gound

16.27 ANNEXURE-2

TECHNICAL PARAMETERS FOR DISCONNECTORS/ ISOLATORS

S.N	Particulars	132kV
1.	Rated voltage (rms) Un	145 kV
2.	Rated frequency	50 Hz
3.	System earthing	Effectively earthed
4.	Type	SF6 insulated
5.	Rated continuous current (A) at 50^0C ambient temp.(as applicable)	1200/600 (for line /transformer /bus coupler) (as applicable)
6.	Rated short time withstand current of isolator and earth switch(as applicable)	31.5 kA for 1 second
7.	Rated dynamic short circuit withstand current withstand current of isolator and earth switch(As applicable)	80 kAp
8.	Rated insulation level:	
	One minute power freq. Withstand voltage: To earth :	275 kV rms.
	One minute power freq. Withstand voltage: Across isolating distance	315 kV rms.
	1.2/50 micro sec. Lighting impulse withstand voltage (+ve or –ve polarity) To earth:	±650 kVp
	1.2/50 micro sec. Lighting impulse withstand voltage (+ve or –ve polarity) : Across Isolating distance	±750 kVp
	Rated switching impulse withstand voltage (250/2500 micro-sec.) Dry & wet :between line terminals and ground:	N.A
	Rated switching impulse withstand voltage (250/2500 micro-sec.) Dry & wet :Between terminals with Isolator open:	N.A
9.	Mechanical Endurance clause as per IEC	M1
10.	No. of spare auxiliary contacts on each isolator	4 NO and 4 NC
11.	No. of spare auxiliary contacts on each earthing switch	4 NO and 4 NC

16.28 ANNEXURE-3

TECHNICAL PARAMETERS FOR CURRENT TRANSFORMERS

S.N	Particular	132kV
1.	Rated voltage Un	145 KV (rms)
2.	Rated frequency	50 Hz
3.	System neutral earthing	Effectively Earthed
4.	Rated short time thermal current for 1 second (as applicable)	31.5 kA
5.	Rated dynamic current	78.75kA
6.	Rated insulation levels	
i.	1.2/50 micro second impulse voltage	±650 kVp
ii.	one minute power frequency withstand voltage	275 kV (rms)
7.	Maximum temperature rise over an ambient temperature of 40^0C	As per IEC 60044-1
8.	Radio interference voltage at 1.1 Un/√3 and frequency range 0.5 to 2 MHz	500µV
9.	One minute power frequency withstand voltage between sec. Terminal & earth	3 kV (rms
10.	Partial discharge level	5 pico coulombs

Note: The rating and ratio of the current transformer will be finalized during DDE.

TABLE 3A

REQUIREMENTS FOR 132 kV CURRENT TRANSFORMER (LINE)

No. of cores	Core no.	Applic-ation	Current ratio	Output Burden (VA)	Accuracy Class as Per IEC: 44-1	Min. Knee pt. Voltage Vk	Max. CT Sec.Wdg Resistance (ohm)	Max. Excitation current at Vk (in mA)
5	1	BUS DIFF CHE-CK	2000-1000/1	-	PS	2000-1000/1	10/5	30 on 2000/1 60 on 1000/1
	2	BUS DIFF MAIN	2000-1000/1	-	PS	2000-1000/1	10/5	30 on 2000/1 60 on 1000/1
	3	METE RING	800-600/1	20	0.2S	-	-	-
	4	TRAN BACK UP/ LINE PRTN.	800-600/1	-	-	800-600	8/ 4	25 on 800/1 50 on 400/1
	5	DIFF/ LINE PRTN.	800-600/1	-	-	800-600	8/ 4	25 on 800/1 50 on 400/1

Note: The rating and ratio of the current transformer will be finalized during DDE.

TABLE 3B
REQUIREMENTS FOR 145 kV CURRENT TRANSFORMER

(For Bus coupler bay)

Core no.	Application	Current Ratio	Output Burden (VA)	Accuracy class as per IEC: 60044-1	Min knee point voltage V_K	Max. CT sec. Wdg resistance (ohms)	Max. Excitation current at V_K (in mA)
1	protection	2000-1000/1	-	PS	2000-1000/1	10/5	30 on 2000/1 60 on 1000/1
2	protection	2000-1000/1	-	PS	2000-1000/1	10/5	30 on 2000/1 60 on 1000/1
3	Metering	2000-1000/1	20	0.2S	-	-	-
4	protection	2000-1000/1	-	PS	2000-1000/1	10/5	30 on 2000/1 60 on 1000/1
5	protection	2000-1000/1	-	PS	2000-1000/1	10/5	30 on 2000/1 60 on 1000/1

16.29 ANNEXURE-4

TECHNICAL PARAMETERS FOR VOLTAGE TRANSFORMERS

Sl. No.	Particular	132kV
1	Rated system voltage (Un)	145 KV (rms)
2	Rated frequency	50 Hz
3	System neutral earthing	Effectively earthed
4	System fault level	31.5 kA
5	Rated insulation levels	
i.	1.2/50 micro second impulse voltage	±650 kVp
ii.	one minute power frequency withstand voltage	275 kV (rms)
iii.	250/2500 micro second switching impulse voltage (dry & wet)	NA
6	One minute power frequency withstand voltage for secondary winding	3 kV(rms)
7	Radio interference voltage at 1.1 Un/√3 and frequency range 0.5 to 2 MHz	500µV
8	Rated total thermal burden	
9	Partial discharge level	10 pico coloumbs

TABLE -4A
REQUIREMENT OF VOLTAGE TRANSFORMERS

S.N	PARTICULARS	132 kV		
1	Rated primary voltage	132//√3 kV		
2	Type	Electromagnetic		
3	No. of secondaries	3		
4	Rated voltage factor	1.2 continuous		
		1.5 for 30 seconds		
5	Phase angle error	±10 minutes (for metering core)		
		Sec I	Sec II	Sec III
6.	Rated secondary voltage (V)	110/√3	110/√3	110/√3
7.	Application	Protection	Protection	Metering
8.	Accuracy	3P	3P	0.2
9.	Output burden (VA) (minimum)	50	50	50

16.30 ANNEXURE-5

a) TECHNICAL PARAMETERS OF GIS SURGE ARRESTOR

Sl. No.	Particulars	132 kV
1	Rated system voltage	132kV
2	System neutral earthing	Effectively earthed
3	Rated arrestor voltage	120 kV
4	Nominal discharge current	10 kA of 8/20 µs wave
5	Rated frequency	50 Hz
6	Minimum discharge capability voltage corresponding to minimum discharge characteristics	5 KJ/kV (referred to rated arrestor)
7	Continuous operating voltage at 50^0C	102 kV
8	Min. switching surge residual voltage	
	Max. switching surge residual voltage	280kVp
9	Max. residual voltage at 5 kA	310kVp
11	Max. residual voltage at 10 kA nominal discharge current	330 kVp
12	Max. residual voltage at 20 kA nominal discharge current	
13	Steep fronted wave residual voltage	
14	Long duration discharge class	3
15	High current short duration test value (4/10 micro second wave)	100 kAp
16	Current for pressure relief test	31.5 kA
17	Prospective symmetrical fault current	As per IEC
18	Pressure relief class:	A
19	RIV at 1.1 $U_n/\sqrt{3}$ kV rms(micro volts)	Less than 500
20	Partial discharge at 1.05 COV (pC)	Not more than 5
21	Reference ambient temp.	50 ^{0}C

16.31 ANNEXURE-6

TECHNICAL PARAMETERS FOR SF6/AIR BUSHING

Sl. No.	**Particular**	**132kV**
1	Rated Voltage (kV)	145 kV (rms)
2	Rated Current (Amp)	600
3	1.2/50 micro second impulse voltage (Lightning impulse withstand voltage)	630 kVp
4	250/2500 micro second switching impulse voltage	
5	One minute power frequency withstand voltage	275 kV (rms)
6	Minimum total Creepage distance in mm	3625
7	Minimum Cantilever strength (kN)	5

NOTE:

(i) Extension Module to be coupled shall be compatible with existing GIS. Cost for such extension module shall be included in price of GIS Bus Bar Module and no separate payment shall be made for the extension module/interfacing module/adaptor module.

(ii) **GIS EQUIPENT TO BE INSTALLED AT BAHRABISE SUBSTATION IS OF *TBEA ZONGFA SHANGHAI HIGH VOLTAGE SWITCHGEAR CO. LTD, CHINA* MAKE. SUCCESSFUL BIDDERS SHALL BE PROVIDED WITH THE DETAIL DESIGN/DRAWING REQUIRED AT A LATER STAGE.**

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SECTION - 17

MISCELLANEOUS MATERIALS

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17 MISCELLANEOUS MATERIAL

17.1 General

This specification covers the design, fabrication, properly packing for transportation, delivery, installation, testing and putting into efficient and trouble-free operation of the bus materials, insulators and miscellaneous items complete with all accessories.

17.2 Technical Requirement

17.2.1 Insulators

a) General

All types of insulators shall satisfactorily withstand the specified climatic and service conditions. The strength of insulators as given by the electro-mechanical tests shall be such that the factor of safety when supporting their maximum working loads shall be not less than two and a half.

Design shall be such that stresses due to expansion and contraction in any part of the insulators and fittings do not lead to development of defects.

All insulators, whether cylindrical post or string shall have plain shed profiles.

Damaged insulators shall be replaced at no costs to the Employer.

b) Materials

Porcelain insulators shall be in accordance with IEC standards, where applicable. Porcelain shall be sound, free from defects and thoroughly vitrified and the glazed.

Porcelain glaze shall be smooth, hard, of uniform shade of brown and shall completely cover all exposed parts of the insulators. Outdoor insulator fittings shall remain unaffected by atmospheric conditions producing weathering, acids, alkalis, dust and rapid changes in temperature that may be experienced under working conditions.

Suspension and tension insulators shall comprise porcelain units with ball and socket fittings.

Retaining pins or locking devices for insulating units shall be of phosphor bronze or other approved material, and shall effectively prevent accidental separation of the units.

Unless otherwise approved, the individual units of both the suspension and tension insulator sets shall be identical and interchangeable.

c) Number of discs

- 132 kV: 13 Nos (minimum) per set
- 33 kV: 4 Nos (minimum) per set

d) Marking

Each insulator shall have marked on it the manufacturer's name or trademark, the year of manufacture and the manufacturer's reference mark. Tension and suspension insulators shall also be marked with the guaranteed electromechanical strength. Marks shall be legible and indelible.

e) Post insulator

Post insulator shall be cylindrical type, solid core porcelain, single stacked, provided in accordance with following requirements:

	Type A	Type B
• Rated voltage	145 kV	36 kV
• Nominal voltage	132 k V	33kV
• Impulse withstand voltage	750 kV	250 kV
• Color	Brown	Brown

Test shall be divided into three groups in accordance with IEC 168.

f) Standard particulars of insulator units

Insulator units shall comply with the following requirements. (IEC 305)

1)	Porcelain disc diameter	254 mm
2)	Unit spacing	146 mm
3)	Creepage distance	292 mm
4)	Electro mechanical failing load	12,000 kg
5)	Dry power frequency withstand voltage	70 kV
6)	Wet power frequency withstand voltage	40 kV
7)	Dry impulse withstand voltage	120 kV
8)	Puncture voltage	120 kV

Dimension and tolerances of ball and socket coupling shall comply with IEC Publications 120, and the internal height of the socket shall also comply with the requirements of IEC Publication 372-1 (1977)

17.2.2 Bus Conductor and Fittings

The bus-bar system to be adopted shall be as follows:

- For132 kV it shall be of double bus-bar type with single breaker connecting system.
- For 33 kV it shall be of single bus-bar type with single breaker connecting system. The bus-bar system shall be designed in such a way that at least one bay in each end can be extended in future without major construction.

a) General

Bus bars and electrical connections in outdoor substations shall be in accordance with IEC, BS, ASTM or equivalent national standards in respect of current rating and material analysis.

Bus conductor to be supplied shall be twin ACSR-Cardinal conductor or aluminum tube for 132 kV and single ACSR-Cardinal conductor or aluminum tube for 33 kV. For connection purpose aluminum tube or ACSR-Cardinal conductor may be used. Minimum size and material of each bus shall be as following:

Bus	Material	Min. Size
- 132 kV Main	ACSR- Cardinal	Twin
- 132 kV Branch	ACSR- Cardinal	Single

The 132 kV bus-bars shall be designed for the following conditions:

	Current Carrying Capacity	Fault Level
Main bus-bar -	2500 A	31.5 kA
Branch bus-bar -	*1200 A*	31.5kA

The Contractor shall submit detailed calculation for approval.

Materials used for busbars and connections shall be stressed not to more than two-fifths of their elastic limit. Provision shall be made for expansion and contraction with variation in conductor temperature and busbars shall be arranged so that they may be readily extended in length with a minimum of disturbance to existing equipment.

Busbars shall be in continuous lengths between supports. Connectors shall be of approved type, and if necessary type tested. Connections dependent upon site welding techniques will not be permitted.

Busbars and connections shall be so arranged and supported that under no circumstances, including short circuit conditions, the clearances between live metal and earth, or between other conductors, cross the safe limit.

b) Strain Bus and Fittings

The conductor shall be aluminum conductor steel reinforced (ACSR)"Cardinal" (Overall cross sectional area of 574.3 sq. mm.).

The conductor shall be constructed of hard-drawn aluminum and zinc-coated steel wires which have the mechanical and electrical properties in accordance with the latest revisions of ASTM or equivalent.

The direction of lay of the outer layer shall be right-hand. The direction of lay shall be reversed in successive layers; continuous layer shall in all cases have opposite lay.

The external form and surface of the finished conductor shall be uniformly cylindrical upon completion of manufacture and shall remain so when erected in place on the line.

The surface of the conductor shall be free from points, sharp edges, abrasions or other departures from smoothness or uniformity that would tend to increase radio interference and corona loss. When the conductor is subjected to tensions up to 50 percent of its rated ultimate strength, the conductor surface shall not depart from its general cylindrical form, nor shall any of the strands move relative to each other in such a way as to get squeezed out of place and disturb the longitudinal smoothness of the conductor. Strands of a section of "popped" cable shall not protrude more than 1/2 of their diameter of a strand. The conductor shall be capable of withstanding the normal handling necessary for manufacture and erection, such as, reeling, unreeling, and pulling through stringing sheaves under sufficient tension to keep the conductor off the ground, etc., without being deformed from the cylindrical form that causes to increase radio interference and corona loss.

The make-up and lay of wires shall be such as to produce a conductor essentially free from a tendency to untwist or spring when cut. The steel wires shall be preformed or post-formed so that when the conductor is cut and the aluminum wires are stripped away from the core as required for splicing, the steel wires can be readily regrouped and easily held in place with one hand to allow a splicing sleeve to be slipped over the steel core wire at the cut end of the conductor.

This forming of the core is required and shall be done in a manner which will not in any way scratch, scrape, remove or otherwise damage the zinc coating of the steel core wires, individually or collectively.
The conductor shall be free from excessive amounts of die grease, metal particles and dirt. The Bidder shall describe in complete detail the method, which he proposes to use to clean the conductor in normal production. The effectiveness of the cleaning process shall be subject to verification.

Where dissimilar metals are in contact, approved means shall be provided to prevent electro-chemical action and corrosion. Unless otherwise approved, joints and surfaces of copper or copper alloy fittings shall be tinned.

Suspension and tension conductor clamps shall be of approved types and shall be as light as possible. Those for aluminum conductor shall preferably be compression type. Suspension and tension clamps shall be designed to avoid any possibility of deforming the stranded conductor and separating the individual strands.
Tension conductor clamps shall not permit slipping of or damage to, or failure of the complete conductor or any part thereof, at a load less than 95 per cent of the ultimate strength of the conductor.

Clamps and fittings made of steel or malleable iron shall be galvanized. All bolts and nuts shall be as specified and shall be locked in an approved manner.

c) Tubular Bus and Fittings

Tubular bus shall be made of first melting aluminum alloy, cold rolled or hard-drawn and assembled using corona free fittings. The bus–bar shall be designed and manufactured in such a way to dampen any vibration.
The tubular bus conductor shall be designed to withstand mechanical forces due to short circuit currents; and its temperature when carrying full load current shall not exceed 75 degree C. A safety factor of 2 for normal working loads and 1.5 with short circuit currents shall be used. Vibration of bus shall be checked for the design wind conditions.

The tubular bus shall include a small drain hole in any low section. Where joints are required they shall be of the thin leaf type. They are required at all potheads and as required on bus bars. Bus supports for main tubular buses shall include rigid fixed conductor clamp with slide fit on adjacent supports.

All bus support clamps shall be cast of first melting aluminum alloy. Each clamp shall be adjustable for alignment with insulator and furnished with four galvanized steel mounting bolts.

- Bolted type clamps shall be furnished with first melting alloy and, bolts, nuts and washers shall be finished with an anodic coating and lubricated. The clamps for tubing shall have dimensions and sections suitable for splicing two pieces of tubing in the clamp.
- Flexible elements of expansion bus support clamps shall be laminated aluminum strap, which has current capacity equivalent to the tube.

Terminal connectors for aluminum shall be of first melting cast aluminum alloy. All terminal pads shall be furnished with stainless steel bolts, nuts and Belleville washers.

The bolted type terminal connectors shall be a multi grip type terminal and furnished with first melting aluminum alloy with bolts, nuts and washers finished with anionic coating and lubricated.

Bolted type connectors shall be furnished with first melting aluminum alloy with bolts, nuts and washers finished with anionic coating and lubricated.

Angle connectors:

All angle connectors shall be of streamlined, bolted type and made of first melting cast aluminum alloy. Tap element sockets shall be deep enough to allow for error in cut-off.

- Couplers: All couplers shall be of bolted type and made of first melting cast aluminum alloy.
- Corona Bells: All corona bells shall be streamline internal type and cast of first melting aluminum alloy.

The Contractor shall submit calculations regarding selection of the size of the bus material for approval.

d) Overhead ground wire

Overhead shield wire shall be galvanized steel wire, stranded with a minimum cross sectional area of 61.7 sq mm and shall comply with BS 183.

Earth wires shall be greased as for conductors and the outer strands shall have a right hand lay.

Each completed shield wire shall be bare and shall be composed of the specified number of strands.

The nominal diameter of individual wires shall have a variation of not more than plus or minus one and one-half (1.5) percent.

Joints or splices may be made in the individual wires prior to drawings to final size or in the finished wire composing the strand. Such joints shall have protection to corrosion equivalent to that of the finished wire itself and shall not decrease the strength of the finished strand below the specified minimum breaking strength. Joints in the individual wires in the finished strand shall be separated by at least 15.2 meters.

All strands in the wire shall lay naturally in their true position in the completed cable, shall tend to remain in position when the cable is cut at any point, and shall permit restraining by hand after being forcibly raveled at the end of the cable. The strand shall be free from imperfections and consistent with good commercial practice with a carefully controlled finish completely free from any dirt, loose metal particles, nicks, scratches, abrasions or deformities of any nature.

Each item of material to be furnished by the Contractor shall be accompanied by the manufacturer's routine factory test certificates/reports.

17.3 Tests

17.3.1 Insulators

The insulators shall be tested in accordance with IEC standards. Certified copies of the tests shall be submitted for approval to the Employer.

a) Design tests

- Power frequency wet withstand voltage test
- Critical - impulse flashover test
- Impulse withstand test
- Radio-interference voltage test
- Compression strength test
- Thermal shock test

b) Quality conformance tests

- Visual and dimensional test
- Porosity test
- Galvanizing test
- Cantilever strength test
- Torsional strength test
- Tensile strength test

c) Routine tests

- Flashover test
- Tension tests

17.3.2 Bus Materials

Following shop tests shall be performed by the manufacturer on the bus material. The Contractor shall submit such test reports to the Employer for approval before dispatch.

a) Aluminum Tube

- General inspection
- Chemical composition of aluminum alloy
- Conductivity measurement of aluminum tube

- Dimension and weight measurement
- Certified report of aluminum alloy from the original manufacturer

b) Bus Support Clamp and Connector

- General inspection
- Dimension measurement
- Chemical composition of aluminum alloy
- Certified report of aluminum alloy from the original manufacturer

c) Connectors for Stranded Conductor

- General inspection
- Measurement of dimensions
- Compression tests
- Certified report of aluminum alloy from the original manufacturer

d) Miscellaneous Hardware

- General inspection
- Measurement of dimensions
- Tension test
- Galvanizing test

17.4 Packaging and Marking

17.4.1 Insulator

a) Packaging

The insulators shall be packed in strong wooden boxes with a waterproof lining. These boxes shall provide adequate protection against salt spray, chemical attack and damage that might be encountered in transportation and rough handling during loading, transportation to job site, unloading to temporary storage, ocean transportation, etc.

b) Marking

In addition to marks required for shipping purposes, each crate and pallet shall be marked with shipper's identity, Employer's name and address and quantity and type of contents etc. Also, the gross, tare and net weights in kilograms shall be stenciled on each pallet.

17.4.2 Bus Materials

a) Packing

The conductor shall be furnished on non-returnable wooden reels, and shall be properly protected to prevent displacement, chafing, distortion, damage from corrosive atmosphere or other damage to the conductor, which might be encountered in shipping, storage for handling, etc. Each layer of conductor shall be separated from the adjacent layer in such a manner as to prevent abrasion or other damage during handling and shipping.

The non-returnable reels shall be made of strong materials suitably strengthened for ocean transport and treated to withstand rotting or any type of damages due to ocean atmosphere. The reels shall be capable of withstanding all stresses due to braking and string operations. The Employer will accept the use of returnable reels, but any additional costs in disposing such reels shall be the responsibility of the Contractor.

b) Marking

In addition to marks required for shipping purposes, each reel-head shall be stenciled to show serial number, type of conductor, length of conductor in meters, the gross, tare, and net weights in kilograms. Each reel shall also be plainly marked to indicate the direction in which it should be rolled to prevent loosening of the conductor on the reel. Those reels from which test samples were taken shall be marked "TESTED" with length of sample conductor removed and removal included in the markings.

17.5 Guarantee

Any defects in materials or workmanship or other failure to meet requirements of these specifications, which are disclosed prior to the Operational Acceptance Certificate by the Employer, be corrected entirely (including removal and replacement) at the expense of the Contractor.

Any latent defects not disclosed before date of the Operational Acceptance Certificate but disclosed within Defects Liability Period shall be corrected promptly by and at the expense of the Contractor.

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SECTION - 18

VISUAL MONITORING SYSTEM (VMS)

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Section 18 Technical Specification for Visual Monitoring System

18.1 Visual monitoring system for watch and ward of Substation premises:

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

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

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

1. The operation of each and every isolator pole of the complete yard in case of AIS Sub-station.
2. The Operation of each bays of GIS Hall as Applicable.
3. All the Transformer, all the Entrance doors of Control Room Building, GIS Hall and Switchyard Panel room as applicable.
4. All the gates of switchyard.
5. Main entrance Gate
6. All other Major AIS Equipment (such as CB, CT, CVT, SA etc. as applicable)

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

18.2 Technical requirements of major equipment of Visual Monitoring System

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

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

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

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

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

calculation for the UPS considering the total load requirement of Video Monitoring System.

18.3 System requirements:

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

b) All cameras may be connected through a suitable LAN which shall be able to perform in 765 kV class sub-station environment without fail.

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

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

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

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

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

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

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

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

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

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

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

18.4 Video Surveillance Application Software

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

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

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

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

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

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

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

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

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

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

18.5 Network video recorder

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

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

1.	Server Spec	Intel Quad Core (or better) 3.0 Ghz (min.) , 8 MB Cache , 4 GB memory , with suitable NVIDIA graphics card,3 TB HDD , Raid 5
2.	Recording and Display Frame Rate	Real-time 25 frames per second per channel , manual select
3.	Recording Resolution	(PAL): 1280X720 , 704(H) x 586(V) It should be possible to select lower resolutions
4.	Compression Method	H.264/MPEG-4 or better and latest
5.	Video Motion Detection Capable	Standard and built-in (selectable in menu)
6.	Monitoring Options	Split screen 1, 2, 4 , 8, 16, 32 or more cameras
7.	Playback Options	Search, still image capture
8.	Alarm/Event Recording Capable	To be provided with built-in external alarm input/ output ports minimum(8 in, 2 out)

9.	Network Operation Capable	To be provided by using WAN or LAN router
10.	Remote Internet Viewing Capable	Using WAN or LAN router
11.	HDD Storage Consumption	1GB ~ per hour / channel variable based on frame speed and resolution settings, as well as compression
12.	Operation	Triplex operation (simultaneous recording, playback, network operation)
13.	Number of Video Channel	32
14.	Audio Recording Capable	32
15.	Input Voltage	230V AC or equivalent with UPS as a
		back up for 30 minutes.

18.6 VMS Camera

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

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

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

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

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

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

g) Housing of cameras meant for indoor use shall be of IP 42 or better rating whereas outdoor camera housing shall be of IP 66 or better rating. Housing shall be robust and not have the effect of electromagnetic induction in 765/400KV switchyard.

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

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

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

1.	Image Sensor	2-megapixel Progressive ,1 / 3" CMOS/CCD sensor, Minimum illumination 0.1 Lux
2.	Min Luminous	0.5LUX(Color) 0.05Lux(Black)
3.	Camera Enclosure Type	IP66 Grade
4.	Iris/Focus	Auto/Manual
5.	Video Compression	Dual Stream H.264 and MPEG 4 user selectable
6.	Support Dual-stream	primary/secondary stream, H.264/MPEG 4 optional

7.	Video Definition	Primary stream:1600x1200,1280x960,1280x720,
		Secondary stream:800x600,400x288,192x144
8.	Video Parameters	Brightness, hue, contrast, saturation and image quality
9.	Video Frame Rate	PAL: 1-25frames/second NTSC:1-30frames/second
10.	Video Compression BR	32Kbit/S - 6Mbit/S
11.	Video Output	One channel composite Streaming
12.	Supported Protocols	TCP, UDP, IP, HTTP, FTP, SMTP, DHCP, DNS,ARP, ICMP, POP3, NTP, IPsec, UpnP, RTP, RTCP
13.	Operating Temperature	-5 ~ +50Ĥ
14.	Operating Humidity	10 ~ 90%

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

1.	Image sensor	1/3 type Solid State Progressive Scan CCD,WDR(High Definition)
2.	Security	Multiple user access with password protection
3.	Effective Pixels	(PAL): Main Stream：1280x720 Sub Stream：640x360、320x280 selectable
4.	Compression	Dual Stream H.264 and MPEG 4 user selectable
5.	Signal System	50 Hz
6.	S/N (signal to noise) Ratio	Better than 50 dB
7.	Electronic Shutter	1/60 ~ 1/10,000 sec. automatic or better
8.	Scanning System	Progressive/interlace
9.	Low Light Sensitivity (lux)	Color: 0.5 Lux; B&W:0.02 Lux
10.	Lens	Minimum 10x (minimum) optical in High Definition (The system shall be able to zoom the images on the monitor without any distortion to the maximum level of optical zoom)
11.	Lens Size	Minimum 4.1~73.8 mm
12.	Lens Aperture	F1.6(wide)~F2.8(tele), f=4.1~41.0mm, 10X Zoom, Video Auto Focus Angle of View Horizontal : 52°(wide) , 2.8°(tele)
13.	PTZ Data Transfer Baud/Bit Rates Supported	Selectable 2400 bps / 4800 bps / 9600 bps
14.	Panning Range	Complete 360 degrees (horizontal)
15.	Pan Speed	Adjustable, 0.1 degrees / second ~ 250 degrees / second
16.	Tilting Range	Minimum 180° Tilt Rotation
17.	Tilt Speed	Adjustable, 0.1 degrees / second ~ 150 degrees / second

18.	In Built Storage	Camera should have inbuilt storage TF or SD format for recording and storing Pictures
19.	IP Class	IP66 Standard
20.	Working temperature	-0 ~ +50
21.	Working Humidity	10 ~ 90%

18.7 PTZ-Keyboards

The features of PTZ shall include:

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

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

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SECTION – 19

DIGITAL PROTECTION COUPLER

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SPECIFICATION FOR DIGITIAL PROTECTION COUPLER

1.0 Digital protection coupler for protection signaling through optical fiber cable system.

1.1 The Digital protection signaling 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 signaling 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 2Mbps port. It shall provide suitable interfaces for protective relays, which operate at 220/110V DC. Power supply points shall be immune to electromagnetic interface.

1.2 Principle of operation

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

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

1.3 Loop testing

An automatic loop testing routine shall check the tele protection channel.

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

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

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

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

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

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

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

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

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

i) 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 operate time without propagation delay	≤ 8 ms
v)	Interface to Protection relays	
	Input:	Contact Rating:

Rated voltage : 250 volts DC
Maximum current rating: 5 amps

Output: Contact Rating:
Rated voltage : 250 volts DC
Rated current : 0.1 A DC Other
parameters : As per IEC-255-0-20

vi) Alarm contact
Rated voltage : 250 volts DC
Rated current : 0.1 A DC Other
parameters : As per IEC-255-0-20

vii) Digital communication interface: G 703(E1)

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SECTION - 20

INSPECTION, TESTING AND COMMISSIONG

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20 INSPECTION, TESTING AND COMMISSIONING

20.1 Scope of work

The whole of the Works supplied under the Contract shall be subject to inspections and tests by the Employer and/or their Representatives during manufacture, erection and after completion. The inspections and tests shall include, but not be limited to, the requirements of this section of the Specifications.

The Contractor shall provide all appliances, apparatus, supervision, labor and services necessary to carry out all tests at his own cost, unless specifically stated otherwise.

The Contractor shall furnish the detailed schedule of his schedule for routine test before dispatch from factory and commissioning plan at least one month prior to the scheduled date. The schedule shall include the testing/commissioning procedures, testing sequences and details of special testing equipment, tests and commissioning record formats, information about relevant standards etc.

The scope of the commissioning program includes the site testing and putting into successful operation of all the equipment supplied under the Contract, for 132kV, 33kV, AC & DC plants and all secondary voltages systems. Testing of energy meters and certification of their accuracy shall also be included.

20.2 Objectives of Commissioning Test

The objectives of commissioning work, prior to the successful energisation of equipment/system at full voltage and connection to the system, are the following:

- Confirm the integrity (correctness) of installation.
- Confirm the integrity of insulation, connections and phasing.
- Ensure proof of equipment characteristics.
- Review workmanship.
- Confirm the correct implementation of the design.
- Check equipment ratings.
- Check settings and operation of protective relays.
- Check and measure resistivity of grounding grid and grounding system.
- Confirm the proper functioning of SCADA system.

20.3 Quality Assurance, Inspection and Testing

To assure that the supply and services under the scope of this Contract whether manufactured or performed within the Contractor's works or at his subcontractor's premises or at the Site or at any other place of work, are in accordance with the Specifications, the Contractor shall adopt suitable quality assurance program to control such activities at all points necessary. Such program shall be outlined by the Contractor and shall be finally accepted by the Employer after discussions before the award of the Contract. A quality assurance program of the Contractor shall generally cover, but not be limited to the following:

(a) His organization structure for the management and implementation of the proposed quality assurance program.
(b) Documentation control system.
(c) Qualification data for bidder's key personnel.
(d) The procedure for purchases of materials, parts, components, and selection of sub-contractors' services including vendor analysis, source inspection, incoming raw materials inspection, and verification of materials purchases.
(e) System for shop manufacturing including process controls and fabrication and assembly controls.
(f) Control of non-conforming items and system for corrective actions.
(g) Control of calibration and testing of measuring and testing equipment.
(h) Inspection and test procedure for manufacture.
(i) System for indication and appraisal of inspection status.
(j) System for quality audits.

(k) System for authorizing release of manufactured products to the Employer.
(l) System for maintenance of records.
(m) System for handling storage and delivery.
(n) A quality plan detailing out the specific quality control procedure adopting for controlling the quality characteristics relevant to each item of supply.

The quality plan shall be mutually discussed and approved by the Employer after incorporating necessary corrections by the Contractor as may be required.

20.3.1 Quality Assurance Documents

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

The Employer, through his duly authorized representatives, reserves the right to carry out Quality Audit and Quality Surveillance of the systems and the procedures of the Contractor's and the subcontractor's Quality Management and Control Activities.

20.3.2 Inspection, Testing and Inspection Certificates

The provisions of the clauses on Test and Inspection of the General Conditions of Contract and Special Conditions of Contract shall be applicable to the supply and erection portions of the Works. The Employer shall have the right to re-inspect at his expenses, any material though it would have been previously inspected and approved by him at the Contractor's works before, and if, after the same are inspected at Site following the latter, material is found defective, then the Contractor shall bear the cost of this inspection and reinstatement according to specification.

20.4 Tests at Manufacturers Works

20.4.1 General

Where no specific test is specified, then the various items of materials and equipment shall be tested in accordance with the relevant Indian, British, IEC, or American Standards. Where no appropriate standard is available, tests shall be carried out in accordance with the maker's standard practice, which shall be subject to the Employer's approval.

At least fourteen days' prior notice, in writing or by telefax, shall be given to the Employer of the readiness of the plant for test or inspection and every facility shall be provided by the Contractor and sub-Contractor (s) to enable the Employer or their Representative to carry out the inspections and witness the tests. This includes progress, test rig and packing inspections also.

Inspection of equipment will not be carried out unless the Employer has approved copies of the relevant sub-orders, drawings and test procedures.

No equipment shall be packed, prepared for shipment, or dismantled for the purpose of packing for shipment, unless it has been satisfactorily inspected, or inspection has been waived by the Employer.

Functional electrical and mechanical tests shall be carried out on the completed plant after assembly in the Works. The extent and method of recording the results shall be agreed by the Employer in sufficient time to enable the tests to be satisfactorily witnessed or to make any changes to the proposed program of tests.
All instruments and apparatus used in the performance of the tests shall be subject to the approval of the Employer and, if required by the Employer, shall be calibrated to an agreed standard at a laboratory of national standing to be nominated by the Contractor and approved by the Employer.

The costs of carrying out such calibration shall be borne by the Contractor in all cases.

The costs of making any test shall be borne by the Contractor. This shall apply to tests performed at the site or elsewhere.

After receiving the prior information about the completion of manufacturing at the factory, the Employer will depute his personnel to the Contractor's factory to witness the fabrication, assembly and testing of any or all parts of major equipment. The number of the Employer's personnel and equipment to be witnessed will be as listed below. The duration of such visits shall be as per inspection/testing requirements.

- 132 kV Circuit Breakers 2 persons, 1 visit
- 132/33 kV Power transformers 2 persons , 1visit
- 33/11 kV Distribution transformer 2 persons , 1visit
- Control & Relay Panels 2 persons, 1 visit
- Substation Automation/Communication 2 persons , 1 visit
- Disconnecting Switch 2 persons , 1 visit
- Instrument transformers 2 persons , 1 visit
- 11 kV Switchgear 2 Persons ,1 Visit
- Power Cables 2 Persons, 1 Visit
- GIS 2 Persons, 1 Visit

20.5 Test Certificates

All principal test records, test certificates and performance curves shall be supplied to the Employer in number of copies and time frame mentioned in section-2.

These test records, certificates and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Employer or his representative. The information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificate refers and should also bear the Contract reference title. Specified requirements shall be shown on each certificate for comparison with actual test results.

When all equipment has been tested, test certificates of all factory and site tests shall be compiled by the Contractor into volumes and bound in an approved form complete with index. Two copies of each volume shall be supplied to the Employer's representative and five copies to the Employer.

20.6 Type Tests

Type tests are required to prove the general design of the equipment and the Contractor may submit certificates of such design tests, which have been carried out on identical equipment. Notwithstanding any provision in BS, IEC or ANSI Standards, the Employer shall have the right to accept such certificates in lieu of the specified type tests or to reject them.

The type tests prescribed shall be carried out at the Contractor's cost in all cases, where either such certificates are not available or are rejected by the Employer.

20.7 Responsibilities

To ensure that the test jurisdiction and transfer of responsibilities is regulated by strict safety and handover procedures, the Contractor agrees the interface with the Employer to establish and implement handover procedures consistent with the terms of these Specifications.

The Employer shall retain full jurisdiction over all commissioning activities, which may affect the operation of the existing system. In these circumstances and when so requested, shall provide technical advices and assistances.

The Contractor shall be responsible for technical guidance and assistance in establishing the scope and method of tests, witnessing of the testing, assessment of results, and re-negotiation of the changes in test schedules

which may be necessary as a result of other circumstances, such as delays in the delivery, possible equipment failures.

20.8 Safety Procedures

The Contractor shall share the responsibility for safety procedures with the Employer.

The Contractor shall establish and implement a work permit and tagging system and associated safety procedures (subject to the review of Employer) for all equipment, systems and areas not covered by the Employer's safety procedures.

The Employer will assume responsibility for the establishment and implementation of tagging, safety and work permit procedures for the protection of personnel and equipment, as soon as equipment and systems are connected to or are energizeable from the existing system.

20.9 Training of the EMPLOYER'S Staff

The Contractor shall plan for the Employer's staffs' participation, either continuously or on a regularly recurring basis, in the commissioning work and:

Allow the Employer's staffs to become familiar with the operating and maintenance aspects of the new equipment supplied by him,

Maintain a continuing assessment with the Employer of the precautions required in, or possible consequences of, initial energization of equipment,

Allow for the above two necessary objectives in the preparation of schedules.

The Contractor shall station at site, at least, one technical expert for a minimum of six months continuously after commissioning to rectify any problems, as well as train the Employer's attending staffs. If required, the length of his stay shall be extended as per requirement, which shall be at the Employer's discretion.

20.10 Commissioning Staff

The Contractor shall provide commissioning personnel including skilled and unskilled labor as required. Submit a list with names, experience and proposed duration of the stay of key personnel on site, consistent with the construction schedule, along with the commissioning program.

Ensure that only staffs assigned to commissioning fulfills that duty for the duration of the assignment.

Ensure that commissioning staffs have authorization, and the competence, to undertake minor repairs or to make temporary redesigns and to reconnect systems to meet the specified system performance to preclude delays in energization and putting into commercial service of any part of the works.

20.11 Test Equipment

The Contractor shall ensure that all instruments, tools and other equipment required for testing and commissioning are available on site, ensure that the test equipment is of satisfactory quality and condition and, where necessary, is calibrated by an approved authority or standard.

Make arrangements for the provision of power supplies for testing with necessary vector configuration, voltage and current rating.

20.12 Commissioning Program

Prepare a commissioning program for approval by the Employer and for incorporation into the Project master construction program. Allocate adequate time in this program to permit full commissioning of all components.

Carry out all testing during normal working hours as far as practicable. Tests, which involve existing apparatus and system outages, may be carried out outside normal working hours. Give the Employer sufficient notice to allow for the necessary outage arrangements to be made in conformity with the testing program.

Note that no tests listed in the agreed program will be waived except upon the instructions or consent of the Employer in writing.

20.13 Test Procedures

The following basic tests, in addition to others, shall be carried out:

- Measurement of insulation resistance.
- AC withstand voltage test

20.14 Requirements for Field Tests

The field tests shall be carried out in presence of Employer under the following conditions:

AC withstand test voltages for conductors and outdoor equipment shall be normal operation voltage of the transmission line and, withstand voltage test shall be carried out for ten (10) minutes by the normal voltage mentioned above.

The field tests shall be carried out by the Contractor after adjustment of all the equipment have been completed.

Expandable and lead wires and other materials required for the field tests shall be arranged by the Contractor. The Contractor shall be responsible for providing all measuring instruments, test equipment and tools required for the tests.

Preparation of the test record sheets and test reports shall be the responsibility of the Contractor and the results of the field tests shall be submitted by the Contractor for Employer's approval.

Measurement of insulation resistance of the equipment of voltage less than 11 kV shall be performed at 1,000 V. Measurement of insulation resistance of the equipment of voltage ≥11 kV, 5,000 V, motor driven insulation tester shall be used.

After completion of the measurement of insulation resistance mentioned above, ac withstand voltage test shall be performed by the normal operation voltage of the existing power system in accordance with the following procedure:

- 11, 33 and 132 kV Main Circuit: The 11 kV, 33 kV and 132 kV circuit breakers and disconnecting switches, except for circuit breakers receiving power for the test from the existing power system through a transmission line, shall be closed, succeeding, normal operation voltage shall be charged on the equipment and bus conductors for ten (10) minutes for ac withstand voltage test. The indication value of meters mounted on the board during the ac withstand voltage test shall be recorded on the test record sheets prepared by the Contractor.

The Contractor shall submit test procedures, consisting of detailed test methods and samples of the related test record forms, for all equipment to be tested, to the Employer for approval along with the commissioning program. The Contractor shall also strictly adhere to these procedures for the commissioning tests.

20.15 Records

Maintain an up-to-date record of all commissioning activities on site.

Record the results of the tests clearly on forms and formats approved by the Employer and with clear references to the equipment and items tested, so that the record can be used as the basis for maintenance tests, in future.

Submit the required number of site test records to the Employer as soon as possible after completion of the tests.

Record the details of the test equipment and instruments used in the test sheets, in those cases where the instrument or equipment characteristics can have a bearing on the test results.

20.16 As-Built Drawings

Keep an ongoing record of all changes on a master set of drawings. Produce and supply a minimum of five complete sets of marked-up "As Constructed/As-Built" drawings before leaving the Site. Correct and re-issue the original drawings as soon as possible as per this specification.

20.17 Test Methods

Carry out all necessary tests for commissioning the substations. The following clauses detail the tests which are considered to represent the minimum required in addition to those specified under the appropriate IEC Publications, other approved standards and the manufacturer's instructions for each item of equipment.
Strictly adhere to the methods of testing approved by the Employer.

20.18 Site and Commissioning Tests for Main and Auxiliary Equipment

General Checks

- Make a general check of all main and auxiliary equipment. Include a check of the completeness, correctness and condition of ground connections, labeling, arcing ring, paint surfaces, cables, wiring, pipe-work, valves, blanking plates and all other auxiliary and ancillary items.
- Check for oil and gas leaks and that insulators are clean and free from external damage. Check that loose items, which are to be handed over to the Employer, e.g., blanking plates, tools, spares, etc. are in order and are correctly stored or handed over.

20.18.1 Power Transformers

Make all tests as per commissioning tests called for in the Manufacturers' instructions manual.

Record and submit to Employer in a hardcover binder, all test data obtained.

20.18.2 Circuit Breaker Tests

- For the SF6 circuit breakers, test the gas system to prove the gas density, its dryness and its di-electric strength. Measure the gas leakage rate.
- Check and set pressure switches settings when required. Also test mechanical operating systems.
- Carry out contact resistance tests. In the case of multi-interrupter circuit breakers, perform resistance tests at each interrupter or pair of interrupters as well as through the series of interrupters on each pole.
- Test local and remote trip/close operation and perform circuit breaker and auxiliary contact timing tests on all circuit breakers.

20.18.3 Control/ Relay Panels, energy meters and Switchboards

- Carry out general testing and inspection, as referred to above. The Contractor shall also carry following tests: a) Carrier signal testing b) protective relay testing c) Instrument transformers testing c) Phase correcting testing. Functionally test and perform the timing tests on circuit breakers and AC and DC circuits, associated with stand-by auxiliary supplies and stand-by generating sets, particularly where automatic operation is defined.
- Carry out insulation measurement tests of secondary circuits with a 1000 V DC megger before and after high voltage testing.
- Check shutters, interlocking, earth procedures and the inter-changeability of components.

- Carry out a high voltage 50 Hz dielectric test on each bus at 75% of the specified value for the equivalent factory test.

20.18.4 Disconnecting Switch and Earth Switches

- Test all disconnecting switch and earth switches operationally to confirm contact pressures, contact resistance, simultaneous-operation of all phases and the ease of operation.
- Check the local and remote indications and the operation of auxiliary contacts. Check the earthing mat at the operating positions and check the availability of connecting points for maintenance earthing arrangements.
- Test the earth switches and maintenance earthing devices to confirm the opening and closing sequences and check the ground mat connections, indications and manual locking devices.

20.18.5 Lightning Arresters

- Inspect and verify the condition and satisfactory mounting of the arresters and their earth connections, electrodes and operation counters. Note the counter readings.

20.18.6 Busbars and Connections

- Test flexible busbars and connections to ensure that the correct tensions, sags and clearances will be maintained over the range of environmental conditions and loads without stress to other equipment. If dynamometers are used to check the sags and tensions, check them before and after use.
- Check rigid busbars and connections to ensure that the busbars will not cause overloading of the supporting insulators under load conditions and under the range of climatic variations applicable to the Site. Ensure that expansion and contraction of the equipment is fully accommodated by flexible connections.

Test conductivity on selected connections and joints.

- Perform high voltage DC tests on all HV cables and isolated phase bus bars at 75% of the specified value for the equivalent factory test. Carry out with at least 1000 V DC megger the insulation measurement test, before and after high voltage tests.

20.18.7 Batteries and Battery Charging Equipment

- Test the insulation to earth of the complete DC system.
- Test the batteries and chargers to confirm the charger ratings, adjustment, alarm systems and battery capacity for the specified length of time at maximum expected loading.
- Record the specific gravity and cell voltages of the batteries during the initial charge and when fully charged and maintain proper regular records until the battery is taken over by the Employer.
- Interlocking
- Check all interlocking arrangements, both electrical and mechanical.

20.19.8 Grounding System

- Carry out the tests and measurements in accordance with IEEE Standard 80.
- Test the effectiveness of the bonding and grounding and make conductivity tests on selected joints on the main grounding system and at the connections to equipment and structures. Check the precautions taken to avoid corrosion attack on the grounding system.
- Measure the resistance of the grounding system to the remote earth indicating method and equipment used. Separate test probes of minimum 300 to 600 meters length to effectively test the grounding system.
- Perform grounding resistance measurements with the transmission line earth wires disconnected from the grounding grid.

20.18.9 Area Lighting

- Check all lighting circuits including the operation of relevant photoelectric cells and remote/local commands.
- Measure the lighting levels throughout the substation on horizontal surface 800 mm above ground level and on all vertical surfaces of transformers, marshaling kiosks, etc.
- Measure the lighting levels in the area surrounding the substation up to 20 m from the fence.

20.18.10 Particular Constraints and Special Tests

- The Contractor shall be prepared to cooperate with any special tests requested by the Employer.

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TECHNICAL SCHEDULE

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21.1 Schedule A.1 : System parameters of 132kV, 33kV & 11kV systems

Sl. No.	Description of Parameters	132kV System	33kV System	11kV System
1	System Operating Voltage	132kV	33kV	11kV
2	Max. Operating voltage of the System (V_{rms})	145kV	36kV	12kV
3	Rated Frequency	50Hz	50Hz	50Hz
4	No. of Phase	3	3	3
5	Rated Insulation levels			
a.	Full wave impulse withstand Voltage (1.2/50 microsec.)	750 kV_{peak}	250 kV_{peak}	95 kV_{peak}
b.	One minute power frequency dry and wet withstand Voltage (V_{rms})	325 kV_{rms}	95 kV_{rms}	28 kV_{rms}
6	Minimum creep age distance (25mm/kV)	4,650 mm	1,300 mm	NA
7	Min. Clearances in air			
a.	Phase to Phase	1,500 mm	480 mm	NA
b.	Phase to earth	1,500 mm	480 mm	NA
8	Rated Short Circuit current for 1 sec. duration	25 kA	25 kA	25 kA
9	System Neutral Grounding	Solidly Grounded	Solidly Grounded	Solidly Grounded

21.2 Schedule A.2 : Technical Particulars for Power Transformer

S.No.	Description	*132/33 kV*	*33/11kV*
1.	Rated capacity	*24/27/30 MVA*	*6/8MVA*
2.	Quantity required	One (1) no.	One (1) no.
3.	Type	Outdoor, Oil-immersed	Outdoor, Oil-immersed
4.	Type of cooling	*ONAN/ONAF1/ONAF2 (24/27/30 MVA)*	*ONAN/ONAF (6/8 MVA)*
5.	Temperature rise above 40 degree C ambient temperature		
	a) In oil by thermometer	50 degree C	50 degree C
	b) In winding by resistance	55 degree C	55 degree C
7.	Number of phases	3(three)	3(three)
8.	Maximum voltage (line to line)		

S.No.	Description	*132/33 kV*	*33/11kV*
	a) Primary	145 kV	36 kV
	b) Secondary	36 kV	12 kV
9.	Rated Voltage (line to line)		
	a) Primary	*132 kV*	*33 kV*
	b) Secondary	*33 kV*	*11 kV*
10.	Insulation level of winding		
	a) Basic impulse level as per IEC 76		
	- Primary	*750 kV (crest)*	*250kV (crest)*
	- Secondary	*250 kV (crest)*	*95kV (crest)*
	b) Power frequency induced over voltage (1 minute)		
	- Primary	*325 kV(rms)*	*95kV(rms)*
	- Secondary	*95 kV(rms)*	*28kV(rms)*
11.	Connections		
	a) Primary	Star	Star
	b) Secondary	Star	Star
12.	Vector group reference	YNyn0	YNyn0
13.	Type of tap changer/make	*On-load/MR German*	
14.	Range of taps	*± 10 %*	*± 10 %*
15.	Number of taps	*17*	*17*
16.	Method of tap changer control		
	- Mechanical local	Yes	Yes
	- Electrical local	Yes	Yes
	- Electrical remote	Yes	Yes
	"MASTER-FOLLOWER-INDEPENDENT" and "AUTO - MANUAL" selection	Yes	Yes
17.	Percent impedance voltage at rated MVA and 75 degree C On normal tap	*≈11 % (at normal tap)*	*≈8 % (at normal tap)*
18.	System grounding		
	a) Primary	Solidly grounded	Solidly grounded
	b) Secondary	Solidly grounded	Solidly grounded
19.	Neutral terminals & BCT		
	- Primary	Required	Required
	- Secondary	Required	Required
20.	Tank Mounted Lightning Arrester		
	HV	-	-

S.No.	Description	*132/33 kV*	*33/11kV*
	LV	Required	-
21.	Bushing Current Transformers		
	a) Number of core & current ratio HV Phase Neutral	 *3 * 200/1A* *1 * 200/1A*	 *3 * 200/1A* *1 * 200/1A*
	b) Number of core & current ratio LV Phase Neutral	 *3 * 800/1A* *1 * 800/1A &* *1 * 200/1A*	 *3 * 600/1A* *1 * 600/1A &* *1 * 200/1A*
	c) Accuracy class	5P20	5P20
22.	Site Attitude	2200 m MSL	

21.3 Schedule A.3: Circuit Breaker

132KV SF6 CIRCUIT BREAKER

Sr. No.	Description	132kV Circuit Breaker
1.	Type	SF6, outdoor type
2.	Voltage rating: a) Nominal system voltage b) Rated maximum voltage	 132 kV 145 kV
3.	Insulation level a) Impulse withstand voltage b) Power-frequency withstand voltage (1 min.)	 750 kV (crest) 325 kV (rms)
4.	Frequency	50 Hz
5.	Current rating a) Rated continuous current at 40 degree C ambient b) Short circuit breaking current	 1250 A 25 kA
6.	Creepage distance	4,625 mm
7.	Auxiliary supply a) Control circuit b) Space heater and auxiliary equipment.	 110 V DC AC, 230/400V, 50 Hz
8.	Operation	Two (2) Nos. breaker single pole operation type for 132 kV transmission line bay for Bahrabise-1 and Bahrabise -2 feeders and remaining three pole operation type for others feeders)
9.	Reclosing duty cycle	O-0.3 sec-CO-3 min-CO

Sr. No.	Description	132kV Circuit Breaker
10.	Total maximum break time	60 ms
11.	First pole to clear factor	1.3
12	Additional Auxiliary Contacts	8 NO, 8 NC
13.	Maximum make time	120 ms
14.	Spring charging motor	110 V DC
15.	Attitude at site	2200 m above MSL

33KV SF6 CIRCUIT BREAKER

Sr. No.	Description	33kV Circuit Breaker
1.	Type	33kV VCB, outdoor type
2.	Voltage rating: a) Nominal system voltage b) Rated maximum voltage	 33 kV 36 kV
3.	Insulation level a) Impulse withstand voltage b) Power-frequency withstand voltage (1 min.)	 250 kV (crest) 95 kV (rms)
4.	Frequency	50 Hz
5.	Current rating a) Rated continuous current at 40 degree C ambient b) Short circuit breaking current	 1250 A 25 kA
6.	Creepage distance	1,300 mm
7.	Auxiliary supply a) Control circuit b) Space heater and auxiliary equipment.	 110 V DC AC, 230/400V, 50 Hz
8.	Rated Capacitor Breaking current	≥400A
9.	Rated Back to Back Capacitor Bank Breaking current	≥20kA
8.	Operation	Three pole operation type
9.	Reclosing duty cycle	O-0.3 sec-CO-3 min-CO
10.	Total maximum break time	60 ms
11.	First pole to clear factor	1.3
12	Additional Auxiliary Contacts	8 NO, 8 NC
13.	Maximum make time	120 ms
14.	Spring charging motor	110 V DC

Sr. No.	Description	33kV Circuit Breaker
15.	Attitude at site	2200 m above MSL

21.4 Schedule A.4: Disconnecting Switch with and without ground switch

S. No.	Description	Disconnecting switch 132 kV	Disconnecting switch 33 kV
1.	Type	3-poles, center break	3-poles, three columns, center rotating ,double break or 3-poles, centre break
2.	Rated Voltage	132 kV	33 kV
3.	Frequency	50 Hz	50 Hz
4.	Insulation levels		
	a) Basic impulse level (BIL)	750 kV (crest)	250 kV (crest)
	b) Power frequency withstand voltage (For1 minute)	325 kV (rms)	95 kV (rms)
5.	Current ratings		
	a) Continuous current	1250 A	1250A
	b) Rated Short Time current (1 sec.)	25 kA	25 kA
6.	Operating mechanism of disconnecting switch	Motor operated (both local and remote operation) and manual	Local, manual operation
7.	Auxiliary power supply		
	a) Space heater and cubicle	230V,1-phase, 50Hz	230V,1-phase, 50Hz
	b) Control circuit	110 V DC	110 V DC
	c) Operating motor	230/400 V, 50 Hz	-
8.	Applicable standard	IEC	IEC
9.	Enclosure Protection	IP-55W	IP-55W
10.	Attitude at site	2200 m above MSL	

21.5 Schedule A.5: 132 kV & 33 kV INSTRUMENT TRANSFORMER

CAPACITIVE VOLTAGE TRANSFORMER FOR 132KV AND VOLTAGE TRANSFORMER 33KV

Sr. No.	Description	132kV CVT	33kV VT

Sr. No.	Description	132kV CVT	33kV VT
1.	Type	Outdoor, oil immersed for protection and metering.	Outdoor, epoxy resin encapsulated for protection and metering.
2.	Rated primary voltage	132kV	33 kV
3.	Max. system voltage	145 kV	36 kV
4.	Impulse withstand voltage	750 kV (crest)	250 kV (crest)
5.	Power frequency withstand voltage (1min,rms)	325kV(rms)	95 kV (rms)
6.	Rated frequency	50Hz	50Hz
7.	Connection	Line to ground	Line to ground
8.	Number of secondary winding	2	2
9.	Voltage ratio	132/√3/0.11/√3/0.11/√3 kV	33/√3 / 0.11/√3/0.11/√3 kV
10.	Rated burden	100 VA & 50 VA	50 VA
11.	Accuracy class	3P and 0.2 for metering	3P and 0.2 for metering
12.	Rated voltage factor	1.1 Continuous	1.1 Continuous
13.	Creepage distance	4,625 mm	1,300 mm
14.	Applicable standard	IEC 60186	IEC 60044-2
15.	Attitude at site	2200 m above MSL	

132 KV AND 33KV CURRENT TRANSFORMER

Sr. No.	Description	132kV CT	33kV CT
1.	Type	Outdoor, oil immersed for protection and metering.	Epoxy resin capsulated outdoor for protection and metering.
2.	Rated primary voltage	132 kV	33 kV
3.	Maximum system voltage	145 kV	36 kV
4.	Impulse withstand voltage	750 kV (crest)	250 kV (crest)
5.	Power frequency withstand voltage (1min,rms)	325kV (rms)	95 kV (rms)
6.	Rated frequency	50 Hz	50Hz
7.	Number of core	5	*2*
8.	Short time thermal ratings	25 kA	25 kA
9.	Current ratio	*1200-600/1A* *600-300-150/1A*	*800-600/1A* *400-200/1A*
10.	Rated burden for each core	30 VA	20 VA
11.	Accuracy class	Class X, 5P20 for protection and 0.2 for metering	5P20 for protection and 0.2 for metering

12.	Creepage distance	3,300 mm	825 mm
13.	Applicable standard	IEC 60044-1	IEC 60044-1
14.	Attitude at site	2200 m above MSL	

21.6 Schedule A.6: Lightning Arrestor

S. No.	Description	120 kV LA	30 kV LA
1.	Type	Gap less, Metal – oxide, Outdoor	Gap less, Metal –oxide, Outdoor
2.	Mounting	Pedestal mounted	Both tank and pedestal mounted as appropriate
3.	Rated frequency	50Hz	50Hz
4.	System voltage	132 kV	33 kV
5.	Rated voltage	120 kV	30 kV
6.	Impulse withstand voltage (BIL)	750 kV (crest)	250 kV (crest)
7.	Power frequency withstand voltage	325 kV (rms)	95 kV(rms)
8.	Nominal discharge current of 8/20 micro second wave shape	10 kA	10 kA
9.	Applicable Standard	IEC 60099-4	IEC 60099-4

21.7 Schedule A.7: 11 kV Switchgear

Sr. No.	Description	Unit	Value
Bus Bar			
1	Rated Frequency	Hz	50
2	Voltage rating: a) Nominal system voltage b) Rated maximum voltage Rated Voltage	 kV kV	 11 12
3	Insulation level a) Impulse withstand voltage b) Power-frequency withstand voltage (1 min.)	 kV peak kV rms	 95 28
4	Rated Continuous Current	A	800
5	Rated Short Time Current	kA	25
6	Rated Duration of Short Circuit time	Sec	1
7	Auxiliary supply a) Control circuit b) Space heater and auxiliary equipment.	 V DC V AC	 110 230/400V, 50 Hz
8	Attitude at site	m	2200
Circuit Breaker			
1	Rated Frequency	Hz	50
2	Voltage rating: a) Nominal system voltage b) Rated maximum voltage Rated Voltage	 kV kV	 11 12
3	Insulation level a) Impulse withstand voltage b) Power-frequency withstand voltage (1 min.)	 kV peak kV rms	 95 28
4	Rated Continuous Current	A	As per Single Line Diagram
5	Rated Short Time Current	kA	25
6	Rated Duration of Short Circuit time	Sec	1
7	Internal Arc Fault Performance Time Standard	kA Sec	25 0.1 IEC 62271:200
8	Total maximum break time	ms	60
9	Maximum make time	ms	120
10	Additional Auxiliary Contacts		8 NO, 8 NC
11	Spring charging motor	V	110

21.8 Schedule A.8: STATION AUXILIARY SUPPLY

Sr. No.	Description	33/0.4 kV Transformer
1.	Rated power	*250 kVA*
2.	Rated voltage -Primary -Secondary	 33 kV 400 / 230 V
3.	Max. system voltage -Primary -Secondary	 36 kV 440 V
4.	Rated frequency	50 Hz
5.	Connection -Primary -Secondary	 Delta Wye, Solidly Grounded
6.	Cooling system	ONAN
7.	Voltage vector group	Dyn 11
8.	Rated impedance voltage	~4.5 %
9.	BIL of winding and bushing for primary side	250 kV (crest)
10.	Withstand voltage 50 Hz, 1 min. -Primary -Secondary	 95 kV 3 kV
11.	Off-circuit tap changer voltage taps on HV side	+/- 5 %
12.	Mounting	*Platform on ground*
13.	Bushing (suitable for) -HV -LV	 Exposed for connection with overhead conductor Enclosed for cable connection
14.	Insulation temperature class (IEC 76)	A
15.	Max. allowable noise level at 3 meter hemispherical radius	44 dB
16.	Applicable standard	IEC
17.	Site Altitude	2200m above MSL

21.9 Schedule A.9: GROUNDING CONDUCTORS

Sl. No.	Item	Size	Material
a)	Main Earthing Conductor to be buried in ground	Min 100 sq mm	Copper
b)	Conductor above ground& earthing leads (for equipment)	Min 100 sq mm	Copper
c)	Conductor above ground& earthing leads(for columns & aux. structures)	>100 sq mm	Copper
d)	Earthing of indoor LT panels, Control panels and outdoor marshalling boxes, MOM boxes, Junction boxes& Lighting Panels etc.	>100 sq mm	Copper
e)	Rod Earth Electrode	16mm dia, 3000mm long	Copper Clad Steel
f)	Pipe Earth Electrode (in treated earth pit) as per IS.	40mm dia, 3000mm long	Copper Clad Steel
g)	Earthing for motors	100 sq mm	Copper
h)	Earthing conductor along outdoor cable trenches	100 sq mm	Copper
I)	Earthing of Lighting Poles	20 mm dia 3000 mm long	Copper Clad Steel

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FORMS AND PROCEDURES

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FORM OF COMPLETION CERTIFICATE

Date: _____

IFB No: _____

_____

To: _____

Dear Ladies and/or Gentlemen,

Pursuant to GC Clause 24 (Completion of the Facilities) of the General Conditions of the Contract entered into between yourselves and the Employer dated _____, relating to the _____, we hereby notify you that the following part(s) of the Facilities was (were) complete on the date specified below, and that, in accordance with the terms of the Contract, the Employer hereby takes over the said part(s) of the Facilities, together with the responsibility for care and custody and the risk of loss thereof on the date mentioned below.

1. Description of the Facilities or part thereof: _____

2. Date of Completion: _____

However, you are required to complete the outstanding items listed in the attachment hereto as soon as practicable.

This letter does not relieve you of your obligation to complete the execution of the Facilities in accordance with the Contract nor of your obligations during the Defect Liability Period.

Very truly yours,

_____
Title
(Project Manager)

FORM OF OPERATIONAL ACCEPTANCE CERTIFICATE

Date: _____

IFB No: _____

_____

To: _____

Dear Ladies and/or Gentlemen,

Pursuant to GC Sub-Clause 25.3 (Operational Acceptance) of the General Conditions of the Contract entered into between yourselves and the Employer dated _____, relating to the _____, we hereby notify you that the Functional Guarantees of the following part(s) of the Facilities were satisfactorily attained on the date specified below.

1. Description of the Facilities or part thereof: _____

2. Date of Operational Acceptance: _____

This letter does not relieve you of your obligation to complete the execution of the Facilities in accordance with the Contract nor of your obligations during the Defect Liability Period.

Very truly yours,

_____
Title
(Project Manager)

CHANGE ORDER PROCEDURE AND FORMS

Date: _____

IFB No: _____

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ANNEXURES:

CHANGE ORDER PROCEDURE

1.1 General

This section provides samples of procedures and forms for implementing changes in the Facilities during the performance of the Contract in accordance with GC Clause 39 (Change in the Facilities) of the General Conditions.

1.2 Change Order Log

The Contractor shall keep an up-to-date Change Order Log to show the current status of Requests for Change and Changes authorized or pending. Entries of the Changes in the Change Order Log shall be made to ensure that the log is up-to-date. The Contractor shall attach a copy of the current Change Order Log in the monthly progress report to be submitted to the Employer.

1.3 References for Changes

a. Request for Change as referred to in GC Clause 39 shall be serially numbered CR-X-nnn.
b. Estimate for Change Proposal as referred to in GC Clause 39 shall be serially numbered CN-X-nnn.
c. Acceptance of Estimate as referred to in GC Clause 39 shall be serially numbered CA-X-nnn.
d. Change Proposal as referred to in GC Clause 39 shall be serially numbered CP-X-nnn.
e. Change Order as referred to in GC Clause 39 shall be serially numbered CO-X-nnn.

Note:

(a) Requests for Change issued from the Employer's Home Office and the Site representatives of the Employer shall have the following respective references:

- Home Office CR-H-nnn
- Site CR-S-nnn

(b) The above number "nnn" is the same for Request for Change, Estimate for Change Proposal, Acceptance of Estimate, Change Proposal and Change Order.

ANNEXURE – 1: REQUEST FOR CHANGE PROPOSAL

General

This section provides samples of procedures and forms for implementing changes in the Facilities during the performance of the Contract in accordance with GC Clause 39 (Change in the Facilities) of the General Conditions.
(Employer's Letterhead)

To: _____ Date:

Attention: _____

Contract Name: _____
Contract Number: _____

Dear Ladies and/or Gentlemen:

With reference to the captioned Contract, you are requested to prepare and submit a Change Proposal for the Change noted below in accordance with the following instructions within _____ days of the date of this letter _____.

1. Title of Change: _____

2. Change Request No. _____

3. Originator of Change: Employer: _____
   Contractor (by Application for Change Proposal No. _____1:

4. Brief Description of Change: _____

5. Facilities and/or Item No. of equipment related to the requested Change: _____

6. Reference drawings and/or technical documents for the request of Change:

   Drawing No./Document No. Description

7. Detailed conditions or special requirements on the requested Change: _____

8. General Terms and Conditions:

(a) Please submit your estimate to us showing what effect the requested Change will have on the Contract Price.

(b) Your estimate shall include your claim for the additional time, if any, for completion of the requested Change.

_____

(c) If you have any opinion negative to the adoption of the requested Change in connection with the conformability to the other provisions of the Contract or the safety of the Plant or Facilities, please inform us of your opinion in your proposal of revised provisions.

(d) Any increase or decrease in the work of the Contractor relating to the services of its personnel shall be calculated.

(e) You shall not proceed with the execution of the work for the requested Change until we have accepted and confirmed the amount and nature in writing.

(Employer's Name)

(Signature)

(Name of signatory)

(Title of signatory)

ANNEXURE – 2: ESTIMATE FOR CHANGE PROPOSAL

(Contractor's Letterhead)

To: _____ Date: _____

Attention: _____

Contract Name: _____
Contract Number: _____

Dear Ladies and/or Gentlemen:

With reference to your Request for Change Proposal, we are pleased to notify you of the approximate cost of preparing the below-referenced Change Proposal in accordance with GC Sub-Clause 39.2.1 of the General Conditions. We acknowledge that your agreement to the cost of preparing the Change Proposal, in accordance with GC Sub-Clause 39.2.2, is required before estimating the cost for change work.

1. Title of Change: _____

2. Change Request No./Rev.: _____

3. Brief Description of Change: _____

4. Scheduled Impact of Change: _____

5. Cost for Preparation of Change Proposal: _____

(a) Engineering (Amount)

(i) Engineer _____ hrs x _____ rate/hr = _____
(ii) Draftsperson _____ hrs x _____ rate/hr = _____
Sub-total _____ hrs _____

Total Engineering Cost

(b) Other Cost

Total Cost (a) + (b)

_____
(Contractor's Name)

_____
(Signature)

_____
(Name of signatory)

_____
(Title of signatory)

ANNEXURE – 3: ACCEPTANCE OF ESTIMATE

(Employer's Letterhead)

To: _____ Date:

Attention: _____

Contract Name: _____
Contract Number: _____

Dear Ladies and/or Gentlemen:

We hereby accept your Estimate for Change Proposal and agree that you should proceed with the preparation of the Change Proposal.

1. Title of Change: _____

2. Change Request No./Rev.: _____

3. Estimate for Change Proposal No./Rev.: _____

4. Acceptance of Estimate No./Rev.: _____

5. Brief Description of Change: _____

6. Other Terms and Conditions: In the event that we decide not to order the Change accepted, you shall be entitled to compensation for the cost of preparation of Change Proposal described in your Estimate for Change Proposal mentioned in para. 3 above in accordance with GC Clause 39 of the General Conditions.

_____
(Employer's Name)

_____
(Signature)

_____
(Name and Title of signatory)

ANNEXURE – 4: CHANGE PROPOSAL

(Contractor's Letterhead)

To: _____ Date: _____

Attention: _____

Contract Name: _____
Contract Number: _____

Dear Ladies and/or Gentlemen:

In response to your Request for Change Proposal No. _____, we hereby submit our proposal as follows:

1. Title of Change: _____

2. Change Proposal No./Rev.: _____

3. Originator of Change: Employer: _____
   Contractor: _____

4. Brief Description of Change: _____

5. Reasons for Change: _____

6. Facilities and/or Item No. of Equipment related to the requested Change: _____

7. Reference drawings and/or technical documents for the requested Change:

Drawing/Document No.	Description

8. Estimate of increase/decrease to the Contract Price resulting from Change Proposal:[2]

		(Amount)
(a)	Direct material	_____
(b)	Major construction equipment	_____
(c)	Direct field labour (Total hrs)	_____
(d)	Subcontracts	_____
(e)	Indirect material and labour	_____

[2] Costs shall be in the currencies of the Contract.

(f) Site supervision _____

(g) Head office technical staff salaries _____

Process engineer _____ hrs @_____ rate/hr _____
Project engineer_____ hrs @_____ rate/hr _____
Equipment engineer_____ hrs @_____ rate/hr _____
Procurement_____ hrs @_____ rate/hr _____
Draftsperson_____ hrs @_____ rate/hr _____
Total _____ hrs

(h) Extraordinary costs (computer, travel, etc.) _____

(i) Fee for general administration, % of Items _____

(j) Taxes and customs duties _____

Total lump sum cost of Change Proposal _____

(Sum of items (a) to (j))

Cost to prepare Estimate for Change Proposal
(Amount payable if Change is not accepted)

9. Additional time for Completion required due to Change Proposal

10. Effect on the Functional Guarantees

11. Effect on the other terms and conditions of the Contract

12. Validity of this Proposal: within [Number] days after receipt of this Proposal by the Employer

13. Other terms and conditions of this Change Proposal:

(a) You are requested to notify us of your acceptance, comments or rejection of this detailed Change Proposal within _____ days from your receipt of this Proposal.

(b) The amount of any increase and/or decrease shall be taken into account in the adjustment of the Contract Price.

(c) Contractor's cost for preparation of this Change Proposal:

_____
(Contractor's Name)

_____
(Signature)

_____
(Name of signatory)

_____
(Title of signatory)

ANNEXURE – 5: CHANGE ORDER - 1

(Employer's Letterhead)

To: _____ Date: _____

Attention: _____

Contract Name: _____
Contract Number: _____

Dear Ladies and/or Gentlemen:

We approve the Change Order for the work specified in the Change Proposal (No. _____), and agree to adjust the Contract Price, Time for Completion and/or other conditions of the Contract in accordance with GC Clause 39 of the General Conditions.

1. Title of Change: _____

2. Change Request No. /Rev.: _____

3. Change Order No. /Rev.: _____

4. Originator of Change: Employer: _____
   Contractor: _____

5. Authorized Price:

   Ref. No.: _____ Date: _____
   Foreign currency portion _____ plus Local currency portion _____

6. Adjustment of Time for Completion

   None Increase _____ days Decrease _____ days

7. Other effects, if any

_____
Authorized by: Date: _____

(Employer)

_____
Accepted by: Date: _____
(Contractor)

ANNEXURE – 6: CHANGE ORDER - 2

(Employer's Letterhead)

To: _____ Date: _____

Attention: _____

Contract Name: _____
Contract Number: [_____

Dear Ladies and/or Gentlemen:

We instruct you to carry out the work in the Change Order detailed below in accordance with GC Clause 39 of the General Conditions.

1. Title of Change: _____

2. Employer's Request for Change Proposal No./Rev.: _____ dated: _____

3. Contractor's Change Proposal No./Rev.: _____ dated: _____

4. Brief Description of Change: _____

5. Facilities and/or Item No. of equipment related to the requested Change: _____

6. Reference Drawings and/or technical documents for the requested Change:

Drawing/Document No.	Description

7. Adjustment of Time for Completion:

8. Other change in the Contract terms:

9. Other terms and conditions:

(Employer's Name)

(Signature)

(Name of signatory)

(Title of signatory)

ANNEXURE – 7: PENDING AGREEMENT CHANGE ORDER

(Contractor's Letterhead)

To: _____ Date: _____

Attention: _____

Contract Name: _____
Contract Number: _____

Dear Ladies and/or Gentlemen:

We hereby propose that the below-mentioned work be treated as a Change in the Facilities.

1. Title of Change: _____

2. Application for Change Proposal No./Rev.: _____
   dated: _____

3. Brief Description of Change: _____

4. Reasons for Change:

5. Order of Magnitude Estimation (in the currencies of the Contract):

6. Scheduled Impact of Change:

7. Effect on Functional Guarantees, if any:

8. Appendix:

_____
(Contractor's Name)

_____
(Signature)

_____
(Name of signatory)

_____
(Title of signatory)

VOLUME - II OF III

SECTION - 23

PAYMENT OF WORKS

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23. PAYMENT OF WORKS

This contract is a fixed price Turnkey Contract and the terms of payment is set out in Volume I of Bidding Document.

Invoices of materials supplied and erection work shall be submitted separately for the purpose of accounting.

This section provides general guidelines for interim progress payment of different equipment and works covered under this contract.

Interim Certificates for site work shall be restricted in scope to the following items:

a. Substation equipment (transformers, 132 kV & 33 kV equipment , 12 kV Switchgear, GIS etc)
b. Substation Auxiliaries (AC & DC Supply, earthing, cabling, illuminations, fire protection etc.)
c. Control & Relay Panels
d. Site Grading Works
e. Slope protection / Retaining wall
f. Steel structure
g. Architectural & finishing works
h. Roads, Pavements & fencing
i. 33 kV overhead line
j. Spare Parts & Testing Equipment

The Contractor shall submit to the Employer for approval a draft blank printed Form of Measurement Certificate, for each line item at an early stage in the Contract.

All measurements for the purpose of payments shall be made jointly between representatives of the Contractor and the Employer.

No extra payments will be made for the followings, which are not mentioned in the price schedule and required for execution of the work:

- Design, Engineering and project management services.
- Supply of Construction power and water.
- Deployment of man powers required for construction, erection testing and commissioning.
- Providing tools & tackles, consumables, construction machineries, vehicles, testing equipment, spare parts required for construction, erection, testing and commissioning.
- Laptop, software, probes, cables etc. required for communication and protection system.
- Additional costs of access and transport of personnel, materials and erection equipment up to the substation.
- Pumping out of water and flooding conditions
- Shuttering, planking and close timbering of excavation, form of foundation, grouting, tests etc.
- Lean Concrete for foundation
- Scaffolding necessary if any.
- And other items specifically mentioned in the document.

Costs of all of the above items are deemed to be included in the quoted price in price schedule.

Payment for various items as per the Price Schedule shall be as follows:

Table 23.1: Schedule for Interim Payment

S.No.	Description	Unit	Basis of Payment
1	Transformer	No.	Based on no. of transformer
2	Circuit Breaker with support structure	No.	Based on no. of Circuit breaker with support structure
3	Current Transformer	No.	Based on no. of current transformer
4	Capacitive Voltage Transformer	No.	Based on no. of capacitive voltage transformer
5	Disconnecting Switch	No.	Based on no. of Disconnecting switch
6	Lightning Arrestor	No.	Based on no. of Lightning Arrestor
7	11 kV Switchgear	Set	Based on Set of 11kV switchgear
8	Auxiliary Power Supply System	Set	Based on set of transformer, distribution switchboard etc.
9	Battery and Battery Charger	No./Sets	Based on no./sets of battery and battery charger
10	Illumination System	LS/Sets	Based on measured value
11	Fire detection and alarm system		
11.1	Fire extinguisher	No.	Based on no. of extinguisher
11.2	Fire detection and alarm system	LS	Based on set measured value
12	Cables along with clamps, glands, lugs and straight joints etc.		
12.1	11/33/132 kV Power Cable including termination joints etc	m	Based on measured value
12.2	LV Power and Control Cables	LS	Based on measured value
13	Erection Hardware	Lot/LS	Based on measured value
14	Grounding		
14.1	Galvanised EHS for Lightning Shield Wire	LS	Based on measured value
14.2	Earthing of SS with Conductor, electrode	LS	Based on measured value
15	Control and Relay panels	Sets	Based on sets of control and relay panel
16	Substation Automation System/Communication/SCADA	No	Based on no of bays
17	Integration of all bays at Pangtan and Bahrabise SS With SIEMENS (Power 7) SCADA System at LDC	Lot/LS	Based on measured value
18	Visual Monitoring System for watch and ward	LS	Based on measured value
19	GIS Bus Bar Module (Cost of required extension module inclusive)	Sets	Based on measured value
20	Digital Protection Coupler	Nos.	Based on measured value
21	Steel structures	LS/Sets/Nos/MT	Based on measured value as applicable
22	Miscellaneous works		
22.1	Exploration Works	location	Based on measured value

S.No.	Description	Unit	Basis of Payment
22.2	Soil resistivity works	lot	Based on measured value
22.3	Site Grading with earth filling by borrow pit earth Including compaction and leveling	Cu m	Based on measured value
23	Water Supply including testing	LS	Based on measured value
24	Crushed Rock Surfacing including Laying of Sand and Plastic	Cu m	Based on measured value
25	Foundation (Civil Works: Material plus Labor all included)	No./LS/sets	Based on measured value as applicable
26	Re bars applicable ONLY for miscellaneous civil works as per requirement	kg	Based on measured value
27	Gabion Box Protection/Stone Masonry	Cu m	Based on measured value
28	Gravel Laying for Approach Road with Compaction	Cu m	Based on measured value
29	Water supply system including testing of water quality	LS	Based on measured value
30	Control Building (Material plus Labor all included)	LS	Based on Building Progress
31	Two nos. two storied staff quarter (Material Plus Labor all included)	LS	Based on Building Progress
32	One storied guard house (material plus labor all included)	LS	Based on Building Progress
33	Stone soling and compaction works on access road	Sq m	Based on measured value
34	Switchyard fencing	Rm	Based on measured value
35	Asphalt Road	Sq m	Based on measured value
36	33 kV Overhead line	Km	Based on measured value

VOLUME - II OF III

SECTION - 24

TENDER DRAWINGS

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Section	Description
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Section - 23	Payment of Works.
Section - 24	Tender Drawings
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Section - 26	Substation Equipment Data Sheet TDS
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Section - 1	Price Schedule

LIST OF TENDER DRAWINGS

Sl. No.	Drawing Number	Drawing Description
1.	DWG 001	Location Map of Pangtan 132/33/11 kV Substation Project
2.	DWG 002	Construction Layout map of 132/33/11 kV Pangtan Substation
3.	DWG 003	Single Line Diagram of 132/33/11 kV Pangtan Substation
4.	DWG 004	Layout Plan & Section of 132/33/11 kV Pangtan Substation
5.	DWG 005	Layout Section of Substation
6.	DWG 006	Architectural Drawing of Control Building
7.	DWG 007	Architectural Drawing of Staff Building
8.	DWG 008	Internal and Access Road
9.	DWG 009	Sectional Drawings of Retaining Wall/Slope Protection and Drains
10.	DWG 010	Chain Link Fence and Gate Details
11.	DWG 011	Typical Foundation Detail

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SECTION-25

GENERAL TECHNICAL REQUIREMENT-CIVIL WORKS

CIVIL, ARCHITECTURAL & BUILDING WORKS

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SECTION-25
CIVIL WORKS

25.1 GENERAL

The intent of specification covers the following:

Design, engineering, drawing and construction of all civil works at sub-station. All civil works shall also satisfy the general technical requirements specified in other Sections of Specification and as detailed below. They shall be designed to the required service conditions/loads as specified elsewhere in this Specification or implied as per relevant British standard codes (BS Codes)/ equivalent International Standards.

All civil works shall be carried out as per applicable Standards and Codes. All materials shall be of best quality conforming to relevant International Standards and Codes. In case of any conflict between Standards/ Code and Technical Specification, the provisions of Technical Specification shall prevail.

The Contractor shall furnish all design, drawings, labour, tools, equipment, materials, temporary works, constructional plant and machinery, fuel supply, transportation and all other incidental items not shown or specified but as may be required for complete performance of the Works in accordance with approved drawings, specifications and direction of NEA.

The work shall be carried out according to the design/drawings to be developed by the Contractor and approved by the NEA. For all buildings, structures, foundations etc. necessary layout and details shall be developed by the Contractor keeping in view the functional requirement of the substation facilities and providing enough space and access for operation, use and maintenance. Certain minimum requirements are indicated in this specification for guidance purposes only. However, the Contractor shall quote according to the complete requirements.

25.1.1 STANDARD AND REFERENCES

All equipment, materials, fabrication and tests under these Specifications shall conform to the latest applicable standards, manuals and Specifications contained in the following list or, to equivalent applicable standards, manuals and Specifications, established and approved in the country of manufacturer, and approved as equal by Employer.

IS	Bureau of Indian Standard
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standard Institute
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing Materials
AWS	American Welding Society
JIS	Japanese Industrial Standards
DIN	Deutsches Institute für Normung

Any details not specifically covered by these standards and specifications shall be subject to approval of Employer. In the event of contradictory requirements between the standards and these Specification requirements, the terms of the Specifications shall apply.

Unless specifically mentioned, reference to standards and specifications or to equipment and materials of the particular manufacture shall be considered as followed by "or equivalent". The Contractor may propose equivalent specifications, materials or equipment, which shall be equal in every respect to that specified. If the Contractor, for any reason, proposes equivalents to or, deviates from, the above standard, he shall state the exact nature of the change and shall submit complete specifications of the materials, as well as copies of pertinent standards, for the approval of Employer and decision of Employer in the matter of quality shall be final.

25.1.2 SCOPE OF WORKS

The following works shall be carried out at Pangtan and Bahrabise substations so as to complete the Civil, Architectural and Structural steel works in all respects, as required for the proper functioning of the substations.

- Exploration works for soil strength for foundations of steel structures, equipment, control buildings, staff quarters, and culvert roads.

All offices, housing facilities, plants and equipment, temporary structures and works, temporary construction and access roads and everything else which will be used or needed for the performance of the works.

Together with the bid, the Bidder shall submit a drawing showing the overall layout of the proposed site installation with details of survey. A final layout for site installation shall be prepared by the Contractor and approved by Employer before any construction work takes place at the site.

- Site grading
- Design, manufacture, supply, installation and testing of substation steel structures.
- Design of RCC foundations of steel structures, equipment, lighting fixtures, control building, staff quarters etc.
- Design and construction of approach roads including Culvert Bridge.
- Construction of cable trench system, conduit, duct bank and hand hole
- Design and construction of approximately 2 kilometres of 33 kV double circuit line in single steel galvanized pole of 13 mtr height.
- Design and construction of control building, staff quarter, Guard house, Vehicle Parking Shade, and Badminton court.
- Crushed rock surfacing in switchyard
- Construction of complete drainage system including switchyard and substation area with RCC slab cover.
- Supply and construction of water supply system.
- Supply and installation of fire fighting system.
- Design, supply, installation and construction of ventilation and air-conditioning equipment/units in the control buildings and staff quarter as specified

- Design, supply and installation of Illumination systems for all buildings including Staff Quarter, Guard house, Vehicle Parking shade, badminton court, outdoor Switchyard, Substation area, internal as well as access road to Substation, boundary wall periphery etc.
- Design and supply of furniture and miscellaneous indoor facilities for control building, staff quarters, guard house.
- Supply and installation of miscellaneous outdoor facilities as specified in this chapter.
- Design and construction of protection works.
- Design and construction of switchyard fence and gate/s.
- Design and construction of slump pit/pits for transformer oil.
- All associated and necessary civil and architectural works to complete the specified scope of work.
- Other miscellaneous items as per BOQ.

25.1.3 GENERAL OFFICIAL ACCESSORIES

OFFICE ACCOMMODATION

The contractor shall provide at his own expense adequate temporary accommodation and toilet facilities for his worker as well as working office space for his staffs and Employer/ Engineer on duty for construction supervision and keep the same in good order. This may be done to suit site conditions with the approval of the Employer / Engineer. The above mentioned temporary structures shall be removed on the completion of works at contractors own cost.

BOARDS

A board of size of 1.5m x 1.0m shall be made and put at an approved place on the site. This board shall be painted in approved color with names of (a) The proposed construction (b) The Contractor (c) The Employer and other details as directed by the Employer/ Engineer.

25.1.4 Working Schedule

A binding graphical working schedule with an explanatory report shall be submitted before the construction period. The working schedule and any amendments to it during the construction period will require Employer's approval.

25.2 GEOTECHNICAL INVESTIGATION

25.2.1 The Contractor shall perform a detailed soil investigation to arrive at sufficiently accurate, general as well as specific information about the soil profile and the necessary soil parameters of the site in order that the foundation of the various structures can be designed and constructed safely and rationally.

A detailed soil report including field data duly certified by site engineers of NEA will be submitted by the Contractor for specific approval of NEA**.** The report shall contain all soil the design of civil foundations.

25.2.2 The Contractor may visit the site to ascertain the soil parameters. **Any variation in soil data shall not constitute a valid reason for any additional cost & shall not affect the terms & conditions of the contract.** Field tests must be conducted covering entire substation area including all the critical locations i.e. Control Room and other Buildings, Lightning Mast, Towers, transformers etc.

25.2.3 SCOPE OF WORK

This specification covers all the work required for detailed soil investigation and preparation of a detailed report. The work shall include mobilisation of necessary equipment, providing necessary engineering supervision and technical personnel, skilled and unskilled labour etc. as required to carry out field investigation as well as, laboratory investigation, analysis and interpretation of data and results, preparation of detailed Geo-technical report including specific recommendations for the type of foundations and the allowable safe bearing capacity for different sizes of foundations at different founding strata for the various structures of the substation. The Contractor shall make his own arrangement for locating the co-ordinates and various test positions in field as per the information supplied to him and also for determining the reduced level of these locations with respect to the benchmark indicated by the NEA.

All the work shall be carried out as per latest edition of the corresponding relevant British standard codes (B S Codes)/ equivalent International Standards. The Agency carrying out the soil investigation work must have the experience of carrying out soil investigation successfully in the relevant field. NEA shall assess the capability of the agency for soil investigation work for which technical inputs may be furnished to NEA.

25.2.4 Bore Holes

Boreholes shall be made to obtain information about the subsoil profile, its nature and strength and to collect soil samples for strata identification and for conducting laboratory tests. The minimum diameter of the borehole shall be 150mm and boring shall be carried out in accordance with the provisions of IS: 1892 and this specification:

All boreholes shall be minimum 7m deep for normal open cast type foundations. If the strata with Standard Penetration Test – N value measured greater than 100 with characteristics of rock is met, the borehole shall be advanced by coring at least 3m further, limited to total 7m depth, with prior approval of the Employer.

Casing pipe shall be used when collapse of a borehole wall is probable. The bottom of the casing pipe shall at all times be above the test of sampling level but not more than 15 cm above the borehole bottom. In case of cohesion less soils, the advancement of the casing pipe shall be such that it does not disturb the soil to be tested or sampled. The casing shall preferably be advanced by slowly rotating the casing pipe and not by driving.

In-situ tests shall be conducted and undisturbed samples shall be obtained in the boreholes at intervals specified hereafter. Representative disturbed samples shall be preserved for conducting various identification tests in the laboratory. Water table in the borehole shall be carefully recorded and reported following IS: 6935.

No water or drilling mud shall be used while boring above ground water table. For cohesionless soil below water table, the water level in the borehole shall at all times be maintained slightly above the water table

The borehole shall be cleaned using suitable tools to the depth of testing or sampling, ensuring least or minimum disturbance of the soil at the bottom of the borehole. The process of jetting through an open tube sampler shall not be permitted. In cohesive soils, the borehole may be cleaned by using a bailer with a flap valve. Gentle circulation of drilling fluid shall be done when rotary mud circulation boring is adopted.

On completion of the drilling, the Contractor shall backfill all boreholes as directed by the Employer.

25.2.5 Standard Penetration Test (SPT)

This test shall be conducted in all types of soil deposits encountered within a borehole, to find the variation in the soil stratification by correlating with the number of blows required for unit

penetration of a standard penetrometer. Structure sensitive engineering properties of cohesive soils and sifts such as strength and compressibility shall not be inferred based on SPT values. No extra payment shall be made for carrying out Standard Penetration Tests.

The test shall be conducted at depths as follows:

Location	Depths (m)
Normal Soils	2.0, 3.0, 5.0, 7.0

The spacing between the levels of standard penetration testing and next undisturbed sampling shall not be less than 1.0 m. The Equipments, other accessories, procedures for conducting the test and collection of the disturbed soil samples shall conform to IS: 2131 and IS: 9640. The rods shall be straight, tightly coupled and the air release valve shall be checked. The test shall be conducted immediately after reaching to the test depth and cleaning of bore hole.

The test shall be carried out by driving a standard split spoon sampler in the borehole by means of a 650N hammer falling freely from a height of 750mm for 450mm depth, recording the number of blows for every 75mm. The number of blow for the last 300mm drive shall be reported as measured N value.

This test shall be discontinued when blow count has reached 100 or the penetration is less than 25 mm for 50 blows, whichever is earlier, or sampler starts jumping. At the level where the test is discontinued, the number of blows and the corresponding penetration shall be reported. Sufficient quantity of disturbed soil samples shall be collected from the split spoon sampler for identification and laboratory testing. The sample shall be visually classified and recorded at the site as well as properly preserved without loss of moisture content and labeled.

Undisturbed samples shall be collected in accordance with the recommendation of relevant British standard codes (B S Codes)/ equivalent International Standards. Or an alternative recognize method as agreed by NEA. Undisturbed samples shall be taken in cohesive material or weak cemented granular material where ever possible at 1.0 m interval or at each change in stratum.

The depth of Water Table, if encountered, shall be recorded in each borehole. In case the soil investigation is carried out in winter/summer, the water table for rainy season shall be collected from reliable sources and recorded in the report.

All samples, both disturbed and undisturbed, shall be identified properly with the borehole number and depth from which they have been taken.

The sample shall be sealed at both ends of the sampling tubes with wax immediately after the sampling and shall be packed properly and transported to the Contractor's laboratory without any damage or loss.

The logging of the boreholes shall be compiled immediately after the boring is completed and a copy of the bore log shall be handed over to the Engineer-in-charge.

25.2.6 Trial Pits

The Contractor shall excavate two number trial pits for Pangtan substation as and where directed by NEA, of Plan area 10 sq. m and not exceeding 4 m depth. Undisturbed samples shall be taken from the trial pits as per the direction of the NEA. All Trial Pits shall be re-filled with approved material after the tests are complete and shall be compacted in layers of not more than 500 mm. **There is no extra payment for this work. This work shall be part of under Contract item "Geotechnical investigation"**

25.2.7 Plate load test

Two number of Plate load tests shall be conducted each at the location of control room, Staff quarter and 132/33 kV transformer area (approx.) as applicable only to determine the bearing capacity, modulus of sub grade reaction and load/settlement characteristics of soil at shallow depths by loading a plane and level steel plate kept at the desired depth and measuring the settlement under different loads, until a desired settlement takes place or failure occurs. The specification for the equipment and accessories required for conducting the test, the test procedure, field observations and reporting of results shall conform to relevant BS standard. Plate load test shall be performed at the proposed foundation depth below finished ground level for bearing capacity.

Undisturbed tube samples shall also be collected from the pit at 1.0 m depth and bottom of pit from natural ground level for carrying out laboratory tests.

The size of the pit in plate load test shall not be less than five times the plate size and shall be taken up to the specified depth. All provisions regarding excavation and visual examination of pit shall apply here.

Unless otherwise specified the reaction method of loading shall be adopted. Settlement shall be recorded from dial gauges placed at four diametrically opposite ends of the test plate.

The load shall be increased in stages. Under each loading stage, record of Time vs. Settlement shall be kept as specified in relevant British standard codes (B S Codes)/ equivalent International Standards.

Backfilling of the pit shall be carried out as per the directions of the NEA**.** Unless otherwise specified the excavated soil shall be used for this purpose. In cases of gravel-boulder or rocky strata, respective relevant codes shall be followed for tests. **There is no extra payment for this work. This work shall be part of under Contract item "Geotechnical investigation"**

25.2.8 Laboratory Test

1. The laboratory tests shall be carried out progressively during the field work after sufficient number of samples has reached the laboratory in order that the test results of the initial bore holes can be made use of in planning the later stages of the field investigation and quantum of laboratory tests.

2. All samples brought from field, whether disturbed or undisturbed shall be extracted/prepared and examined by competent technical personnel, and the test shall be carried out as per the procedures laid out in the relevant British standard codes (B S Codes)/ equivalent International Standards.

   The following laboratory tests shall be carried out

   a) Visual and Engineering Classification

   b) Atterberg limits Tests.

   c) Natural moisture content, bulk density and specific gravity.

   d) Grain size distribution analysis.

   e) Swell pressure and free swell index determination.

   f) California bearing ratio.

   g) Consolidated drained test with pore pressure measurement.

   h) Chemical tests on soil and water to determine the carbonates, sulphates, nitrates, chlorides, Ph value, and organic matter and any other chemical harmful to the concrete foundation.

i) In case rock is encountered, the soil test required for rock as per relevant British standard codes (B S Codes)/ equivalent International Standards including following tests shall also be conducted.

(i) UCC test.

(ii) Point load index test.

25.2.9 Test Results and Reports

The Contractor shall submit the detailed report in two (2) copies wherein information regarding the geological detail of the site, summarised observations and test data, bore logs, and conclusions and recommendations on the type of foundations with supporting calculations for the recommendations. The contractor shall also submit the bearing capacity calculation in editable soft copy to NEA. Initially the contractor shall submit draft report and after the draft report is approved, the final report in two (2) copies shall be submitted. The field and laboratory test data shall bear the signatures of the Investigation Agency, Contractor and also site representative of NEA.

The report shall include, but not limited to the following:-

a) A plan showing the locations of the exploration work i.e. bore holes, trial pits. Plate load test, electrical resistivity test, CBR sample location etc.

b) Bore Logs: Bore logs of each bore holes clearly identifying the stratification and the type of soil stratum with depth. The values of Standard Penetration Test (SPT) at the depths where the tests were conducted on the samples collected at various depths shall be clearly shown against that particular stratum.

Test results of field and laboratory tests shall be summarised strata wise as well in combined tabular form. All relevant graphs, charts tables, diagrams and photographs, if any, shall be submitted along with report. Sample illustrative reference calculations for settlement, bearing capacity, pile capacity shall be enclosed.

Recommendations: The report should contain specific recommendations for the type of foundation for the various structures envisaged at site. The Contractor shall acquaint himself about the type of structures and their functions from the NEA. The observations and recommendations shall include but not limited to the following:

a) Geological formation of the area, past observations or historical data, if available, for the area and for the structures in the nearby area, fluctuations of water table etc.

b) Recommended type of foundations for various structures. If piles are recommended the type, size and capacity of pile and groups of piles shall be given after comparing different types and sizes of piles and pile groups.

c) Allowable bearing pressure on the soil at various depths for different sizes of the foundations based on shear strength and settlement characteristics of soil with supporting calculations. Minimum factor of safety for calculating net safe bearing capacity shall be taken as 3.0 (three). Recommendation of liquefaction characteristics of soil if applicable shall be provided.

d) Recommendations regarding slope of excavations and dewatering schemes, if required.

e) Comments on the Chemical nature of soil and ground water with due regard to deleterious effects of the same on concrete and steel and recommendations for protective measures.

f) If expansive soil is met with, recommendations on removal or retainment of the same

under the structure, road, drains, etc. and thickness of treatment shall be given. In the latter case detailed specification of any special treatment required including specification or materials to be used, construction method, equipments to be deployed etc. shall be furnished. Illustrative diagram of a symbolic foundation showing details shall be furnished.

g) Recommendations for additional investigations beyond the scope of the present work, if considered such investigation as necessary.

f) In case of foundation in rocky strata, type of foundation and recommendation regarding rock anchoring etc. should also be given.

Payment for the Contract item "Geotechnical investigation" will be made at the unit location price bid. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, labor and other operations related to soil testing.

25.2.10. Electrical Resistivity Test

This test shall be conducted to determine the Electrical resistivity of soil required for designing safety-grounding system for the entire station area. The specifications for the equipments and other accessories required for performing electrical resistivity test, the test procedure, and reporting of field observations shall confirm to relevant British standard codes (B S Codes)/ equivalent International Standards. The test shall be conducted using Wagner's four electrode method as specified in relevant British standard codes (B S Codes)/ equivalent International Standards.. Unless otherwise specified at each test location, the test shall be conducted along two perpendicular lines parallel to the coordinate axis. On each line a minimum of 8 to 10 readings shall be taken by changing the spacing of the electrodes from an initial small value of 0.2 m up to a distance of 50.0 m.

25.3 CONTOUR SURVEY, SITE LEVELLING

25.3.1 CONTOUR SURVEY & SITE LEVELLING:

The land for construction of substation will be handed over to the successful bidder as on where basis progressively after award of work. The contractor shall carry out survey work by taking spot level at 05 m x 05 m grid interval with respect to temporary bench mark transferred from permanent bench mark in the locality if available either on bridge, government buildings of local authorities or any other permanent structure. The contractor shall submit the spot levels (in grid format) in editable soft copy in excel format and contour map with contour interval of 0.5 m in editable auto cad soft drawing.

The contractor will level the area required for construction of substation work either at single level, multi level or gradual slope with the finished ground level as approved by NEA during detailed engineering based on highest flood level. The levelling area shall be decided by NEA during detailed Engineering stage.

The layout and levels of all structure etc shall be made by the Contractor at his own cost from the general grids of the plot and benchmarks set by the Contractor and approved by NEA. The Contractor shall provide all assistance in instruments, materials and personnel to NEA for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

25.3.2 SCOPE

This clause covers clearance of site, contour survey, site levelling, maintaining finished ground level by cutting/filling in all types of soil and soft/ disintegrated rock, supplying and compaction

of fill material if required. Numbering, Blazing, Cutting/felling of trees and their storage as directed by District Forest Office has also been taken under the present scope.

25.3.3 GENERAL

Site shall be cleared, surveyed and levelled/sloped by the contractor as per approved general arrangement drawing or levelling area decided during detailed engineering after award of work.

Work covered under this clause comprises the site clearance, survey work/setting out and making profiles (preparation of plot plan, setting up Bench Mark and taking spot levels at 05m x 05 m interval, preparation of contour plan with contour interval of 0.50 m), Earth work in Excavation & filling in specified area with all lifts and leads and earth work in filling with borrowed earth with all leads and lifts (Borrow areas including payment of royalty for borrowed earth shall be arranged by the contractor at his own cost). During detailed engineering stage, the contractor will prepare the levelling proposal for optimum levelling and submit to NEA for approval. Contractor shall submit the hard copy and editable soft copy of levelling proposal (levelling quantity calculation in Excel form and levelling drawing in Auto CAD) to NEA for approval.

25.3.4 Filling material shall conform to relevant British standard codes (BS Codes)/ equivalent International Standards. Unsuitable filling material if any shall be removed and replaced by suitable fill material. The filling shall be compacted in layers to achieve 95% of standard Proctor's density at Optimum moisture contents (OMC). Cohesion less material shall be compacted to 70% relative density (minimum). Levelling/Filling shall be carried out as per relevant British standard codes (B S Codes)/ equivalent International Standards.

25.3.5 All materials involved in excavation shall be classified by NEA in the following groups:

All kinds of soils and soft/disintegrated rocks (Not requiring blasting): The material which can be quaried/excavated with pick, shovel, jumpers, scarifiers, crowbars and mechanical implements and will include various types of soils, plain cement concrete, shingle, river/nallah boulders, soling of road/foot path, stone masonry, soft conglomerate and laterite stone, lime stone and hard conglomerate etc.

Hard Rocks: All kinds of rocks which can only be excavated by machines and requires blasting, chiselling in edging or in another agreed method and will also include reinforcement cement concrete.

25.3.6 The quantity of excavation in all types of soils and soft/disintegrated rock shall be worked out by using initial and final level and no void deduction shall be made to calculate net quantity of earth work with 95% compaction.

25.3.7 The volume of hard rock shall be computed on the basis of stack of excavated rubble after making50 % deduction for voids.

25.3.8 The surface of excavation or filling shall be neatly dressed to the required formation level with tolerance of (±) 100 mm.

Measurement and payments of "**Contour Survey, Site levelling"** shall not be made. Therefore bidders are instructed to include all the cost to procure contour survey, site levelling in elsewhere in the contract items in BOQ. Other payments shall be as per BOQ.

25.4 SITE PREPARATION, EXCAVATION, BACKFILL & DISPOSAL OF SURPLUS EARTH.

25.4.1 SITE PREPARATION

The layout and levels of all structure etc shall be made by the Contractor at his own cost from the general grids of the plot and benchmarks set by the Contractor and approved by the NEA.

The Contractor shall give all help in instruments, materials and personnel to the NEA for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

25.4.2 SCOPE

This clause covers clearing of the site, maintaining the finished ground level with available surplus excavated suitable back fill material generated from foundation works etc.

25.4.3 GENERAL

1) The Contractor shall develop the site area to meet the requirement of the intended purpose. The site preparation shall conform to the requirements of relevant sections of this specification or as per stipulations of relevant British standard codes (B S Codes)/ equivalent International Standards.

2) The fill material shall be suitable for the above requirement. The fill shall be with such a material that the site so designed shall not be affected by erosion from wind and water from its final compacted position or the in-situ position of undisturbed soil.

3) Material unsuitable for founding of foundations shall be removed and replaced by suitable fill material to be approved by the NEA.

4) Backfill material around foundations or other works shall be suitable for the purpose for which it is used and compacted to the density described under Compaction. Excavated material not suitable or not required for backfill shall be disposed off in areas as directed by purchaser up to a maximum lead of 2 km.

25.4.4 EXCAVATION AND BACKFILL

SCOPE

This clause covers excavation for foundation works of Towers, Equipment support structures, Transformer foundations, External Lighting poles, Cable trenches, Buildings, Fire Wall, etc, backfilling of Foundations Works.

1. Excavation and backfill for foundations shall be in accordance with the relevant British standard codes (B S Codes)/ equivalent International Standards.

2. Whenever water table is met during the excavation, it shall be dewatered and water table shall be maintained below the bottom of the excavation level during excavation, concreting and backfilling.

3. When embankments are to be constructed on slopes of 15% or greater, benches or steps with horizontal and vertical faces shall be cut in the original slope prior to placement of embankment material. Vertical faces shall measure not more than 1 m in height.

4. Embankments adjacent to abutments, culverts, retaining walls and similar structures shall be constructed by compacting the material in successive uniform horizontal layers not exceeding 15 cm in thickness (of loose material before compaction). Each layer shall be compacted as required by means of mechanical tampers approved by the Purchaser. Rocks larger than 10 cm in any direction shall not be placed in embankment adjacent to structures.

5. Earth embankments of roadways and site areas adjacent to buildings shall be placed in successive uniform horizontal layers not exceeding 20 cm in thickness in loose stage measurement and compacted to the full width specified. The upper surface of the embankment shall be shaped so as to provide complete drainage of surface water at all times.

25.4.5 COMPACTION

1. The density to which fill materials shall be compacted shall be as per relevant BS and as per direction of NEA. All compacted sand filling shall be confined as far as practicable. Backfilled earth shall be compacted to minimum 95% of the Standard Proctor's density at OMC. The sub grade for the roads and embankment filling shall be compacted to minimum 95% of the Standard Proctor's density at OMC. Cohesion less material sub grade shall be compacted to 70% relative density (minimum).

2. At all times unfinished construction shall have adequate drainage upon completion of the road's surface course, adjacent shoulders shall be given a final shaping, true alignment and grade.

3. Each layer of earth embankment when compacted shall be as close to optimum moisture content as practicable. Embankment material which does not contain sufficient moisture to obtain proper compaction shall be wetted. If the material contains any excess moisture, then it shall be allowed to dry before rolling. The rolling shall begin at the edges overlapping half the width of the roller each time and progress to the centre of the road or towards the building as applicable. Rolling will also be required on rock fills. No compaction shall be carried out in rainy weather.

25.4.6 REQUIREMENT FOR FILL MATERIAL UNDER FOUNDATION

The thickness of fill material under the foundations shall be such that the maximum pressure from the footing, transferred through the fill material and distributed onto the original undisturbed soil will not exceed the allowable soil bearing pressure of the original undisturbed soil. For expansive soils, the fill materials and other protections etc. to be used under the foundation is to be got approved by the NEA.

25.4.7 DISPOSAL OF SURPLUS EARTH

The surplus earth generated from foundation work shall be disposed away from levelling area boundary at low lying areas within 2Km lead. The surplus earth if disposed within substation main boundary, the same shall be spread in uniform layers and compacted with suitable compacting equipment to achieve 95% compaction at O.M.C.

Separate measurement and payment of BOQ item "Site grading with earth filling by borrow pit earth including compaction and levelling etc all to complete the specified works as per technical specification" shall be made in Cu. M. Therefore in the price schedule, the unit price shall include full compensation for all the costs incurred in furnishing all materials and all other operations related to fill including but not limited to:

(a) Obtaining materials from cutting zone of switchyard as well as from the Employer's approved source.

(b) Transporting materials to job site from source, to temporary stockpiles and/or points of final disposition.

(c) Placing and compacting material.

(d) Levelling the top surface of both cut and fills areas to the finished grade.

25.5 ANTIWEED TREATMENT, SAND FILLING, PLASTIC LAYING & STONE SPREADING

25.5.1 SCOPE OF WORK

The Contractor shall furnish all labour, equipment and materials required for complete

performance of the work in accordance with the drawings, specification.

Crushed Rock spreading along with sand and black plastic 200 gauze laying shall be done in the areas of the switchyard under present scope of work within fenced area.

25.5.2 GENERAL REQUIREMENT

The material required for site surfacing/stone filling shall be free from all types of organic materials and shall be of standard quality, and as approved by the NEA.

The material to be used for stone filling/site surfacing shall be uncrushed/crushed/broken stone of 40 mm nominal size (ungraded single size) conforming to relevant BS. Hardness, flakiness shall be as required for wearing courses shall be as are per relevant BS.

(a) Hardness

Abrasion value as per relevant BS.

Impact value as per relevant BS.

(b) Flakiness Index

One test shall be conducted as per relevant British standard codes (B S Codes)/ equivalent International Standards.

Anti weed treatment

After all the structures/equipment's are erected, 3-4 layers (as instructed by employer) anti weed treatment shall be applied in the switchyard where ever stone spreading along with fine sand filling followed by laying of plastic of suitable thickness is to be done and the area shall be thoroughly de-weeded including removal of roots. The recommendation of local agriculture or horticulture department may be sought where ever feasible while choosing the type of chemical to be used. The anti-weed chemical shall be procured from reputed manufacturers. The doses and application of chemical shall be 3 times more than manufacturer's recommendation.

NEA shall decide final formation level so as to ensure that the site appears uniform devoid of undulations. The final formation level shall however be very close to the formation level indicated in the approved drawing.

The surface of the switchyard area shall be maintained, rolled/compacted to the lines and grades as decided by NEA. The sub grade shall be consolidated by using one ton roller with suitable water sprinkling arrangement to form a smooth and compact surface. The roller shall run over the sub grade till the soil is evenly and densely consolidated and behaves as an elastic mass.

In areas that are considered by the NEA to be too congested with foundations and structures for proper rolling of the site surfacing material by normal rolling equipments, the material shall be compacted by hand, if necessary. Due care shall be exercised so as not to damage any foundation structures or equipment during rolling compaction.

After completion of the compaction inside the switchyard area, contractors has to fill the 100 mm fine sand and over which black plastic of suitable thickness shall be laid before spreading the stones of first layer.

A final layer of 150 mm thickness of uncrushed/crushed/broken stone of 40 mm nominal size (ungraded size) shall be spread uniformly over sand and plastic cover layer.

Separate measurement and payment of BOQ item "Crushed rock surfacing including laying of sand and plastic as per technical specifications" shall be made in Cu.M as per BOQ. There will be no separate payment for sand and plastic works.

25.6 ROADS

25.6.1 Road inside/outside NEA boundary

Asphalt Pavement

General

This specification covers all construction works for 5 - 8 meter wide driveway road within Employer's premises. The approach road to substation shall be 10 mtr wide with 5 mtrs width black top in it

Grading

Finish grade of roads and packing area shall be as directed by Employer.

Pavement Materials

Sub-base

Sub-base shall be a non-plastic, sandy, granular material with a C.B.R. value greater than 15. It shall be free of deleterious material and subjected to the Employer's approval. Thickness of sub-base course shall be 30cm compacted.

Base course

Base shall be of WBM (water bound macadam) using crushed aggregate with a CBR value greater than 80. The filler material for WBM shall be stone dust. It shall be free of deleterious material and subjected to the Employer's approval. Thickness of base course shall be 15cm compacted.

It shall conform to following gradation:

Sieve size	Percentage passing
1 1"/2	100
3/4"	90 - 100
3/8"	50 - 80
No.4	35 - 55
No.30	10 - 30
No.200	2 - 9

Wearing course

Wearing course shall be of asphalt concrete mixture (minimum 50mm after compaction).

Asphalt Concrete Mixture

Asphalt concrete shall be a mixture of mineral aggregate and paving asphalt mixed at a central mixing plant. Its components shall be as specified herein.

Paving asphalt shall be a stream -refined asphalt produced from crude asphalt petroleum or mixture of refined liquid asphalt and refined solid asphalt. It shall be homogeneous and free from water and residues of coal, coal tar or paraffin oil. It shall have a penetration grade of 85-100 when tested according to ASTM D-5.

Aggregate for asphalt concrete shall be a composition of coarse aggregate and fine aggregate. Both shall be clean and durable.

Composition of Grading

The grading of the combined aggregates and the percentage of asphalt shall be as follows.

Percentages shown are based on weight of dry aggregates.

Sieve size	Percentage passing	
	Minimum	Maximum
3/4"	100	
1/2"	95	100
3/8"	72	88
No.4	46	60
No.8	28	42
No.30	15	27
No.50	10	20
No.200	4	7
Asphalt content (%)	4.8	6.0

Road curb

Both side of road edge shall be provided with R.C.C curb having it's corner chamfered. Minimum projection of curb from road surface shall not be less than 100 mm.

Payment

The unit price bid in the Price Schedule shall include the cost of design, all labor, all material, civil construction works, etc.

The area in road which are not blacktopped shall be well compacted with mixed gravel material and will not be measured in Asphalt Road quantity and thus no separate measurement and payment shall be made.

The road edge RCC curb area shall be measured in Asphalt Road quantity.

Payment for the Contract item "Asphalt Road" will be made at the unit price per Sq. m of finish surface, therefore in the Price Schedule, such unit price shall include full compensations for all costs incurred in grading, furnishing all materials, equipment and labor and all other operations.

25.7 TRANSFORMERS FOUNDATION & TRANSFORMER SHIFTING RAIL FOUNDATION

The Contractor shall design, prepare drawing and provide a RCC Rail cum road system integrated with the Transformer foundation to enable installation and the replacement of any failed unit. The transfer track system shall be suitable to permit the movement of any failed unit fully assembled (including OLTC, bushings) with oil. This system shall enable the removal of any failed unit from its foundation to the nearest road. If trench/drain crossings are required then suitable R.C.C. culverts shall be provided in accordance with relevant BS. The Contractor shall provide a pylon support system for supporting the fire fighting system.

Each Transformer including oil conservator tank and cooler banks etc. shall be placed in a self-sufficient pit surrounded by retaining walls (Pit walls). The clear distance of the retaining wall of the pit from the Transformer shall be 20% of the Transformer height or 0.8m whichever is more. The oil collection pit thus formed shall have a void volume equal to 130% for 132 kV & below of total oil in the Transformer. The minimum height of the retaining walls shall be 15 cm above the finished level of the ground to avoid outside water pouring inside the pit. The bottom of the pit shall have an uniform slope towards the sump pit. While designing the oil collection pit, the movement of the Transformer must be taken into account.

The grating shall be made of MS flat of size 40 mm x 5 mm placed at 30 mm center to center and 25 mm

x 5 mm MS flat at spacing of 150 mm at right angle to each other. Maximum length of grating shall be 2000 mm and width shall not be more than 500 mm. The gratings, supported on ISMB 150 mm, shall be placed at the formation level and will be covered with 100 mm thick layer of broken/crushed/non-crushed stone having size 40 mm to 60 mm which acts as an extinguisher for flaming oil. All steel works used for grating and support in transformer foundation shall be painted with Zinc phosphate primer (two packs) conforming to relevant British standard codes (B S Codes)/ equivalent International Standards.

Each oil collection pit shall be drained towards a sump pit within the collection pit whose role is to drain water and oil due to leakage within the collection pit so that collection pit remains dry. No separate measurement and payment for design and construction oil collection pit shall be made. Bidders are instructed to include all the cost of oil drainage pit in the respective transformer foundations.

MATERIALS

Complete foundation shall be made of reinforced cement concrete and shall be designed as per guidelines for design of foundations given in Article 8.0 in this chapter.

25.8 FOUNDATION / RCC CONSTRUCTION

25.8.1 GENERAL

1. Work covered under this Clause of the Specification comprises the design, drawing and construction of foundations and other RCC constructions for buildings foundation, switchyard tower structures, bus supports, equipment supports, cable trenches, Transformer, jacking pad, pulling blocks, fire protection walls, control cubicles, marshalling kiosks, auxiliary equipments, Control building , Staff quarter ,Guard house, culvert Bridge, water tanks, Panel room, or for any other equipment or service and any other foundation required to complete the work. This clause is as well applicable to the other RCC constructions.

2. Concrete shall conform to the requirements mentioned in relevant British standard codes (B S Codes)/ equivalent International Standards. And all the tests shall be conducted as per relevant British standard codes (B S Codes)/ equivalent International Standards. However, a minimum grade of M25 concrete shall be used for all foundations and structural/load bearing members as per relevant British standard codes (B S Codes)/ equivalent International Standards if not separately specified in BOQ. Other grade of concrete shall be used if specified in BOQ/ drawings with approval of employer.

3. If the site is sloppy, the foundation height will be adjusted to maintain the exact level of the top of structures to compensate such slopes.

4. The switchyard foundation's plinths and building plinths shall be minimum 300 mm and 500 mm above finished ground level respectively.

5. Minimum 75 mm thick lean concrete (1:3:6) shall be provided below all underground structures, foundations, trenches etc. to provide a base for construction.

6. Concrete made with Ordinary Portland slag cement shall be carefully cured and special importance shall be given during the placing of concrete and removal of shuttering.

7. The design and detailing of foundations shall be done based on the approved soil data and sub-soil conditions as well as for all possible critical loads and the combinations thereof. The Spread footings foundation or pile foundation as may be required based on soil/sub-soil conditions and superimposed loads shall be provided.

8. If pile foundations are adopted, the same shall be cast-in-situ driven/bored or pre-cast or under reamed type as per relevant parts of relevant British standard codes (B S Codes)/ equivalent International Standards. Only RCC piles shall be provided. Suitability of the adopted pile foundations shall be justified by way of full design calculations. Detailed design calculations

shall be submitted by the contractor showing complete details of piles/pile groups proposed to be used. Necessary initial load test shall also be carried out by the bidder at their cost to establish the piles design capacity. Only after the design capacity of piles has been established, the Contractor shall take up the job of piling. Routine tests for the piles shall also be conducted. All the work (design & testing) shall be planned in such a way that these shall not cause any delay in project completion.

9. The cement shall be ordinary Portland cement of approved brand and manufacture and shall comply in all respects with the I.S. 269-1967 for ordinary Portland cement. It shall be delivered on the site in packages with an unbroken seal fixed by the manufacturer and plainly marked with the name of brand and the manufacture. It shall be stored in a dry place, in regular piles not exceeding six bags high and in such a manner that it will be efficiently protected from moisture and contamination, and that the consignments can be used up in the order in which they are received. Set cement shall be immediately removed from the work and replaced by the Contractor at his own expense. If desired, tests shall be made by taking samples of cement from stores or elsewhere from the works. The selection of samples and procedure for testing shall comply with appropriate I.S. specification.

10. All aggregates shall conform to I.S. 383 - 1970. Aggregate shall, where possible, be derived from a source that normally produces aggregate satisfactory for concrete, and if requested by the Employer/ Engineer, the Contractor shall supply evidence to this effect. If instructed to do so, the contractor shall supply samples of the aggregate for the purpose of making preliminary concrete test cubes as herein-after specified.

    Aggregate shall consist of naturally occurring sand and gravel or stone crushed or uncrushed, or a combination thereof. They shall be hard, strong, dense, durable, clean and free from veins and adherent coating. As far as possible, flaky and elongated pieces should be avoided.

    Aggregate shall not contain any harmful materials, such as iron pyrites, coal, mica, shale or similar laminated materials, clay, alkali, soft fragments, organic impurities etc. in such quantity as to affect the strength or durability of the concrete or in addition to the above for reinforced concrete, any material which attack the reinforcement. Aggregate which are chemically reactive with the alkalis of cement are harmful, as cracking of concrete may take place. These aggregate shall be protected from spilling oils, mobiles, diesels over it on site.

11. The fine aggregate shall be natural sand or sand derived by crushing suitable gravel or stone and shall be free from coagulated lumps. Sand derived from a stone unsuitable for coarse aggregate shall not be used as the fine aggregate.

    The fine aggregate shall conform to the requirements of I.S. 383 - 1970. Fine aggregate shall not contain more than 3% of material removable by decantation test, nor more than 1% dry lumps. The total of coal, clay lumps, shale, soft fragments and other deleterious substance shall not be more than 5%.

    The percentage of clay lumps shall be determined by examining the various fractions that remain after the material has been tested for grading. Any particles that can be broken with fingers shall be classified as clay lumps and the total percentage of clay lumps shall be determined on the basis of the total original weight of the sample. The fine aggregate shall be well graded from fine to coarse and shall meet the following gradation requirements:

Table - 1 GRADATION FOR FINE AGGREGATE

Sieve designation Percentage by weight passing

Sieve Designation	10mm	No.4	No.16	No.30	No.50	No.100

Fine Aggregate	100	95-100	45-80	25-55	10-30	2-10

Blending will be permitted in order to meet the gradation requirements for the fine aggregate.

12. The coarse aggregate shall be crushed stone aggregate. The pieces of aggregates shall be angular. Friable, flaky and laminated pieces, mica, shale shall only be present in such quantities as not to affect adversely the strength and durability of the concrete as ascertained by tests on concrete cubes. After twenty four hours immersion in water, a previous dried sample shall not have gained in weight more than 5% and not more than 10% if it is to be used in plain concrete or elsewhere as described. The coarse aggregate shall conform to the requirements of I.S. 383 - 1970. The percentage of wear at 500 revolutions of Los Angeles Rattler Test shall not be more than 50%. The coarse aggregate shall meet the gradation of Table-2. Moreover it should conform previous specification on coarse aggregate.

Table - 2 GRADATION FOR COARSE AGGREGATE.

Percentage by weight passing

Sieve Designation		40mm	25mm	20mm	10mm
40mm & down		90-100	20-25	0-15	0-5
20mm & down			100	90-100	20-25

All R.C.C. work shall be carried out in strict accordance with this specification, I.S. Specifications and the working drawings. Any discrepancies in the dimensions on the drawings or any points not clear to the Contractor shall be brought to the notice of the Employer/ Engineer or clarified in advance before proceeding with the work.

The Contractor shall allow for all wastage in all materials. He shall also allow for all tests of concrete materials and if required produce manufacturer's certificate for cement and steel unless issued by the Owner.

i. All form work should be get checked for levelling and dimensions as well as all necessary supporting spouts from the Employer/ Engineer.

ii. Only after getting the formwork checked, reinforcement should be placed properly as according to the drawing and detailing.

iii. The date and time of any casting of concrete should be informed to the Engineer/Employer's 2 days in advance.

No concrete work shall be cast in the absence of the Employer/ Engineer. The Contractor shall personally check that both the formwork and reinforcement have been correctly placed and fixed and satisfy himself that all work preparatory to casting is completely ready, before requesting the Employer/ Engineer for final inspection and approval.

13. The materials used in the works shall be of the qualities and kinds specified. Materials delivered to the works shall be equal to the approved samples which shall be deposited with the Employer/ Engineer at least 30 days before it is required for use in work. The quantity of all necessary materials should be checked by the Employer/ Engineer for any casting. Delivery shall be made sufficiently in advance of constructional requirements to enable further samples to be selected and tested if so desired by the Employer/ Engineer. No material shall be used in the works until

approved. Materials failing to comply with the approved samples and specification shall be immediately removed from the works at the Contractor's Cost.

14. In general, water cement ration (w/c ratio) of the concrete mix shall be kept minimum during casting. Generally one bag of cement concrete mix shall use 35.6 litres of water or as necessary. As moisture content of fine and coarse aggregate varies, for workability of concrete mix, the Employer/ Engineer may vary the water quantity and once the water quantity to be placed for one bag of cement concrete mix, is fixed by the Employer/ Engineer, the Contractor shall follow it strictly. As information to the Contractor, the Employer/ Engineer will depute one checking supervisor to the mixing batch, the quantity of water used shall be varied to suit the moisture content of the aggregate, and shall be just sufficient to produce a dense concrete, consistent with practical workability.

15. The interval between adding the water to the dry mix and completion of the concrete placing operation shall not exceed 20 minutes nor, when an approved admixture that accelerates the initial setting of the cement be used, exceed ten minutes or as directed by the Employer/ Engineer.

    Except where otherwise approved for slabs and large sections concrete shall be placed in the formwork by shovels or other approved implements and shall not be dropped from height more than 1.5 m nor handled in a manner to cause segregation. Accumulations of hardened concrete dropping on the reinforcement shall be avoided. Concrete shall be sorted along the formwork to that position.

    Each layer of concrete while being placed shall be compacted by approved methods of ramming or mechanical vibrations to form a dense surface free from honey combing and tolerably free from water marks and air holes or other blemishes. The concrete shall be tamped against the face of the formwork so as to produce dense fair surface. The number and type of mechanical vibrations shall be approved before compacting by vibration. Placing and compaction of concrete shall be done in such a manner as not to disturb concrete already placed, and reinforcement projecting from concrete already placed shall not be vibrated or jarred. For concreting reinforced concrete walls and other structures having least lateral dimensions of 13mm. or under, each layer of concrete while being placed shall be properly compacted by approved methods of mechanical vibrations produced by internal or external mechanical vibration.

    The laying of concrete over slabs should be uniform thick of required thickness after vibration. This can be confirmed by dipping wooden pegs of required length. The level of all slabs should be in level unless otherwise specified and directed by the Employer/ Engineer. If required, the Employer/ Engineer will check the thickness and give order to the contractor to fill up the newly vibrated slab concrete surface. Any slab thickness after construction, if found less thickness than specified, the contractor will be responsible for above job.

    Any water accumulating on the surface of the newly placed concrete shall be removed by approved means and no further concrete shall be placed thereon until such water is removed. No fresh concrete shall be brought into contact with the concrete containing cement of different type. Unless otherwise approved or instructed, concrete shall be placed in a single operation to the full depth of slabs, beams, and members similar thereto and shall be placed in horizontal layers not exceeding 0.50m deep in walls, columns until completion of the part of the work between construction joints as specified hereafter or of a part of approved extent. At the completion of a specified or approved part of a construction, joints of the form and in the position herein after specified shall be made. If a temporary cessation of concrete placing be unavoidable elsewhere, a construction joint shall likewise be made.

16. The contractor must use vibrator on beams and slabs to compact the newly laid concrete.

Generally two types of vibrator shall be used.

a) NEEDLE OR IMMERSION TYPE OF VIBRATOR

Casting fall beams and columns shall be compacted by means of needle type of vibrator. 4" dia needle type vibrator shall be used over beam section more than 350mm x 400mm and rest of section need only 2" dia needle type vibrator.

b) FLAT BOTTOM VIBRATOR FOR SLABS

The contractor shall require flat bottom type of vibrator to compact all concrete over slabs. No immersion type of vibrator will be allowed to compact the concrete over slab.

Moreover, the contractor shall require at least two number of vibrator for one casting and other should kept in standby position. In case vibrator got damaged or not in working condition during casting, the vibrator shall be immediately replaced. If the contractor shall fail to replace another vibrator during casting, no further casting of concrete will be permitted. The contractor shall in that case, immediately remove the remaining concrete mix from the site of work.

Segregation is likely to take place when the concrete is tipped into the form work and this should be avoided. The concrete mix should not contain surplus water and sand which will develop segregation under influence of vibratory compaction. The distribution of new concrete should be uniform over the whole section and the surface kept horizontal all the time thus ensuring the movement of concrete is downward only. Vibrators shall not be used as a spreading or distributing agent.

The vibrators shall be of rotary out of balance immersion type or the electro-magnetic type and operate at a frequency of not less than 4,000 cycles per minute. The vibration shall be of such a power - input as to produce an acceleration of 1 to 3 m/sec in the mass of the compacted concrete. The vibrators shall be provided for continuous operation.

Vibration shall continue during the whole period occupied by placing the concrete, the vibration being adjusted so that the centre of vibration approximates to centre of the mass being compacted at the time of placing. The concrete should not be over vibrated and the period of insertion of internal vibrator should be about 15 seconds at any point.

The concrete shall be judged to be compacted when the mortar fills the spaces between the coarse aggregate so as to form a glistening and even surface except for slight irregularities where the coarse aggregate breaks this smooth surface. When this condition has been attained, the vibrators shall be withdrawn slowly.

The vibrator must not be placed against the steel or the formwork, the minimum distance being 8 mm. It must be placed in such a position that formwork, reinforcement and recently laid concrete are subjected to the minimum amount of vibration.

17. Construction joints shall be made in the positions hereinafter specified or elsewhere as approved. Such joints shall be truly vertical or horizontal as the case may be, except that in an inclined or curved members the joint shall be strictly at right angles to the axis of the member.

Construction joints shall be made horizontally at the top of the foundations and horizontally 8 mm. below the lowest beam soffit at the head of columns. Concrete in the ribs and slabs of small tee, all beams shall be placed in one operation, but, for large beams concrete in the rib upto a level 2.5 mm. below the slab soffit shall be placed first. Concrete in haunches or splays on the beams or braces and concrete in the head of adjoining portion of the columns shall be placed at the same time as that in the beams or braces. Concrete in splays at the junction of walls and slabs shall be placed at the same time as that in the slab. Construction joints in the length of a

beam shall be avoided where practicable, but where joints are unavoidable they shall be made as previously approved by the Employer/ Engineer. Construction joints in slabs shall be made parallel to the main reinforcement, and where required at right angles to the main reinforcement, they shall be made at a place previously approved by the Employer/ Engineer.

Before placing new concrete against concrete already set, the face of the old concrete shall be cleaned and scum removed. The face shall be roughened and any loose aggregate removed there from. Immediately before placing the new concrete the face of the old concrete shall be thoroughly wetted and a coating of neat cement grout applied. The new concrete shall be well rammed against the prepared face before the grout sets. Construction joints will not be paid separately.

18. Immediately after placing or finishing, concrete surface not covered by forms shall be protected from loss of surface moisture for at least seven days when the average daily temperature is at least 21^{o}C, where Portland cement has been used. Protection from loss of surface water shall be done by any of the following methods where applicable to the type of work involved:

i) By water covering.

ii) By covering of surfaces with water impervious paper.

iii) By application of approved impervious membrane.

Surfaces from which forms have been removed before the curing period has elapsed shall be protected as specified for surfaces not covered by forms. Membrane curing shall not be used on surfaces required to receive additional concrete or concrete fill, nor on cement finish costs that are to receive dust proofing or hardening treatments, nor during hot weather.

Water curing shall be performed by keeping the concrete surface wet by ponding, by continuous spraying or by covering the surface with an approved water-saturated covering such as 2.5 mm. of sand or sawdust, or by one or more layers of burlap. The exposed concrete surfaces shall be saturated with water throughout the full stipulated curing period. Where forms remain in place during the curing period, they shall be kept sufficiently wetted with clean water to reduce cracks and to prevent joints from opening in the forms.

The impervious membrane curing compound shall be an approved non-bituminous, colourless, liquid sealing compound in atomized form so as to preserve the natural color of the concrete. The curing compound shall be applied as soon as surface water has disappeared from concrete surfaces with approved pressure spraying equipment in accordance with the manufacturer's directions and in sufficient thickness to form an effective water seal. No compounds shall be used which will adversely affect the subsequent installation of finished flooring.

Joints of sheet membrane used for curing shall be lapped at least 150mm and sealed with water proof tape as recommended by the manufacturer. Polyethylene sheet shall be considered the water-impervious paper for purposes of interpretation of this item. No liquid curing compound may be used without specific written approval of the Employer/ Engineer regarding type, manufacturer, location and extent of use and application procedures.

19. The concrete surface shall in general be smooth finish. However, immediately after stripping form work, minor defects and honey combed areas shall be patched and holes filled before the concrete is thoroughly dry, patch areas shall be chipped away to 2.5 mm depth, with regular edges perpendicular to the surface. Area to be patched shall be thoroughly wet including the areas at least 150 mm. wide entirely surrounding them, just prior to placing the patching mortar. Mortar shall be of the same material and proportions as used for the concrete, without coarse aggregate. A sufficient quantity of white cement shall be substituted for part of the ordinary cement so that the patching mortar, when dry, will match the surrounding concrete. Water in

the mix shall be kept to a minimum and mortar shall be retempered without adding water and shall be allowed to stand for one hour prior to use during which time it shall be mixed to prevent setting. The mortar shall be thoroughly compacted into place, screeded so as to leave the patch slightly higher than surrounding surfaces, left undisturbed for one to two hours to permit initial shrinkage and finished to match the adjoining work. Where patches exceed 2.5 mm. deep, they shall be trimmed and wet as specified, after which the opening shall be filled to within 2.5 mm. of the surface. After sufficient shrinkage time has elapsed, the patching shall proceed as described above.

Patches shall be kept wet for five days. Tie holes left by the withdrawal of rods, or holes left by removal of ends of ties shall be filled solidly with mortar. For holes passing entirely through the wall, plunger-type grease gun or other device to force mortar through the wall, starting at the back face, shall be used. When a hole is completely filled, excess mortar shall be struck off with a cloth flush with the surface. Holes not passing entirely through walls shall be filled solidly with mortar. Any excess mortar shall be struck off with a cloth on the wall surface. The surface of non-shuttered faces concrete work other than slabs shall be smoothed with a wooden float (or if approved with a steel trowel) to give a finish equal to that of the rubbed down shuttered faces. Concealed concrete faces shall be left as it is except that honeycombed surfaces shall be made good.

The top faces of slabs not intended to be surfaced shall be levelled and floated to a smooth finish at the levels or falls shown on the drawings or elsewhere.

The floating shall not be executed to the extent of bringing excess fine material to the surface. Ribbed surfaces of slabs shall where instructed be formed at the time of taming and levelling. Indentation in slab or stair surfaces shall be formed by approved implements giving the depth and patterns instructed. The top faces of slabs intended to be covered with screed, granolithic or similar surfacing shall be left with a spade finish.

The soffits of slabs and faces of walls intended to be rendered shall be roughened by approved means to form a key. Concrete surfaces to take finishes other than those specifically referred to herein shall be prepared in an approved manner to suit the finish as instructed.

20. The Employer/ Engineer shall instruct that a loading test be made on the works or any part thereof if in his opinion such a test be deemed necessary for one or more of the following reasons:

a) The site - made concrete test cubes failing to attain the specified strength.

b) Over - loading during construction of the works or part thereof.

c) The shuttering being prematurely removed.

d) Concrete improperly cured.

e) Any other circumstances attributable to alleged negligence on the part of the Contractor which in the opinion of the Employer/ Engineer may result in the works or part thereof being less than the expected strength.

f) Any reason other than the foregoing.

The test shall be made at the contractor's own cost. If the test be instructed to be made for one or more of the reasons from (a) to (e) inclusive, and If the test be instructed to be made for the reason (f), the contractor shall make the test and shall be reimbursed for all cost relating thereof irrespective of the result of the test.

For the purpose of the load test on floors, roofs and similar structures and their supports, the test load shall be equivalent to 1 and 2/3 times the superimposed load for which the works or part

thereof to be tested have been designed. The test load shall not be applied within 90 days (or 28 days if rapid hardening Portland cement be used) of the completing of placing of the concrete in the part of the works to be tested, and the latter shall not be supported during the test by shuttering or other non-permanent support. Means shall be taken to ensure that in the event of a failure under the test temporary support of the loaded member shall be immediately available. The test shall proceed strictly as instructed. For the loading test on floors, roofs or similar structures the result shall be deemed satisfactory if upon removal of the test load the residual deflection does not exceed one - quarter of the maximum deflection after 24 hours loading. If the residual deflection exceeds this amount the test loading shall be repeated, and the result shall be deemed to be satisfactory if the residual deflection after removal of the second test load does not exceed one-quarter of the maximum deflection occurring during the second test.

If the result of the loading test be not satisfactory, the Employer/ Engineer shall instruct that part of the works concerned shall be taken down or removed and reconstructed to comply with this specification, or that such other remedial measures shall be taken as to make the works secure. If the test be instructed to be made for one or more of the reasons (a) to (e) inclusive as herein before specified, the Contractor shall take down or remove and reconstruct the defective work or shall take the remedial measures instructed at his own cost.

25.9 REINFORCEMENT

25.9.1 INSTALLMENT OF REINFORCEMENT STEEL

Supplying and fixing Fe 500 grade TMT bar steel reinforcement or equivalent in RCC work including bending, binding with GI wire, placing in position including the cost of binding wire, as per drawing.

Reinforcement shall be free from pitting due to corrosion, loose rust, mill scale, paint, oil, grease, adhering earth, or other materials that may impair the bond between the concrete and the reinforcement or that may in the opinion of the Employer/ Engineer cause corrosion of the reinforcement or disintegration of the concrete.

25.9.2 BAR REINFORCEMENT

Bar reinforcement described TMT (Fe 500) shall be hot rolled deformed bars or cold twisted steel bars. With respect to manufacture, quality, physical properties and related requirements, reinforcement of the fore-going descriptions shall comply with appropriate parts of IS Standards Nos. 432-1966, 1139-1966 and IS 1786-1966 for mild steel and tor steel respectively.

25.9.3 CERTIFICATES AND TESTS FOR REINFORCEMENT

The contractor shall carry out ultimate strength, yield stress and elongation and cold bend test and other Standard tests as required in discretion of employer for each type and each size of bar to sample steel reinforcement to his own cost (including all cost associated travelling and daily allowance cost of one employer's representative as per NEA's prevailing rate) from reputed laboratory in presence of employer's representative. Tests for the purpose of obtaining the information shall conform to relevant I.S. specification.

For each consignment of bar reinforcement used in the works, the Contractor shall, if required, supply a certificate giving the ultimate strength, yield stress and elongation and the result of the cold bend test for each type and each size of bar. Tests for the purpose of obtaining the information shall conform to relevant I.S. specification.

The reinforcements supplied for which the Manufacturer's test sheets or other records are not available, or where in the opinion of the Employer/ Engineer has been subject to corrosion or other bad effects, the Employer/ Engineer shall select as many test pieces as he deems necessary, and the Contractor shall supply and deliver the test pieces free of cost without reimbursement

and pay the cost of preparing and testing them as well. This test shall be performed in presence of the Employer/ Engineer.

25.9.4 DIMENSIONS OF REINFORCEMENT

The size of reinforcement bar described in the working drawings or elsewhere shall be the minimum and the rolling margin and other tolerances shall be wholly above this size. The length of a reinforcement bar shall not be less than the length on the drawing or elsewhere and shall not be more than 50 mm in excess of that length. Bar bending schedule shall be prepared by the Contractor and submitted for approval of the Employer/ Engineer. Such schedules shall be prepared based on reinforcement details, prior to the execution of the work. Nothing extra shall be paid for this.

25.9.5 BENDING REINFORCEMENT

Reinforcement bars shall be bent by approved means producing a gradual and even motion. Bars shall comply with the dimensions described in the drawings. Overall dimensions of bent or internal dimensions of bending or the like shall be within a tolerance of 30 mm. Any discrepancies or inaccuracies found by the Contractor in the drawings or other documents shall be immediately reported to the Employer/ Engineer whose interpretation and requirements relating there to shall be accepted. The internal radius of bends shall be not less than twice the size of the bars unless described to the contrary on the bending lists or elsewhere in the drawing. Hooks and other anchorage bends for tor steel shall be bent to an internal radius of the twice diameter of the bar. This internal radius of the bends of corners of binders or stirrups or links shall be half.

25.9.6 FIXING REINFORCEMENT

Reinforcement shall be accurately fixed and by approved means maintained in the position described in the drawings. Bars intended to be in contact shall be securely wired together at all such points with 16 gauge soft iron tying wire. Binders, stirrups and links shall tightly embrace the bars with which they are intended to be in contact and shall be securely wired or, if approved, spot welded thereof.

Reinforcement shall be lapped, joined or spliced only at the positions described. Splices and the like found to be necessary elsewhere shall be formed only if and as instructed. Lapping shall be provided as shown in the drawing and as permitted. Where practicable bars in each member shall be assembled and fixed in the form of a rigid cage or skeleton before placing in the moulds or formwork. For this, all lapping bar on beams and slabs shall be scattered i.e. as far as possible minimum number of laps shall be permitted in one section of slab and only one lap will be permitted at one section in case of beams. In case of columns the lapping of bar shall be permitted only at the centre zone of column.

25.9.7 LAPPING LENGTH

a) In case of beams and slabs, lapping length shall be 57 dia. of designed bar.

b) In case of columns the lapping length shall be 45 dia. of the designed bar.

Immediately before concreting, the reinforcement shall be checked for position, cleanliness, and freedom from rust or retarding liquid. Means shall be taken to ensure that reinforcement remains correctly in position with required cover during the placing and compacting of the concrete.

Reinforcement projecting from work being concreted or already concreted shall not be bent out or its correct position for any reason unless approved and shall be protected from deformation or other damage. Reinforcement left projecting for bending with future extensions shall be thoroughly coated with cement grout wash or encased in concrete or other-wise protected from

corrosion as instructed.

25.9.8 COVER OF CONCRETE AND SPACING OF BARS

Unless otherwise described, the clear cover of concrete to the reinforcement shall be as follows:

Horizontal, Vertical or Inclined Slabs

15 mm or the size of the bars whichever is greater.

Lintels

20 mm or the size of the bar whichever is greater.

Beams

25 mm or the size of the main bars whichever is greater. Binders and the like 15 mm minimum.

Columns

Cover for main bars for columns not exceeding 20 mm diameter shall be 25 mm and the main bars in columns exceeding 20 mm diameter shall be 40 mm or the size of the main bars whichever is greater, 15mm minimum for rectangular binders or links or helical binding.

CHAIRS AND SUPPORTS FOR REINFORCING BARS

Chairs of appropriate depth in suitable form shall be installed on all top bars in case of slab. The shape of chair shall be checked by the Employer/ Engineer. The spacing for slab top bar chairs will be such that during casting time, the reinforcement shall not get disturbed.

CONCRETE CHAIR BLOCK FOR BOTTOM BARS

All bottom bar in slabs shall be raised as accordance with cover for concrete by means of small concrete blocks tied with binding wires. These blocks shall be placed at sufficient intervals during casting time, to maintain the cover for reinforcement.

In case of beams, the bottom blocks as well as side reinforcement shall be provided with concrete chair blocks so that the reinforcement shall not get disturbed during casting.

25.9.9 DESIGN

While designing foundations, following may be taken care of:

1. All foundations except for external lighting poles shall be of reinforced cement concrete. The external lighting pole shall be embedded in plain cement concrete (1:1.5:3) foundation. The design and construction of RCC structures shall be carried out as per relevant BS and minimum grade of concrete shall be M-25. Higher grade of concrete than specified above may be used at the discretion of Contractor without any additional financial implication to the NEA.
2. Limit state method or any other method as per relevant British standard codes (B S Codes)/ equivalent International Standards of design shall be adopted unless specified otherwise in the specification.
3. For detailing of reinforcement relevant BS followed. Cold twisted deformed bars conforming to relevant British standard codes (B S Codes)/ equivalent International Standards. Two layers of reinforcement (on inner and outer face) shall be provided for wall & slab sections having thickness of 150 mm and above. Clear cover to reinforcement shall be as per relevant British standard codes (B S Codes)/ equivalent International Standards.
4. RCC water retaining structures like storage tanks, etc. shall be designed as un cracked section in accordance with relevant British standard codes (B S Codes)/ equivalent International Standards. However, water channels shall be designed as cracked section with limited steel stresses as per relevant

BS.

5. The procedure used for the design of the foundations shall be the most critical loading combination of the steel structure and or equipment and/or superstructure and other conditions which produces the maximum stresses in the foundation or the foundation component and as per the relevant British standard codes (B S Codes)/ equivalent International Standards of foundation design. Detailed design calculations shall be submitted by the bidder showing complete details of piles/pile groups proposed to be used.
6. Design shall consider any sub-soil water pressure that may be encountered following relevant standard strictly.
7. Necessary protection to the foundation work, if required shall be provided to take care of any special requirements for aggressive alkaline soil, black cotton soil or any other type of soil which is detrimental/harmful to the concrete foundations.
8. RCC columns shall be provided with rigid connection at the base.
9. All sub-structures shall be checked for sliding and overturning stability during both construction and operating conditions for various combinations of loads. Factors of safety for these cases shall be taken as mentioned in relevant British standard codes (B S Codes)/ equivalent International Standards or as stipulated elsewhere in the Specifications. For checking against overturning, weight of soil vertically above footing shall be taken and inverted frustum of pyramid of earth on the foundation should not be considered.
10. Earth pressure for all underground structures shall be calculated using co-efficient of earth pressure at rest, co-efficient of active or passive earth pressure (whichever is applicable). However, for the design of substructures of any underground enclosures, earth pressure at rest shall be considered.
11. In addition to earth pressure and ground water pressure etc., a surcharge load of 2T/Sq. m shall also be considered for the design of all underground structures including channels, sumps, tanks, trenches, substructure of any underground hollow enclosure etc., for the vehicular traffic in the vicinity of the structure.
12. Following conditions shall be considered for the design of water tank in sumps, trenches and other underground structures:
    a) Full water pressure from inside and no earth pressure & ground water pressure & surcharge pressure from outside (application only to structures which are liable to be filled up with water or any other liquid).
    b) Full earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.
    c) Design shall also be checked against buoyancy due to the ground water during construction and maintenance stages. Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the superimposed loadings.
13. Base slab of any underground enclosure shall also be designed for empty condition during construction and maintenance stages with maximum ground water table (GWT). Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the super-imposed loadings.
14. Base slab of any underground enclosure like water storage tank shall also be designed for the condition of different combination of pump sumps being empty during maintenance stages with maximum GWT. Intermediate dividing piers of such enclosures shall be designed considering water in one pump sump only and the other pumps sump being empty for maintenance.
15. The foundations shall be proportioned so that the estimated total and differential movements of the

foundations are not greater than the movements that the structure or equipment is designed to accommodate.

16. The foundations of transformer/reactor and circuit breaker shall be of lock type foundation. Minimum reinforcement shall be governed by relevant British standard codes (B S Codes)/ equivalent International Standards.

17. The tower and equipment foundations shall be checked for a factor of safety as per relevant British standard codes (B S Codes)/ equivalent International Standards for two conditions i.e. Normal condition and short circuit condition against sliding, overturning and pull-out. The same factors shall be used as partial safety factor over loads in limit state design also.

25.9.10 ADMIXTURES & ADDITIVES

1. Admixtures shall be used in the concrete for the Works and admixture shall be approved type. When more than one admixture is to be used, each admixture shall be batched in its own batch and added to the mixing water separately before discharging into the mixer. Admixtures shall be delivered in suitably labelled containers to enable identification.

2. Admixtures in concrete shall conform to relevant British standard codes (B S Codes)/ equivalent International Standards. The water proofing cement additives shall conform to relevant BS. Concrete Admixtures/ Additives shall be approved by NEA.

3. The Contractor may propose and the NEA may approve the use of a water-reducing set-retarding admixture in some of the concrete. The use of such an admixture will not be approved to overcome problems associated with inadequate concrete plant capacity or improperly planned placing operations and shall only be approved as an aid to overcoming unusual circumstances and placing conditions.

4. The water-reducing setting-retarding admixture shall be an approved brand as per relevant British standard codes (B S Codes)/ equivalent International Standards.

5. The water proofing cement additives shall be used as required/advised by NEA.

25.10 FORMWORK

25.10.1 CENTERING AND SHUTTERING

Centering and shuttering of plywood and steel formwork in slabs, walls, beams etc. including propping, strutting etc. and removal of forms including applying form oil to shuttering.

25.10.2 DESIGN

Formwork shall be designed and constructed for removal so that the concrete can be properly placed and thoroughly compacted. Formwork shall be firmly supported and adequately strutted, braced, or tied. It shall be capable of adjustment to the lines and dimensions of the finished concrete and it shall be sufficiently strong to resist without distortion, the pressure of concrete during its placing and compaction, and other loads to which it may be subjected. It shall not be liable to suffer distortion under the influence of the weather. When concrete is to be vibrated, special care shall be taken to ensure that the formwork will remain stable and the joints tight. The safety and adequacy of centering and shuttering shall be the sole responsibility of the Contractor. The Contractor shall if required supply to the Employer/ Engineer drawings and calculations for the formwork he proposes to use, for the concrete work.

25.10.3 MATERIAL FOR FORMWORK

All surface of the formwork shall be of plywood or steel plate which shall give uniform concrete surface after removal. No wooden planks or other means of form work shall be acceptable. For struts and props the Contractor shall use sal wood 75mm x 100mm props or Iron lifting type strut over form base i.e. it shall not get depressed at the time of loading or casting. Any strut, if

found defective shall be replaced as directed by Employer/ Engineer.

25.10.4 DEFLECTION AND CAMBER

The Contractor shall make allowance for any settlement or deflection of the formwork that is likely to arise during Construction, so that the hardened concrete conforms accurately to the specified line and level. The Contractor shall also make allowance in the formwork for any camber specified by the Employer/ Engineer to allow for the elastic deflection of structural members and deflection due to creep of the concrete. In the absence of any specified camber, the soffit of all beams and slabs shall be given a camber equal to 1/240 of the span length to ensure that the structure has the prescribed shape after removal of the forms.

25.10.5 SUPPORTS

Formwork shall be constructed so that the formwork to the sides of members can be removed without disturbing the soffit formwork or its supports. Props and supports shall be designed to allow the formwork to be adjusted accurately to line and level and to be erected and removed in an approved sequence without damage to the concrete. Supports shall be carried out which is sufficiently strong to afford the necessary support without damage to any portion of the structure. This may mean in some cases that it be carried down to the foundations or other suitable base. Props and bracing shall be provided for the temporary support of composite construction where separately specified.

25.10.6 JOINTS AND EDGES

All joints in the formwork shall be close-fitting to prevent leakage of cement slurry from the concrete. At construction joints, formwork shall be tightly secured against previously cast or hardened concrete to prevent the formation of stepping or ridges in the concrete. Formwork shall be constructed to provide straight and true angles, arises or edges. Where cambers are shown on the Drawings, the fillets shall be accurately cut to size to provide a smooth and continuous chamfer. Formwork panels shall have true edges to permit accurate alignment at sides and provide a clean line at construction joints in the concrete which shall be fixed with their joints either vertical or horizontal, unless otherwise specified.

25.10.7 SUNDRIES

Formwork shall be provided to the top surface of concrete where the slope or the nature of the work requires it. Provision shall be made for forming holes and chases for services and for building in pipes, conduits and other fixings, as shown on the drawings. The material and position of any ties passing through the concrete shall be as directed by the Employer/ Engineer. Except where corrosion of a metal tie is unimportant, it shall be possible to remove a tie so that no part of it remaining embedded in the concrete shall be nearer to the finished surface of the concrete than the specified thickness of cover to the reinforcement. Any holes left after the removal of ties shall be filled with concrete or mortar of approved mix.

25.10.8 CLEANING AND TREATMENT OF FORMWORK

Spaces to be occupied by concrete shall be free from all rubbish, chipping, shavings, sawdust, dirt and tying wire etc., before concrete is placed. The formwork to be in contact with the concrete shall be cleaned and treated with a suitable non-staining form oil or other approved material. Care shall be taken that oil or composition is kept away from contact with the reinforcement or with concrete at any construction joints. Surface retarding agents shall not be used except with the permission of the Employer/ Engineer. Formwork shall be thoroughly cleaned after each use. Damaged or distorted formwork shall not be used.

25.10.9 **PAINTING ON FORMWORK**

The concrete repellent painting on all contact surface of the formwork shall be of approved non bituminous colourless form oil so as to preserve the natural color of the concrete. The repellent compound shall be applied so as to effect quick removal of form work. It shall be applied as per the manufacture's direction. No compound shall be used which will adversely affect the concrete work or surface. No form repellent compound may be used without specific written approval of the Employer/ Engineer regarding type, manufactures, location and extent of use and application procedures.

25.10.10 **REMOVAL OF FORMWORK**

All formwork shall be removed without shock or vibration that might damage the concrete. Before the soffit and props are removed the surface of the concrete shall be exposed where necessary in order to ensure that the concrete has hardened sufficiently. In no circumstances shall formwork be struck of until the concrete reaches cube strength of at least three times the stress to which the concrete may be subjected at the time of striking. The formwork to vertical surfaces such as walls, columns and sides of beams may be removed after 24 hours in normal weather conditions although care must be taken to avoid damage to the concrete, especially to arise and features. In cold weather a longer period may be necessary before striking. Suitable curing methods should immediately follow the removal of the formwork. The following minimum times shall elapse before removal of formwork:

The times given for the removal of props are based on the assumption that the total live load plus dead weight to be supported at the time of removal is not more than one half the total design load. For horizontal members where the loading is a higher proportion of the total design load these times may need to be increased.

25.11 BRICKWORK

25.11.1 **BRICK MASONERY WORK**

Chimney made first class brick work in foundation, parapet and plinths in cement mortar 1:4 (1cement: 4sand)

25.11.2 **BRICKS**

The bricks shall be table molded with sand from good brick earth and shall be of uniform size, unless otherwise specified. They shall be uniform deep red, cherry or copper color, thoroughly well burnt without being vitrified, regular in shape and size, and shall have sharp and square sides and edges and parallel faces to ensure uniformity in the thickness of the courses of brick work. The bricks shall be free from cracks, chips, flaws stones or humps of any kind. They shall not show appreciable signs of efflorescence either dry or subsequent to soaking in water. The bricks shall be sound, hard, and homogeneous in texture and produce a clear ringing sound when struck with a trowel. In no case, the minimum crushing strength of bricks shall be less than 1000 lbs/sq. inch. The bricks shall be provided with frogs. All bricks which absorb water more than one-sixth of their own dry weight after being soaked for one hour by immersion in water shall be rejected.

25.11.3 **BRICK BATS**

Brick bats shall be well burnt and shall be obtained only from the bricks specified under 9.1.1.above.

25.11.4 **MORTARS**

All brick work shall be laid with specified mortar of good workable consistency.

Cement mortar shall be prepared by mixing cement and sand in the specified proportions the mixing shall be done in a mechanical mixer or by hand mixing as directed by Employer/ Engineer. Water shall be added as required during mixing. Care shall be taken not to add more water than what is actually needed to bring the mortar to the consistency of a stiff paste. Only the quantity of mortar, which can be used within 2 hours of its mixing shall be prepared at a time. Mortar unused for more than 2 hours shall be rejected and removed from the site of work.

25.11.5 **WORKMANSHIP**

Workmanship shall be first class throughout. The workmanship shall be to the approval of the Employer/ Engineer.

25.11.6 **SOAKING OF BRICKS**

All bricks required for masonry in cement mortars shall be thoroughly soaked in clean water for at least one hour in tanks of sufficient size immediately before use. The cessation of bubbles when the bricks are immersed in water is an indication of through soaking of bricks.

25.11.7 **LAYING**

a) Bricks shall be laid in English bond, unless otherwise specified. Half or cut bricks shall not be used except where necessary to complete the bond. Closer in such cases shall be cut to the required size and used near the ends of the walls.

b) The walls shall be taken up truly plumb. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. Vertical joints in alternate courses shall come directly one over the other. The thickness of brick courses shall be kept uniform and for this purpose straight edge with graduations showing the thickness of each brick course including joint shall be used. Bricks shall be laid with frogs upwards.

c) The walls of a structure shall be carried up regularly and nearly at one level and no portion of the work shall be left more than 3 ft. below the rest of the work. Where this is not possible, the work shall be raked back according to bond (and not left toothed) at an angle not exceeding 45 degree.

d) All iron fixtures, pipes, outlets of water, hold fasts of doors and windows, etc. which are required to be built in walls, shall be embedded in cement mortar or in cement concrete bed as specified, in their correct positions as the work proceeds. Nothing extra shall be paid for such extra cement mortar or cement concrete to be used for embedding the fixtures of the nature stated above.

25.11.8 **JOINTS**

Bricks shall be so laid that joints are quite full of mortar. The thickness of the bed joints shall in no case exceed 10 mm unless otherwise specified. The face of joints shall be raked to a minimum depth of 10 mm by raking tool daily during the progress of work when the mortar is still green, so as to provide proper key for the plaster or pointing to be done. Where plastering or pointing is not required to be done, the joints shall be struck flush and finished at the time of laying. The face of brick work shall be cleaned daily and all mortar drippings removed.

25.11.9 **BRICK-ON-EDGE COPING**

The top course of all plinths, parapets, steps and tops of walls below R.C.C. slabs or beams shall be laid with brick on edge, unless otherwise specified. Proper care shall be taken that the bricks forming the top corners and ends of walls shall be properly radiated and keyed into position.

25.11.10 **CURING**

Green work shall be protected from rain by suitable covering. Brick masonry with cement

mortar shall be kept constantly moist on all faces for a minimum period of 7(seven) days.

25.11.11 **BRICK WORK IN SUPERSTRUCTURE**

Chimney made first class brick work in super structure in cement mortar 1:4 (1 cement: 4 sand)

25.11.12 **SCAFFOLDING**

Double scaffolding having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal pieces over which the scaffolding planks shall be fixed. In buildings upto two stories, single scaffolding shall be allowed. In this case, the inner end of the horizontal scaffolding pole shall rest in a hole provided in the header course only. Only one header for each pole shall be left out. The holes left in masonry work for supporting the scaffolding shall be filled and made good, before plastering. The contractor shall be responsible for providing and maintaining sufficiently strong scaffolding so as to withstand all loads likely to come upon it.

25.11.13 **BRICK WORK HALF BRICK THICKNESS**

First class chimney made half brick masonry in cement mortar 1:4 (1 cement: 4 sand) with 4.75 mm. diameter TMT steel reinforcement placed horizontally at every fourth course. It shall be laid in stretcher course as for brickwork specification. Horizontal reinforcement of 5 mm. diameter with proper anchorage to adjoining wall/walls shall be provided at every fourth course.

25.11.14 **MORTAR**

Mortar shall be 1:4 (1 cement: 4 sand) mixed as per specification

25.11.15 **BRICK ON EDGE SOLING**

For that brick soling, the brick shall be Chimney made and will be laid as directed by the Employer/ Engineer.

The brick shall conform to as per clause 11.2. The base on which is to be laid on edge shall be levelled or sloped as required and compacted properly. The bricks shall be laid on edge true to line, slope and pattern as required. The line, level etc. shall be checked by pegging. The brick shall be closely packed to each other as far as practical and the gaps shall be filled with sand for compaction. The workmanship shall be to the approval of the Employer/ Engineer.

25.12 STONE WORK

STONE WORK IN FOUNDATION AND IN SUPERSTRUCTURE

All stone work shall be made with random rubble stone from the best quarry and built in 1:4 cement mortar (1 cement: 4 sand) the stones must be approved by the Employer/Engineer before using in the construction work.

The stone shall be hard, tough sound and durable. No stone shall be less than 6" and more than 18". Face stone should be comparatively larger and uniform in size and colour to with a good appearance. Breadth of face stone should be greater than height. All the stones shall be wetted thoroughly before laying.

The joints should not be thicker than 3/4". Face joint should be thinner. No pointing shall be allowed afterwards. In the corners, the stones should be chiselled at both sides and also on the top of the stone walls where the wall is ending and such surfaces being built up. Not more than 2 feet height of masonry shall be constructed at one time.

25.13 SWITCHYARD FENCING

The work included under this item entails the supply, furnishing and installation of all galvanized wire mesh fence, posts, gates, and appurtenances, complete and in finished condition, including

the furnishing of all labor, materials, plant, tools and equipment including excavation required for the work. The GI post shall be earthed at every four meter by using 25 sq. mm copper clad aluminium conductor.

Materials: The materials shall be as specified below.

Erection: The Contractor shall erect the switchyard fence strictly conforming to this specification. Concrete works shall be in accordance with the details in the item of these Specifications concerning concrete work.

25.13.1 Entrance gate for switchyard

The Contractor shall install 2 no of entrance gates (including small gate for one man entrance in it) at Pangtan SS. Design of the gates to be submitted for the approval of Employer.

Excavation, Foundation, Brick and plaster works, paintings, suitable size RCC pillars for gate mounting etc. necessary for complete installation of the gate shall be covered under the contractor's scope of work. All part of steel/pillar shall be painted according to the direction of Employer. All the details of Switchyard fencing and its' entrance gate/s shall be as per the approved drawing.

The whole assembly of tubular post shall be hot dip galvanized have size greater than 80 mm dia . The zinc coating shall be minimum 610 gram per sq. meter. The purity of zinc shall be 99.95% as per relevant BS.

25.13.2 Installation

1. Fence shall be installed along the switchyard line
2. Chain link mess size 50x50 mm shall be made of GI wire of 10 gauge fence of 2.25 m high.
3. Post holes shall be excavated by approved method.
4. All posts shall be 2.0 m apart measured parallel to ground surface.
5. Posts shall be set in 1:2:4 Plain Cement Concrete block of minimum 0.6x0.6x1.2m depth. 75mm thick plain cement concrete 1:4:6 shall be provided below concrete blocks. Posts shall be braced and held in plumb position and true alignment and elevation until concrete has set.
6. Fence fabric shall not be installed until concrete has cured a minimum of 7 days.
7. Fence fabric panel shall be fixed to the post at 4 nos GI flat each of 50x6, 75 long through 2 nos. of bolts (12 mm diameter) on each flat.

Measurement for payment of item 'Switchyard fence including entrance gate/s' shall be made on the basis of running meter (including gate) of actual quantities performed and be made at the unit price bid. Therefore, in the Price Schedule, the unit price bid shall include the cost of all labor, all material, civil works etc.

25.14 SUBSTATION STEEL STRUCTURES

25.14.1 General Requirements

The major works involving steel structures are as follows:

a) Gantry structures

b) Equipment structures

The Contractor shall assume full responsibility for design and details of the steel structures and for their satisfactory performance. All designs and details shall be subject to the approval of the Employer. The Employer shall have the right to instruct the Contractor to make any changes to

conform to the Contract Document.

No omissions or ambiguities on the drawings or in this Specification shall relieve the Contractor from furnishing first class materials and workmanship. Should any inaccuracies be found, the Contractor shall notify the Employer and any further work done before these discrepancies are corrected shall be at the Contractor's risk.

25.14.2 Materials

The materials shall conform to the following requirements as regards to the quality of steel used for support members:

Item	Description	Unit	Minimum Value
1.1	Mild steel Grade E275 to ISO630 or equivalent		
	(a) Tensile strength	kg/mm^2	24
	(b) Yield strength	kg/mm^2	14
1.2	High strength steel Grade E355 to ISO630 or equivalent		
	(a) Tensile strength	kg/mm^2	36
	(b) Yield strength	kg/mm^2	20

25.14. 3 Design of Steel Structures.

Design Methods: The stress analysis shall be conducted by the force diagram method for all type of steel structures. Any computer program to be employed shall be prepared or approved by a recognized institute and be submitted to the Employer.

Loading Conditions: In additions to dynamic loads imposed by equipment, steel work shall be design to withstand simultaneously wind and other loads as follows:

Design Load

a. Wind Load:

On flat steel surface	121 kg/m^2
For lattice structures	(121 kg/m^2 on 1.71 times the projected area of the members of one face of the structure)
On line trap, disconnecting switches	50 kg/m^2
On overhead ground wire, conductors	75 kg/m^2
On porcelain insulator Strings and all other sections	50 kg/m^2

b. Human Load: 240 kg at the center of the beam.

c. Load due to conductor and weight of equipment and accessories:

Load due to the ACSR conductor shall be wind load, dead weight and short circuit forces.

Weight of equipment including insulator string shall be according to actual installation.

Normal Working Condition: The normal working condition for various loads shall be deemed to work simultaneously. The take-off structures shall be subjected to a vertical uplift of 500 kg at each

supporting point of overhead ground wire and conductor. The tension for conductor and ground wire will be 750 and 350 kg respectively and angle of deviation will be 15^0.

Combination of loads: The Contractor shall calculate the maximum and minimum stresses at any combinations of loading conditions.

Safety Factors: The safety factors shall be not less than two (2) times that the normal working conditions and 1.5 in combination with short circuit forces.

Design and Ultimate Stresses Allowed in Design: For tensile members of steel structures the design stresses shall not exceed the yield point of materials even under test loading conditions. For compressive members, the design stresses shall not exceed the value of the ultimate buckling stress.

Ultimate stress allowed in design shall be as follows:

Members:	
Buckling:	As per ASCE Manuals and Reports on Engineering Practice-No. 52.
Tension:	less than 1.00 Fy
Bearing :	Less than 1.80 Fy
Bolts:	
Shear:	less than 0.60 Fu
Bearing:	less than 1.00 Fu

Where: Fy : Yield point of steel member materials

Fu : Ultimate tensile stress of bolt materials

Limit of Effective Slenderness Ratio: The effective slenderness ratio (L/r) of members shall meet the following limits:

Leg member, main compression member and ground wire peaks = 120

Other members having computed compressive stresses = 200

Secondary members without computed compressive stresses = 250

Tension member = 350

Where: L: Length of the unsupported panel of member

r: Radius of gyration of members.

In determining the slenderness ratio for various members, suitable provisions shall be taken into consideration for various types of end connections, eccentricity of load transfer in the members etc. The unsupported length "L" shall be considered from center to center of intersections or working lines at both ends of members. A single bolt connection shall not be considered as offering restraint against rotation. A multiple bolt connection with minimum two (2) bolts, properly detailed to minimize eccentricities shall be considered to offer partial restraint, if such connection is to a member having adequate strength to resist rotation of joint. Points of intermediate supports shall not be considered as offering full restraint to rotation, if the same is provided only on one flange of the member. For members of double-diagonal web system which are bolted at their point of intersection, max. L/r shall be determined from the following criteria:

'L' is the greatest distance from the point of the intersection to either of the end connections and 'r' is the minimum radius of gyration of the member.

'L' is equal to 0.75 times the distance between the end connections and 'r' is the radius of gyration of the member for its axis parallel to the plane of connected leg.

Minimum Thickness and Size of Steel Members**:** Minimum thickness and size of steel members of structures shall be as follows:

Calculated members		40x5 mm
All other stressed members and secondary members	not less than	40x4 mm
Gusset plates		not less than 5 mm
Bolts and nuts		M-12 mm

In computing the net section of tension members, the diameter of the boltholes shall be taken as 3.0 mm greater than the nominal diameter of the bolts. Net section on both straight and zigzag sections across the members shall be as specified in ASCE or BS.

Connections

a. Bolts: All connections shall be bolted and all stressed members shall be connected by at least one (1) bolt. For structural connections, a maximum of two bolt sizes may be used for each tower type, provided the quantity of each size is not less than 20 per cent of the total requirement for the tower and the bolts in any one connection are uniform in size.

b. Splices: The number of splices shall be practically minimum. Splices shall develop the maximum stress in member or seventy (70%) per cent of compressive strength of gross section or tensile stress of net section. No credit shall be allowed for bearing on abutting areas.

Design Drawings and Calculation. The design drawings shall show the following data and information:

Scaled line diagram of the steel structures showing all redundant bracing members and their sizes completely dimensioned and proving compliance with all clearance requirements.

All loadings and their manners of application including the determination of wind load (wind load on structure shall be applied at each panel point along the height of the steel structure.)

Calculations showing:

a. Total stresses in each member for each loading case and the critical case.

b. The effective slenderness ratio, calculated stress ratio of maximum total stress to calculated stress for each member and strength of connection.

c. The estimated weight of the complete galvanized steel structures.

d. Size and type of steel for each member and number of bolts required for its connection.

e. The compression and uplift reactions and corresponding horizontal shears at each leg of all steel structures (column and equipment supports) for all loading cases.

25.14. 4 Detailing

Detailing shall be as follows:

General: Steel structure dimensions, framing, member sizes and length, number, size and length of bolts, thickness of each filler, and other necessary details to fabricate each piece shall be shown on the approved detail drawings. No change shall be made without the written approval of Employer.

All web members shall be in one piece where practicable. All double-diagonal web system

members shall be connected at their point of intersection by at least one bolt.

Step Bolts: Step bolts shall be of 16 mm diameter and shall have round or hexagonal head. Each step bolt shall be provided with two hexagonal nuts. The minimum bolt length and length of unthreaded portion shall be 180 and 125 mm respectively. Step bolts shall not be used as connection bolts.

The step bolts shall be spaced alternately on the inner gauge line on each face of the angle about 40 cm centers. They shall be furnished for one leg of each steel tower from the base elevation of the steel tower.

Step bolts for lattice single pole or H-frames are not required.

U-Bolts: U-bolts shall be suitably furnished on steel structures to suspend or terminate insulator strings or ground wire assemblies. Size of U-bolts shall withstand all loads acting on it.

Detail Drawings: Detail drawings shall be complete with sizes and detail dimensions of all steel structure members. At each joint, there shall be the number, size and length of bolts, number and size of fillers and detail dimensions of gusset plate, if any.

Bill of Material: Bill of materials shall give the size length and galvanized weight of each member and the total weights of steel structures. It shall also include the number of bolts, nuts and washer per structure.

25.14. 5 Fabrications

Workmanship: Workmanship shall be first class throughout. All pieces must be straight, true to detail drawings and free from lamination flaws and other defects. All clipping, back cuts, grindings, bends, holes and etc. must be true to detail drawings and free of burrs.

All identical pieces bearing the same erection number must be exactly interchangeable with each other and interchangeable in their relative position in all towers or structures of which they form a part.

Threads of bolts and nuts shall be cleanly rolled or cut and the face and head of nut shall be truly at right angle to the axis of the bolt.

Cleaning and Galvanizing

a. Cleaning: After fabrication has been completed and accepted, all materials shall be clear of rust, loose scale, dirt, oil, grease and other foreign substances.

b. Galvanizing: All materials shall be hot-dip galvanized after fabrication and cleaning. Retapping of nuts after galvanizing is not required.

   Galvanizing for structural mild steel products shall meet the requirements of ASTM A123. All holes in materials shall be free of excess shelter after galvanizing.

   Galvanizing for bolts, nuts, washers, lock nuts, step bolts and similar hardware shall meet requirements of ASTM A153. Excess shelter on bolts, nuts, washers, locknuts, step bolts and similar hardware shall be removed by appropriate means acceptable to the Employer.

   Finished materials shall be dipped into the solution of dichromate after galvanizing for white rust protection during sea transportation.

c. Uniformity of Coating: The uniformity of coating test shall be made in accordance with ASTM A239. The minimum repetition times for one minute dip in uniformity test shall be as follow

   Steel shapes and plates..... 6

Bolts, nuts and similar hardware.....4

Galvanizing Coating Weight

Description	Coating Weight (g/sq.m)		Uniformity Test
	Thickness		Time
	Avg. Value	Min. Value	(1 min./1 time)
Shaped steel Over 6mm	more than 700	more than 610	more than 6
Steel plates Under 6mm	more than 610	more than 550	more than 6
Bolts, Nuts & washers etc	more than 470	more than 400	more than 4

d. Straightening after Galvanizing: All plates and shapes which have been warped by the galvanizing process shall be straightened by being re-rolled or pressed. The materials shall not be hammered or otherwise straightened in a manner that will injure the protective coating. If, in the opinion of the Employer, the material has been hard fully bent or warped in the process of galvanizing or fabrication, such defects shall be cause for rejection.

e. Repair of Galvanizing: Materials on which galvanizing has been damaged, shall be acid stripped and re-galvanized, unless, in the opinion of Employer, the damage is local and can be repaired by zinc spraying or by applying a coating of galvanizing repair compound. Where re-galvanizing is required, any member which becomes damaged after having been dipped twice shall be rejected.

f. Shop Assembly: One of each type of steel structures shall be assembled in the shop to such an extent as to insure proper field erection. Reaming of untrue holes will not be permitted. A reasonable amount of drifting will be allowed in assembling. Shop assembled parts shall be dismantled for shipment.

25.14.6 Shop Tests

The following shop tests shall be performed with relevant provisions of the ASTM.

a) General inspection

b) Material tests

c) Assembly test

d) Galvanizing test

The Contractor shall conduct the above mentioned tests in presence of Employer before dispatch of the steel structures. All the cost of tests including cost of travelling, lodging and fooding of two NEA personnel shall be borne by the Contractor. Within seven days after the completion of tests the contractor has to furnish the four certified copies of report of all tests to the Employer.

25.14.7 Payment

Payment for the Contract item "Steel Structures" will be made at the unit/lump/sets sum price per steel structures type as specified in the price schedule. Therefore, in the Price Schedule, such unit/lump/sets sum price shall include full compensation for all costs incurred in furnishing all materials, equipment and labor and all other operations related to steel structure design, fabrication, installation etc.

25.15 CONTROL BUILDINGS

25.15.1 GENERAL

This specification is intended to cover the complete construction of control building and furnishing of the indoor facilities for the project including all design, supervision, materials, equipment, labor and services necessary for or incidental to the construction of control building as specified above. The entire floor shall be constructed on one plain level.

The rooms within the control building shall have area sufficient to install the equipment supposed to be installed (including for the spare bays) with adequate space for service. In any case the plinth area shall not be less than the typical building plan of control building provided with this tender. There will be no column in between 132/ 33 kV control room as shown in reference drawing.

25.15.2 SCOPE OF WORKS

The Contractor shall perform the design, supply, deliver, construction and installation of the equipment, materials and all accessories for the control building as listed below. The drawing has been provided for reference only.

(a) Cleaning and stripping, Excavation, Backfilling and compaction

(b) Concrete work including steel reinforce bars

(c) Plinth level flooring treatment

(d) Brick and Stone Masonry Works

(e) Plaster and Tile Works

(f) Door and Windows

(g) False Ceiling

(h) Heat Insulation and Water Proofing

(i) Water supply, Plumbing (Sanitation), Sewerage and Sanitary Fixtures and septic tank

(j) Indoor Cable Trench

(k) Paint and Glazing

(l) All required Electrical Installation

(m) Ventilation

(n) Fire Fighting and smoke detector System

(o) Furniture and Miscellaneous Indoor Facilities

GENERAL

The scope includes design, engineering and construction, including anti-termite treatment, plinth protection, DPC, peripheral drains, water supply, plumbing, sanitation, fire-fighting, electrification etc. of control room building.

The contractor shall propose building layout and get approval before carrying out detail architectural and structural design.

The architectural features shall match with local architecture. For preparation of architectural drawings of these buildings, the contractor shall depute local Architect of repute who must be well aware of local bye laws and statutory clearances required from Nepal Authority. The buildings shall be designed for loads as applicable in accordance to relevant standards. The

plumbing and sanitary works including overhead water tanks placed on terrace shall also be deemed to be included in the civil works of building. Construction of man holes/chambers, connection of internal plumbing and sanitary system with external sewerage and water supply system shall be considered as a part of civil works of buildings. These works will not be measured and paid separately.

The Control Room Building size shall be as per attached drawings. It will be a single storied RCC Framed structure, constructed near by the switchyard. It shall be so designed that most of the area of switchyard is visible from the Control Room. The building shall have 11 kV indoor switchgear room. The internal cable trenches, panel etc shall be designed by the contractor as per requirement. Layout of these cable trenches, panel layout shall also be prepared by the contractor as per requirement.

The details like floor details, door, windows, ventilator, internal finish details etc shall match with respective room of control room building. External finish shall also match with other building. Contractor shall develop the layout in such a way that its aesthetic look is pleasant. The design of buildings shall be carried out as per relevant International standard/British Standards.

All the works for the control building shall be subject to approval of the Employer. The Employer shall have the right to require the Contractor to make any changes on designs, construction works, materials and equipment to make the structures conform to the Specification, without any additional cost. The Contractor shall prepare the design drawings including all facilities based on attached architectural building drawings and submit the design drawings to the Employer for approval.

The building auxiliary services like air conditioning systems, fire protection and detection systems and all other miscellaneous services shall be designed in accordance with the requirements as specified in relevant section or elsewhere in this Specification. The building shall be constructed as per the design and drawings to be developed by the contractor.

The contractor shall present/ demonstrate / run software showing result used for calculating and designing building (before approval of final design). The software shall be internationally recognized building and structural analysis software.

25.15.3 DESIGN CRIRETIA:

The Building shall be designed:

1. To the requirements of the International standards/British Standards.
2. for the specified climatic and loading conditions.
3. To adequately suit the requirements of the equipments and apparatus contained in the buildings and in all respects to be compatible with the intended use and occupancy.
4. with a functional and economical space arrangement.
5. To be aesthetically pleasing. Different buildings shall show a uniformity and consistency in architectural design, as far as possible.
6. To allow for easy access to the equipments as well as maintenance of the equipments.
7. Wherever access to the roof is required, RCC stair case shall be provided.
8. Fire retarding materials for walls, ceilings doors etc., which would prevent supporting or spreading of fire and wherever required, shall be decided by the bidder and approved by the Employer.
9. Suitable Expansion joints, wherever required, shall be provided as per Codal

Provisions.

10. All the members of the buildings frame shall be designed for the worst combination of loads as per relevant British standard codes (B S Codes)/ equivalent International Standards.

11. Permissible stresses for different load combinations shall be taken as per relevant British standard codes (B S Codes)/ equivalent International Standards.

12. Seismic coefficient Method or Response spectrum method shall be used for seismic analysis of the building for Earthquake forces, as per relevant British standard codes (B S Codes)/ equivalent International Standards.

13. The architecture design of the buildings shall be as per the Nepalese Architecture & Style.

25.15.4 DESIGN LOADS

1. Building structure shall be designed for the most critical combinations of dead loads, super-imposed loads, equipment loads, erection loads, wind loads, seismic loads etc. Any other incidental load, if anticipated, shall be duly accounted for in the design, and shall be clearly mentioned by the bidder.
2. Dead loads shall include the weight of structures complete with finishes, fixtures and partitions, and shall be taken as per relevant British standard codes (B S Codes)/ equivalent International Standards.
3. Super-imposed loads in different areas shall include live loads, minor equipment loads, cable trays, small pipe racks/hangers and erection, operation and maintenance loads, wherever these loads are expected. Equipment loads shall constitute, if applicable, all load of equipments to be supported on the building frame.

AREA	Load (Minimum)
1. For Offices and Residential buildings	3.0 kN/m2
If higher than 3.0 kN/m2.	As per actual Requirement.
2. For Equipment Floors.	6.0 kN/m2
If higher than 6 kN/m2 (Based on Equipment weight and layout plans).	As per actual Requirement.
3. Staircases & Balconies.	3.0 kN/m2
4. Toilets.	2.0 kN/m2
5. Chequered Plate.	4.0 kN/m2
6. Corridors/Walkways.	3.0 kN/m2
7. Accessible Roofs.	1.5 kN/m2
8. Non-accessible Roofs.	0.75 kN/m2

4. Wind load shall be calculated as per relevant British standard codes (B S Codes)/

equivalent International Standards. The Factors affecting the wind speed shall be taken based on the site conditions.

5. Earthquake loads shall be calculated as per relevant British standard codes (B S Codes)/ equivalent International Standards.

6. Wind forces and Seismic forces shall not be considered to act simultaneously.

7. All the load combinations to create worst combinations of loads shall be as per relevant International standards/British Standards.

8. Floors/ Slabs shall be designed to carry loads imposed by equipment, cables, piping, movement of maintenance trucks (if required) and any other load associated with the building. In general, floors shall be designed for live loads as per relevant British standard codes (B S Codes)/ equivalent International Standards. Cable and piping loads shall also be considered in addition to the live loads for floors where these loads are expected.

The Contractor shall use an allowable soil bearing pressure of 10 ton /m2 for the design of foundation for bidding purpose. But this is only reference value. After award of Contract, the Contractor shall carry out detail soil test. There may be variation in the volume of work in final design compared to the bidding design based on soil strength for which the Contractor will not get any extra payment. There is no separate payment for design works.

25.15.5 Excavation and Backfilling

The detail specification for the excavation and backfilling work shall be as specified in Concrete and Foundation works of this chapter.

No separate or direct payment will be made to the Contractor for Excavation and Backfilling. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related to excavation and backfilling work of respective building.

25.15.6 Concrete Work

The detail specification for the concrete work shall be as specified in Article Foundation and RCC works. Concreting in control building shall be done in foundation, tie beam, floor/roof slab, steps, column, beam etc.

No separate or direct payment will be made to the Contractor for concrete works. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related Concrete work of respective building.

25.15.7 Steel Reinforcement Work

The detail specification for work shall be as specified in Article 9 “Reinforcement”. The Contractor shall place all the reinforcement bars in the concrete structures as shown on the approved drawings, bar bending schedules and as directed by the Employer. The reinforcement bars shall be furnished by the Contractor.

No separate or direct payment will be made to the Contractor for steel reinforcement in concrete works. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related steel reinforcement work of respective building.

25.15.8 FLOORS, WALLS & ROOFS

1. All walls shall be non-load bearing in filled panel walls, in brickwork as per the specification. Minimum thickness of external walls shall be 360 mm with 1:4 cement sand mortar. Partition walls if any shall be of 240 mm thick brick masonry in cement sand mortar (1:4).

2. All Floor/Roof slabs shall be regular beam slab construction. However, sunken RCC slab shall be provided in toilet areas as per the requirement.

3. False ceiling as per requirement shall be provided as detailed in Table-1 (Detailed Finish Schedule).

4. Minimum height of skirting above finished floor level shall be 150 mm. The skirting material shall match with the floor finish.

5. Minimum height of the parapet walls shall be 900 mm.

6. Ground floor finish shall be laid over 34 mm thick cement sand mortar,100 mm thick plain cement concrete (PCC) 1:2:4 (1 cement: 2 sand : 4 stone aggregates),one layer of flat brick soling edge to edge, 100 mm thick local sand filling. The earth below ground floor shall be well rammed before laying sand filling.

   Concrete Laying:

   Concrete work shall be done as specified under Concrete and Foundation works. The flooring shall consist of minimum (For each square meter)

   - Concrete mix: (1:2:4), thickness 150 mm with 2 % waterproofing compound,
   - Steel bar as required
   - Gravel layer 100 mm thick

7. First floor details shall comprise of finish as per schedule, 20 mm cement sand mortar and 50 mm thick screed (1:2:4) over RCC slab.

9. Approved Granite shall be installed in all kitchen slabs of control building, staff quarter and guard house and any other place as directed by site Employer. The Granite shall be laid over the bedding course cement mortar (1:4) with cement slurry on its backing. Similarly, vitrified tiles shall be used on the wall for at least 3 ft height from the slab. The interface between the granite slabs and tiles shall be joint filled with proper leveling with appropriate cement. Surface to receive applications of materials shall be clean and free from dirt, dust, oil, grease, and other objectionable matter. Joints shall be straight, levelled, perpendicular, and have even width not exceeding 1.6 mm. Vertical joints shall be maintained plumb for the entire height of the tile work. Damaged or defective material shall be replaced. Upon completion, surfaces shall be thoroughly cleaned. Acid shall not be used for cleaning of Granite and tiles.

No separate or direct payment will be made to the Contractor for Floor, walls roofs. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related to flooring work of respective building.

25.15.9 Roof water proofing and Heat Insulation

The waterproofing on the roof of the control building shall be finished with:

- 2 coat of polymer slurry of Sika-top seal for water proofing directly above roof slab
- 50 mm (average) thick layer of screed concrete of Cement Lime Surkhi (1:2:4) mix and
- 25 mm thick machine made clay tiles in (1:3) cement sand mortar with water proof treatment in joints.

Necessary slopes in water proofing treatment towards the rain water down take pipes shall be provided. The above treatment shall be extended on the adjoin walls up to 300 mm height including parapet,

rounding of junctions of walls and slab. The whole terrace so finished shall be flooded with water for a minimum period of two weeks for curing and for final test. All the work and testing shall be done as instructed by the Employer.

No separate payment for the Contract item "Waterproofing and Heat Insulation" will be made. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, machines, labor and other operations related to "Waterproofing and Heat Insulation" work of respective buildings.

25.15.10 STAIRCASE

The roof of the control Buildings shall be made accessible by means of a steel spiral stair case which shall be structural mild steel tube of 150 diameters (Heavy) as a supporting column rest on the RCC foundation, depth of which shall be 1.2 meter below the ground level. The steps of the staircase shall be checker plate of thickness not less than 6 mm with steel angle section and plates. The hand rail shall be structural mild steel tube of 50 mm diameter (Light). The whole part of the staircase shall be painted as per specification. No separate payment for the Contract item "STAIRCASE" will be made. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, machines, labor and other operations related to stair case work of respective buildings. Wooden staircase railing shall be also be provided by the contractor.

25.15.11 PLASTERING

External surfaces of buildings including parapet wall shall have 2 cm thick plaster thick 1:4 cement sand plaster. Inside wall surfaces shall have 12/15 mm thick 1:4 cement sand plaster. Rough surfaces shall have 15mm and smooth surface shall have 12 mm thick cement sand plaster.

All RCC ceilings shall be provided with 6 mm thick cement sand (fine) plaster (1:3) except for areas with false ceiling.

25.15.12 EXTERNAL PAINTING

External surfaces of the Control Room Building shall be painted with acrylic exterior emulsion paint as per manufacturer's specification and approval of NEA.

25.15.13 BRICK MASONRY WORK

The detail specification for the excavation and backfilling work shall be as specified in Brick Masonry works of this section

Size of Wall

(1) The entire periphery wall shall be constructed in 360 mm thickness.

(2) The entire partition wall shall be constructed in 240 mm thickness.

No separate or direct payment will be made to the Contractor for Brick masonry works. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related to Brick masonry work of respective building and compound wall.

25.15.14 DETAILED FINISH SCHEDULE

The detailed finish schedule for Control building, is given below:

Table- 1: DETAILED FINISH SCHEDULE

Sl. No.	LOCATION	FLOORING & SKIRTING 150 MM HIGH	WALL(INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
1.	Control Room (132/33/11 kV) and 12 kV Switchgear room.	Vitrified tiles 8mm thick size 600 x 600mm (with spare tiles provided - 5% tiles used)	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of 6 mm thick tinted glass by using suitable patch fittings/spider fittings. The glass shall extend horizontally from column to column and vertically from sill level of 0.75 m to bottom of lintel/roof beam. All doors shall be glazed powder coated aluminium doors with 5.5 mm thick Glazing.
2.	Office Room	Vitrified tiles 8mm thick size 600 x 600mm (with spare tiles provided - 5% tiles used)	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing
3	Communication Room	Vitrified tiles 8mm thick size 600 x 600mm with spare tiles provided - 5% tiles used)	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
5.	Battery Room	Acid proof, Vitrified tiles 8mm thick size 600 x 600mm (with spare tiles provided - 5% tiles used)	Premium acrylic emulsion paint on smooth surface applied plaster of paris (2 mm thick), DADO glazed tile 2100mm high	White wash above False Ceiling*	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool. Windows/ventilator shall be of powder coated aluminium with 4mm glazing.
6.	Reception / Barandas	Vitrified tiles 8mm thick size 600 x 600mm (with spare tiles provided - 5% tiles used)	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be UPVC profile casement door.
8.	Toilet	Anti skid Ceramic tiles (with spare tiles provided – 5 % tiles used)	DADO glazed tile 2100mm high, oil bound washable distemper above DADO,	Oil bound washable distemper	Windows/ ventilator shall be of powder coated aluminium with 6 mm thick glazing. All doors shall be flush door shutters made of pre-laminated particle board with powder coated aluminium frame.
12	Kitchen	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M IS 15622 (with spare tiles	DADO glazed tile 2100mm high above kitchen slab, Plastered & Painted OBD Over 2mm POP Finish	DADO glazed tile UP to 1.0M Above Kitchen Platform (Granite with modeling)	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All other doors shall be UPVC profile casement door.

Sl. No.	LOCATION	FLOORING & SKIRTING 150 MM HIGH	WALL(INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
		provided -5% tiles used)			

*Providing and fixing 15mm thick approximately 600 X 600mm seamless ceiling with acoustic board of insulating nature and making cut-outs for electrical fixtures, AC diffusers, openable access etc complete with silhouette profile system with 15mm wide flange incorporating 6mm central recess white / black main runners at 1200mm centre-centre and not greater than 600mm from the adjacent wall. The cross tees shall be provided to make a module of approximately 600mm X 600mm by fitting 600 mm long cross tees centrally placed between 1200 mm long cross tees .Cross tees also have 15mm wide flange incorporating 6mm central recess white/black. The module formed above shall be anchored to the slab with channels or angles, suspenders as per manufacturer's specifications.

Samples of materials proposed for different types of floorings shall be submitted to the Employer for approval before materials represented by the samples are delivered to the site.

No separate or direct payment will be made to the Contractor for Finish schedules works. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related to finish schedule work of respective buildings.

25.15.15 DOORS, WINDOWS AND VENTILATORS

The schedule of doors, windows and ventilators of the Control Room Building shall be as per the detailed finish schedule given in Table-1 (Detailed Finish Schedule), and shall conform to the relevant British standard codes (B S Codes)/ equivalent International Standards. Main entrance door to control room building shall be made of powder coated aluminium frame with 5.5 mm thick glazing.

All doors and windows shall be of aluminum types indicated below. Each window shall consist of a unit including frame, mullions where indicated or required, and anchors. Entrance door shall be in two panels and windows shall be provided with top removable ventilation.

(a) Frames

All frame sections shall be tubular extruded aluminum shapes and of alloy 6063-T52. Frame sections shall be not less than 45mm face dimension x 115mm deep.

(b) Doors and Windows

Doors and windows shall be arranged for inside glazing with aluminum snap-in glazing beads designed to accommodate insulating glass as specified. Snap-in glazing beads shall securely interlock into the extruded window sections. Glazing rebate legs shall not be less than 19mm in height. The contractor shall have to provide the mosquito (Fly) net in the windows of the Buildings.

(c) Mullions, sills and Trims

Mullions, sills, trim and other window sub-assemblies, indicated on the drawings or as necessary to properly complete each aluminum door and window installation, shall be of size and design to suit the window assembly, be compatible with the windows.

(d) Anchors and Clips

Anchors, clips, bolt and screws necessary to secure doors, windows and mullions shall be provided and shall be, at manufacturer's option, either aluminum non-magnetic stainless steel, or zinc coated steel.

(e) Installation

Doors and windows shall be installed without forcing or distortion so that sills and heads are level and jambs are plumb.

(f) Ventilation Works

The contractor shall provide heavy duty exhaust fans to ventilate the battery room, kitchen, toilets of control building

No separate or direct payment will be made to the Contractor for above works. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related to finish schedule work of respective buildings.

25.15.16 CABLE TRENCH INSIDE CONTROL ROOM BUILDING

The detail design of the cable trench shall be the responsibility of the Contractor. All designs and details shall be subject to approval of the Employer. Main cable trench inside the control building shall match in size with main cable trench out site control building.

Type of Cable Trench

Cable trench shall be of reinforced concrete trench with one or more layer of hot dip galvanized light gauge shape steel tray. The cover of trench shall be min. 6 mm thick-chequered plate with steel frame fitted inside and shall be galvanized.

Drainage outlet from the cable trench shall be connected to switchyard drainage system.

No separate or direct payment will be made to the Contractor for Indoor cable trench works. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related for Indoor cable trench work of control building.

25.15.17 PAINT AND GLAZING

Painting

General

All surfaces of the control room shall be painted except the following:

(a) Exterior: Roofing, paving, nonferrous metals, glass, pre-finished items.

(b) Interior: Ceramic tile, glass, pre-finished surfaces, non-ferrous metals, stainless steel, attic surfaces.

Materials

A list of the painting materials and their colors which are to be applied to the specified surfaces shall be submitted to the Employer for approval.

Paint Application

The finished surface shall be free from runs, drops, ridges, waves, pales, brush marks, and variations in color, texture, and finish. The hiding shall be complete, and coat shall be so applied as to produce firm of uniform thickness. Special attention shall be given to insure that all surfaces including edges, corners, crevices, welds, and rivets receive a film thickness equivalent to that of adjacent painted surfaces.

Adjacent areas and installations shall be protected by the use of drop clothes or other approved precautionary measures.

Metal or wood surfaces adjacent to surface to receive water-thinned paints shall be primed and/or touched up prior to the application of water-thinned paints. The first coat on plaster shall include such repeated touching up of suction spots or overall applications of primer sealer as necessary to produce a uniform color and gloss. The first coat on both faces of wood doors shall be applied at essentially the

same time.

(a) Coating Progress: Sufficient time shall elapse between successive coats to permit proper drying. This period shall be modified as necessary to suit adverse weather conditions

Oil base or oleo resinous solvent-type paints shall be considered dry for recoating when the paints feel firm, does not deform or feel stickly under moderate pressure of the thumb, and the application of another coat of paint does not cause lifting or less of adhesion of the undercoat.

Coating shall be as follows:

(1) Control room, Office room and Corridor shall be finished with 1 coat of Plaster of Paris, two coats cement primer whitening and filling up and finally two coats of acrylic emulsion

(2) The exterior top of the Control building shall be finished with texture mat coating.

(3) All other interior and exterior plastered surfaces excluding as mention herein above shall be finished with one coat of cement primer and two coats of acrylic emulsion.

(4) Gloss Finish Wood:

- First coat: 1 coat of Wood Primer.
- Second coat: 2 coats of Synthetic Super Gloss.

(5) Interior Transparent Finish Wood:

- First coat: 1 coat of Wood Primer
- Second coat: 2 coats of Teak Oil

(6) Metal Surface:

- First coat: 1 coat of Metal Primer Chromate
- Second coat: 2 coats of Aluminium Paint

(b) Storage, Mixing and Thinning: At time of application, paint shall show no signs of hard settling, excessive skinning, livering, or other deterioration. Paint shall be thoroughly stirred, strained, and kept at a uniform consistency during application.

Where necessary to suit conditions of surface, temperature, weather, and method of application, package paint may be thinned immediately prior to application in accordance with the manufacturer's directions, but not excess of 0.5 liter of suitable thinner per 4 liter. The use of thinner for any reason shall not relieve Contractor from obtaining complete hiding.

Samples shall be clearly identified by designated name, specification number, batch number, project Contract number, intended use, and quantity involved. At the discretion of the Employer, samples may be tested before approval, or materials may be approved for use based on the test reports furnished. In the latter case, the samples will be retained by the Employer for possible future testing should the material appear to be defective during or after application.

25.15.18 GLASS AND GLAZING

(a) Sheet glass to be used for doors, windows and partitions shall be 6mm thick, tinted glass except as otherwise specified. It shall be of the best quality, free of unevenness, stain or bubbles, and where so required, figured glass shall be used. The glazing for the bathroom door shall be aluminum alloy of thickness not less than 5.5 mm. Glass glazing for the bathroom window shall be of the non-see-through type.

(b) Glazing compounds shall be of suitable type approved for the application.

The use of non-skimming compounds, non-resilient type preformed sealers, and preformed

impregnated type gaskets will not be permitted. Metal sash putty will not be permitted. Materials used with aluminum frames shall be aluminum colored, non-staining, and not require painting.

(c) Channel glazing compound shall be equal in performance, but not limited, to the following:

(1) Non-drying, knife grade polybutene sealant

(2) One-part acrylic terpolymer sealant

(d) Shop-Painted Items: Surfaces of fabricated and assembled items that are finish painted by the manufacturer, or specified to be finish painted under other sections of the Specifications, are exempted from the following schedule requirements for surface preparation and painting, shop primed items shall receive surface preparation and finish painting as required by this section.

(e) Colors and tints, including shades of stain, shall match the respective color specimens selected by the Employer.

Stains shall conform in shade to manufacturer's standard color. Undercoats shall vary slightly from the color of the next coat.

(f) Surface Preparation and Pretreatment: Cleaning and pretreatment of surface prior to painting shall be accomplished in accordance with the detailed requirements specified.

(g) Cleaning: Clots and cotton waste that might constitute fire hazard shall be placed in closed metal containers or destroyed at the end of each day. Upon completion of the work, staging, scaffolding, and containers shall be removed from the site or destroyed in an approved manner.

Paint spots, oil, or stains upon adjacent surface shall be removed and the entire job left clean and acceptable.

No separate or direct payment will be made to the Contractor for Glass and glazing works. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment; labor and other operations related Glass and glazing work of respective buildings.

25.15.19 Illumination

The Contractor shall design and provide illumination system for the control building according to the requirements specified in Chapter 15: Lighting system. The Contractor's designed drawings shall be submitted to the Employer for approval.

The design of illumination works shall be subjected to employer's approval before executing the works.

No separate payment for the Contract item "Illumination" will be made. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, labor and other operations related to Illumination work of the control buildings.

25.15.20 Water supply and sanitary system

The control building unit shall have an adequate water supply system as approved by the Employer. The Control Building unit shall have an underground RCC water tank (min. thickness 150 mm) shall be provided of inner dimensions 4m * 3m * 2m. At least one number of 2,000-liter rooftop galvanized steel type water tanks shall be provided which will be placed on near by other building to control room (max lead 50 mtr). One numbers 2 HP heavy-duty water-pump (L & T make equivalent) shall be used for pumping water from ground-tank to roof-tank with appropriate 1" pipe.

All plumbing works shall be concealed and performed with ½" & 1" pipes to the approval of the Employer. Two ½" tap points for external use shall be provided outside the control building (max total distance 100 mtr) as directed by the Employer.

There will be one number of septic tank/ soak pit construction works and connection works to septic tank with necessary manholes in location specified by Employer. Overflow from septic tank shall be connected to the soak pit, which is ultimately drained to the natural drainage system.

Standards

The works shall be carried out in accordance with the latest revision of relevant standards.

Sanitary Fixtures

The Contractor shall provide sanitary fixtures (bathroom, toilet and kitchen) using products of high quality. Employer shall approve the type, size, color, etc.

1. All plumbing and sanitation works shall be executed to comply with the requirements of the appropriate bye-laws, rules and regulations of the Local Authority having jurisdiction over such matters. The Contractor shall arrange for all necessary formalities to be met with regards to the inspection, testing, obtaining approval and giving notices etc.
2. Polypropylene Random (PPR) pipes having thermal stability for hot and cold water supply conforming to relevant British standard codes (B S Codes)/ equivalent International Standards shall be used for internal piping works for water supply.
3. Heavy duty UPVC pipes with lead joints conforming to relevant International Standards shall be used for complete sanitary works and below ground as directed by employer..

Toilet shall have the following minimum fittings:

i) WC (Western type suction characteristics) 390 mm high along with toilet paper roll holder and all other fittings, in toilets attached to conference room and S/S In-charge office

(ii) Wash basin (550 x 400 mm) with all fittings.

(iii) Bathroom mirror (600 x 450 x 6 mm thick) with hard board backing.

(iv) CP brass towel rail (600 x 20 mm) with CP brass brackets.

(v) Soap holder and liquid soap dispenser.

vi) Showers and taps from reputed manufacturer having IS or NS standard.

4. One no. stainless steel kitchen sink with Drain board (510 x 1040 x 178 mm bowl depth) for pantry shall be provided.
5. 50 mm diameter heavy duty UPVC pipe shall be connected from kitchen & bathroom and 100 mm diameter heavy duty UPVC pipe shall be connected from toilet to the septic tank. Overflow from septic tank shall be connected to the soak pit, which is ultimately drained to the natural drainage system.

All sanitary fixtures and fittings shall be of approved quality and type, manufactured by reputed manufacturers with IS or NS or equivalent standard. All items brought to site must bear identification marks of the Manufacturer.

Workmanship

The installation shall be made in neat, orderly and workmanlike manner, conforming in every way to the accepted standards of the best commercial practice.

Payment

No separate payment for the Contract item "Water Supply and Plumbing & Sanitary System" in the control buildings will be made. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, labor and other

operations related to Water Supply & Plumbing and Sanitary fixtures of the control building.

25.15.21 Fire fighting system

The control building shall be equipped with a fire alarm / fighting system as approved by the Employer to suit its application and size.

Separate or direct Payments for fire fighting equipment shall be made as per bid price (BOQ). The unit/lump-sum price shall include full compensation for all costs incurred in furnishing all design, materials, equipment, labor and all other related works.

25.15.22 Furniture and Miscellaneous Indoor Facilities

The Contractor shall provide furniture and office equipment/goods/material for Pangtan substation. Without limiting the generality of the foregoing, the following shall be provided for the substation.

For Control Building:

(a) Two (2) sets of Desk shall be approximately 1651mm x 746mm high, double pedestal, double wall construction, and plastic laminate on steel top construction with glass top.

(b) Two (2) sets of steel swivel chairs.

(c) Two (2) set of minimum 4 shelves vertical filing cabinet.

(d) One (1) set of minimum 4 shelves drawing cabinet.

(e) Two (2) sets of electric clocks, quartz wall hung type.

(f) Two (2) sets of desk telephones

(g) Kitchen pantry.

(h) One set 40 inches SAMSUNG, LG , SONY or equivalent, energy efficiency smart television set fixed in wall with Dish home connection.

(j) One set steel cup board of 6' x 4' size

(k) One Electric water heater/ dispenser greater than 3.5 ltr with cup and plate set (12 nos)

(l) One set vacuum cleaner LG, HITACHI, SAMSUNG or equivalent with blower function (2000 W)

(m) One set Aluminium frame notice board with support (1 m sq or bigger).

(n) One set Key hanging board

(o) Two sets box type bench with back support & Cushion.

(p) One number of steel Daraj (5.5 ft)

Payment

No separate payment for the Contract item "Furniture and miscellaneous indoor facilities" in the buildings will be made. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, related to furniture and indoor facilities of the respective buildings

25.15.23 FALSE CEILING

Providing and fixing seamless ceiling with acoustic board of insulating nature fixed to the underside of GI frame work. The GI is fixed to the roof Slab with metal expansion fastener. The joint shall be finished with joint paper tape by using jointing Compound recommended by manufacturer with the approval of

NEA.

UNDER DECK INSULATION

The method of fixing shall consist of slotted M.S. angles of appropriate size (minimum 65x50x2mm) fixed to soffit of RCC roof slab at 600mm centres in both directions by Rawl plugs of adequate strength. The slots shall have 14g G.I. tie wire drawn through them.

50mm thick insulation mat Fibreglass Crown - 100 or equivalent shall, be made out of fibre-glass or approved equivalent conforming to IS: 8183, backed with 34g aluminium foil and 22g x 12mm mesh wire netting. The net shall be stretched tightly across the slotted angles or slotted plates holding it in place by means of wires. The joints of the wire netting shall be butted and tightly laced down with 14g G.I. wire. The system shall be got approved from NEA.

No separate measurement and payment shall be made to contractor for **false ceiling, under deck insulation system works** to be carried out for all buildings. Bidders are instructed to include all the above mentioned Plumbing and Sanitation system works to complete the specified job in the bid price of respective buildings.

25.15.24 ELECTRIFICATION

All electrification / wiring shall be executed as per in the chapter lighting system of technical specification/ requirement. All details shall be as per relevant British standard codes (B S Codes)/ equivalent International Standards.

No separate measurement and payment shall be made to contractor for Electrification system works to be carried out for all buildings.

25.16 STAFF QUARTER, GUARD HOUSE and OTHER CIVIL WORKS

25.16.1 GENERAL

This specification is intended to cover the complete construction of building stated above and furnishing of the indoor facilities for the project including all architectural and structural design, supervision, materials, equipment, labor and services necessary for or incidental to the construction . The contractor under taking consideration of BOQ shall develop best design drawing of buildings and civil works. The contractor has to submit quantity sheet as per their design. There is no separate for design /drawing works.

25.16.2 SCOPE OF WORKS

The Contractor shall perform the design, supply, deliver, construction and installation of the equipment, materials and all accessories for Staff Quarter, Guard House, Culvert and other Civil works as listed below. The drawing if provided are for reference only.

a. Design and drawing work
b. Earth work
c. Soling works
d. Cement concrete work
e. Stone masonry work
f. Brick work
g. Wood work
h. Cement plaster and pointing work
i. Flooring work

j. Painting work

k. Aluminium, Iron & Stainless Steel Works

l. Water Supply & sanitary works

m. Supplying and installation of electrical accessories in as specified.

n. Furniture and miscellaneous indoor work as specified

External finish of Staff Quarter, Guard house, shall also match with control room building. Contractor shall develop the layout in such a way that its aesthetic look is pleasant. The design of buildings shall be carried out as per relevant International standard/British Standards.

All the works for all type of building shall be subject to approval of the Employer. The Employer shall have the right to require the Contractor to make any changes on designs, construction works, materials and equipment to make the structures conform to the Specification. The Contractor shall prepare the design drawings including all facilities and submit the design drawings to the Employer for approval.

25.16.3 DESIGN CRIRETIA / DESIGN LOAD

The Contractor shall perform design and drawing similarly as per Article 15.3 and 15.4 of Control Building of this Chapter.

The contractor shall present/ demonstrate / run software showing result used for calculating and designing building (before approval of final design). The software shall be internationally recognized building and structural analysis software.

There shall be two separate two storied staff quarters with two flats in each storey (total no of eight flats). Each flat shall have one no of common room, one no of bed room, one no of kitchen room and one no of toilet cum bathroom.

Guard house shall be single storey building. Guard house shall have one rest room, one kitchen room, one Toilet cum Bathroom and open space for outside supervision.

There will be two number of septic tank construction works in location specified by Employer.

1. EARTH WORK, EXCAVATION AND BACK FILLING WORKS

Complete works shall be performed as per Article 4.0 “site preparation, excavation, Back Fill & disposal of surplus earth”.

There will be no separate payment will be made to the Contractor for Excavation and Backfilling and Sand Filling works. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related to excavation and backfilling work of respective building.

2. SOLING WORKS

The stone shall be hard, tough sound and durable. No stone shall be less than 6" and more than 18". Face stone should be comparatively larger and uniform in size and colour to with a good appearance. Breadth of face stone should be greater than height. All the stones shall be wetted thoroughly before laying. The Brick shall be as described in article 11.2. Laying of Stone and Brick shall be as per Employers instruction.

No separate payment will be made to the Contractor for Soling works.

3. CEMENT CONCRETE WORKS

Complete Concrete Works shall be shall be performed as per Article 8.0 “Foundation /RCC construction”. The concrete mix shall be as mentioned in BOQ. Admixture and additives as per article 9.10.

Complete steel reinforcement work shall be performed as per Article 9.0 “Reinforcement”.

Complete Form Work shall be performed as per Article 10.0 “Form work”.

No separate or direct payment will be made to the Contractor for concrete works. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related Concrete work of respective building

4. STONE MASONARY WORKS

Complete stone masonary works shall be shall be performed as per Article 12.0 “Stone works” of this Chapter.

No separate or direct payment will be made to the Contractor for Stone masonry works. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related stone masonry work of respective building.

5. **BRICK MASONARY WORKS**

Complete Brick masonary works shall be shall be performed as per Article 11.0 “Brick works” of this chapter.

No separate or direct payment will be made to the Contractor for brick masonry works. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related brick masonry work of respective building.

6. WOOD WORKS

Lumber shall be subjected to Employer's approval.

(a) Salwood

(1) Sizes and Pattern: Lumber shall be surfaced- four-sides, and worked according to patterns as are indicated or specified on the drawings. Exposed members for transparent finish shall be matched for compatibility of grain and color between adjoining members; for paint finish, is not required.

(2) Moisture Content: At the time of delivery, the moisture content shall not exceed 15% for material of 2.5cm or less in thickness, and shall not exceed 19% for material over 2.5 cm in thickness.

(b) Teak Plywood: All interior plywood for transparent finish shall be of equal and uniform of color and graining, such as for door panels. Hardwood plywood shall be of premium grade. Plywood for paint finish matching for compatibility is not required, such as for ceiling.

(c) Veneers: Veneers on wood doors, panels and other exposed wood works shall be of 4mm thick.

The Bidder shall furnish satisfactorily functioning installations.

No separate or direct payment will be made to the Contractor for wood works. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related wood work of respective building.

7. CEMENT PLASTER AND POINTING WORKS:

Cement plaster and pointing works shall be shall be performed as per Article 15.11 “Plastering” of this chapter.

No separate or direct payment will be made to the Contractor for cement plaster and pointing works. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related cement plaster work of respective

building.

8. FLOORING WORKS:

Flooring works shall be shall be performed as per Article 15.8 "Floor, walls and roof" of this chapter.

Cast in situ mosaic flooring shall be used for all rooms except living rooms and bedroom in Staff building. Skirting shall not be less than 10 cm high. Mosaic Floor shall be prepared with 12.5mm plaster in 1:2 cement mortar in bottom layer and 6mm thick white cement and marble chips 1:1 in top layer including rubbing and polishing.

Flooring in staircase & steps and lobbies of Staff Quarter shall be of marble flooring. Marble flooring shall be as per Employers instruction.

High Quality Steel railing shall be placed in staircase, Varandhas and other specified places.

No separate or direct payment will be made to the Contractor for flooring works. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related flooring work of respective building.

9. PAINTING WORKS

General

All surfaces of the Building and Boundary wall shall be painted except the following:

(a) Exterior: Roofing, paving, nonferrous metals, glass, pre-finished items.

(b) Interior: Ceramic tile, glass, pre-finished surfaces, non-ferrous metals, stainless steel, attic surfaces.

The Contractor shall perform painting works similarly as per Article 15.17 of Control Building of this Chapter.

No separate or direct payment will be made to the Contractor for painting works. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related painting work of respective building.

10. ALLUMUNIUM, IRON & STAINLESS STEEL WORKS

Windows shall be of aluminium types indicated below. Each window shall consist of a unit including frame, mullions where indicated or required, and anchors.

(a) Frames

All frame sections shall be tubular extruded aluminium shapes and of alloy 6063-T52. Frame sections shall be not less than 45mm face dimension x 115mm deep.

(b) Doors and Windows

Windows shall be arranged for inside glazing with aluminium snap-in glazing beads designed to accommodate insulating glass as specified. Snap-in glazing beads shall securely interlock into the extruded window sections. Glazing rebate legs shall not be less than 19mm in height. The contractor shall have to provide the mosquito (Fly) net in the windows of the Buildings.

(c) Mullions, sills and Trims

Mullions, sills, trim and other window sub-assemblies, indicated on the drawings or as necessary to properly complete each aluminium door and window installation, shall be of size and design to suit the window assembly, be compatible with the windows.

(d) Anchors and Clips

Anchors, clips, bolt and screws necessary to secure doors, windows and mullions shall be provided and shall be, at manufacturer's option, either aluminium non-magnetic stainless steel, or zinc coated steel.

(e) Installation

Windows shall be installed without forcing or distortion so that sills and heads are level and jambs are plumb.

Circular stair case

Circular stair case which shall be structural mild steel tube of 150 diameters (Heavy) as a supporting column. The steps of the staircase shall be checker plate of thickness not less than 6 mm with steel angle section and plates. The hand rail shall be structural mild steel tube of 50 mm diameter (Light) with 3 layers. The whole part of the staircase shall be painted as per specification

No separate or direct payment will be made to the Contractor for aluminium, iron and stainless steel works. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related aluminium, iron and stainless steel work of respective building.

11. WATER SUPPLY AND SANITARY WORKS

Staff Quarter and Guard House unit shall have an adequate water supply system as approved by the Employer. For Staff quarter building at least two numbers of 1,000-liter rooftop stainless steel water tanks (Panchakanya or equivalent) shall be provided on each building (for total two nos of building). One numbers 2 HP heavy-duty water-pump (L & T, or equivalent make) each shall be used for pumping water from existing Underground tank (approx. distance around 50 m from staff quarter) ground-tank to roof-tanks in both staff quarters with minimum 1½" PPR pipe with overflow protection device. Electrical supply to motor and motor housing facility shall be constructed by contractor.

Contactor has to provide separate pipe lines (one inch each) for each floor (total floor no. 2) for each staff quarter building (for total two nos of building from cascaded roof top water tanks for staff quarter). Provision for overflow protection shall be provided in each overhead tank.

Contractor has to construct/make water supply arrangement for Guard house through the rooftop water tank. All the necessary pipe lines for water supply shall be provide by the contractor.

All plumbing works shall be concealed and performed with ½" & 1" PPR pipes to the approval of the Employer.

12. SANITARY FIXTURE

The Contractor shall provide sanitary fixtures, internal plumbing, wiring for water supply for Staff Quarters, and Guard House (bathroom, toilet and kitchen) using products of high quality. Employer shall approve the type, size color, etc.

13. PLUMBING & SANITATION

1. All plumbing and sanitation works shall be executed to comply with the requirements of the appropriate bye-laws, rules and regulations of the Local Authority having jurisdiction over such matters. The Contractor shall arrange for all necessary formalities to be met with regards to the inspection, testing, obtaining approval and giving notices etc.

2. Polypropylene Random (PPR) pipes having thermal stability for hot and cold water supply conforming to relevant British standard codes (B S Codes)/ equivalent International Standards shall be used for internal piping works for water supply.

3. Heavy duty UPVC pipes with lead joints conforming to relevant International Standards shall be used

for complete sanitary works and below ground as directed by employer.

4. Each toilet shall have the following minimum fittings:

(i) WC (Western type) with suction 390 mm high along with toilet paper roll holder and all other fittings, in toilets of each flat of staff quarter (total 9 flats) ;

(ii) WC (Indian Type) Orissa Pattern (580 x 440 mm) with all fittings shall be provided in other 1 nos toilets in guard house.

(iii) The wash basin shall be of white vitreous China lavatory basin of size 560mm x 456mm with one or double tap as per direction, 32mm chrome plate waste pipe 1 meter chain stay and plug, pair of C.P. built in brackets, 32mm C.P. bottle trap, 'S' or 'P' trap, 12mm lead connecting .5m long with both end coupling joint.

(iv) Bathroom mirror (600 x 450 x 6 mm thick) with hard board backing.

(v) CP brass towel rail (600 x 20 mm) with CP brass brackets.

(vi) Soap holder and liquid soap dispenser.

(vi) Shower and other taps as required inside bathroom, toilet and Kitchen

5. One no. stainless steel kitchen sink with Drain board (510 x 1040 x 178 mm bowl depth) for pantry shall be provided in each kitchen (10 nos kitchen)

6. All fittings, fasteners, gratings shall be chromium plated.

7. Supply and fitting of one euro guard equivalent water filter for guest house and associated plumbing.

8. Sewer pipe and fittings, collection pits with cover as required. All pipe shall be connected from kitchen & bathroom and toilet to the septic tank as directed. Overflow from septic tank shall be connected to the soak pit, which is ultimately drained to the natural drainage system.

9. All sanitary fixtures and fittings shall be of approved quality and type, manufactured by reputed manufacturers. All items brought to site must bear identification marks of the Manufacturer.

No separate or direct payment will be made to the Contractor for WATER SUPPLY AND SANITARY WORKS. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related WATER SUPPLY AND SANITARY WORKS of respective building.

14. ELECTRICAL WORK

All Electrical works shall be executed as per details specified elsewhere in the technical specification. All details shall be as per relevant British standard codes (B S Codes)/ equivalent International Standards.

1.The lighting layout for and around Staff Quarter, Guard, park shade and badminton court indicating the type & quantity for items shall be prepared and submitted by the contractor for employer's approval during detailed engineering.

2. The lux levels to be maintained shall be as per following:

Passage, Toilets, Corridor:	100 lux
Park shades:	200 lux
Other rooms:	300 lux
Badminton Court:	500 lux

3. 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.

4. Ceiling fans (1400 mm sweep, AC 230 volts) shall be provided in all the rooms of staff quarter, guard house, as per the requirements. Exhaust fans shall be provided in toilets and Kitchen pantry.

5. The conduit layout drawing, Electrical distribution 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 Staff quarter, Guard buildings.

6. Two power socket shall be provided in each room of Staff Quarter and Guard house. Extra power socket for Geysers in each Bathroom of staff quarter.

7. Doom light with LED Bulb of 12 watt shall be fixed around buildings on outward projected RCC slabs.

8. Other technical specification are as per Chapter 15 "Lighting system".

No separate or direct payment will be made to the Contractor for Electrical work. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related Electrical work of respective building

15. FURNITURE AND MISCELLANEOUS WORKS

The Contractor shall supply following furniture/fixtures/accessories required for staff quarters, one set each for each flat (total no of flats: eight)

- 2 numbers of wooden beds of standard quality & size (4 x 6.5) (with provision for fixing mosquito net) including clothing set (cotton filled bed, cotton filled blanket, bedsheet, 2 nos. pillow - all with cover)
- 1 no of dining tables set including 4 chair with cushion.
- 1 Kitchen pantry and complete drawer cabinet set fully (to be fitted under area the slab of kitchen) for each kitchen room
- Curtain of standard quality for each window of each flats of staff quarter with wooden cover curtain support.
- One sets of sofa with cover of standard quality with two tea tables.
- Energy efficient, double door, 150 L, Refrigerator one set.
- One set 40 inches SAMSUNG, LG, SONY or equivalent, energy efficiency smart television set with Dish home connection.
- Two (2) nos of two door wooden almirah 1500 x600x 2100 mm with drawer in each flat.

No separate or direct payment will be made to the Contractor for Furniture/Fixtures/Accessories. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related to Furniture and miscellaneous work of respective building.

16. Wood Parquet Flooring and Wood Lining on Walls

The contractor should provide material and construct wood / parquet flooring and wood Lining on walls, of the specified standard in the Staff Quarters Building and a portion of Control Room and any other area if specified. Any materials to be used for wood parquet flooring and wall lining works under this Contract shall be of such quality and properties as to withstand the extreme climatic weather conditions of local high altitude regions.

The Contractor shall furnish samples and catalogues, certificates from acceptable sources on all materials, stating its conformity with the specified quality.

Scope

a) Wooden parquet flooring & skirting of suitable design should be done for living and bed rooms of Staff Quarter Building excluding kitchen and bathrooms.
b) Wooden parquet flooring of 4m x 5m area should also be done in the office room of control building (where control personnel will be sitting). The exact location of this area shall be decided based on the layout during detailed design stage subject to the approval of the Employer.
c) Wooden wall lining is to be provided in all bed rooms and living rooms of staff quarter building at inside face of peripheral walls, ie. at inside of walls for which outer face is exposed to atmosphere, up to 1.2 m height from floor level. Similarly Wooden wall lining shall also be provided in the office room of control building.

Payment

No separate or direct payment will be made to the Contractor for **Wood Parquet Flooring and Wood Lining on Walls**. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related to work of respective building.

17. WATER SUPPLY SYSTEM

A boring of appropriate depth shall be done (of minimum 1½" pipe) and water should be pumped by one 2 HP heavy-duty water-pump up to the ground tank manufactured in scope of control Building. Electrical supply and housing of motor shall be constructed by contractor. All the necessary pipe lines for water supply including one 1 inch underground pipe line with tap (for external use max lead 60 mtrs) shall be provide by the contractor. Boring Location shall be approved by employer. Ground water shall be tested to prove its quality for drinking water from reputed laboratory in presence of employer's representative.

No separate or direct payment will be made to the Contractor water supply system work. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment, labor and other operations related to water supply system of respective building.

18. DRAINAGE AND SEWAGE SYSTEM

i. General Requirement

The drainage system is to drain all the storm run-off water and all other water by using pipe converting system, gutter and cable trench system to the public drainage pit outside the substation in accordance with the instructions of Employer. The Contractor shall perform and be responsible for drainage system according to the following specified items. The Contractor shall study and divert the existing drainage system to nearby kholsi with proper protection. All the Contractor's designed drawings shall be submitted to Employer for approval.

ii. Principal Areas of Drainage

1. Switchyard area and cable trench

2. Road surface
3. Control building
4. Compound periphery
5. Staff Quarters and its periphery
6. Existing Store cum office building, guard house, other buildings and their periphery

iii. Drainage Pipe

The Contractor shall design, furnish and install all pipes for drainage system.

Drainage Channel Materials

a) All drains must be built with proper gradient.

Excavation must give allowance to formwork, which shall be refilled with proper compaction.

b) Concrete Pipes: Concrete pipes shall be of Np-3 class or equivalent in required size. Closed pipes shall be used at road crossing.

The Contractor shall design, furnish for drainage in switchyard area with water collection chambers.

c) Mortars for drainage channel shall be a mixture of cement and sand mortar with a ratio of 1:3.

d) Contractor has to furnish drain slope of 1:400 mtrs

iv. **Channel Type Drainage with RCC slab cover**

The surface shall be made as smooth as possible with plasterwork. Side and base shall be constructed in Brick masonry wall. The cover of trench shall be 80 mm thick pre cast RCC slabs (with form work) with the provision of handles (painted) in 3 alternate slab of approved design. The function of the gutter is to drain the surface run-off from the road surface and nearby area. The size and slope of the gutter shall have adequate capacity for drainage of the area.

v. Sump pit

Sump shall be provided for pipe changes in size, direction, and inspection and at inlet of nearby area. The maximum distance at road inlet sump shall not be more than 30 meters. The sump shall be of reinforced concrete type. The sump cover shall be of either steel grating or cast iron.

Only cast iron cover shall be used for inspection sump. The inspection or manhole sump shall be provided at maximum distance of 40 meters. The steel grating shall be strong enough for the load of AASHO H 20-S16.

vi. Payment

Payment for the all above stated works will be done in "Complete Drain System" in Lump Sum. Therefore, in the Price Schedule, the bid price shall include full compensation for all costs incurred in furnishing all material, equipment and labor and other operations related to the scope of work.

19. Outdoor Cable Trench, Duct Bank Conduits and Hand Hole

a. General Requirement

The detail design of the cable trench required in Pangtan SS and Bahrabise SS shall be the responsibility of the Contractor. All designs and details shall be subject to approval of the Employer. The inside depth of the trench shall be minimum 1 m if not specified. Design for 11 kV, 33 kV and 132 kV cable trench shall be proposed by the contractor in accordance to the site condition and requirement.

b. Type of Cable Trench

Concrete cable trenches of adequate size shall be designed and constructed in accordance with the approved drawings and as directed by Employer. Main cable trench leading to control building shall be minimum 1.5 m breadth and 1.4 m depth (inside) and shall able to carry min 3 nos of cable trays fitted at workable interval or as approved .

Cable trench shall be reinforced concrete trench with three layer of hot dip galvanized light gauge shape steel tray. The cover of trench shall be 80 mm thick pre cast RCC slabs (with form work mandatory) with the provision of handles (painted) in 4 alternate slab of approved design. The cover shall be fitted inside the outer wall of cable trench. The top surface shall be smooth finished. The trench and cover where it crosses the road shall be calculated safe for the load of AASHO H20-S16.

Trenches shall be designed with floor drains. Reinforced concrete, cast iron or heavy-duty PVC pipe of minimum 15-centimeter diameter shall be installed in the cable trench sump pit to nearest drainage sump to drain the water in the cable trench.

c. Conduit and Hand Hole

The Contractor shall provide the conduit and hand hole for the cable from the main trench to the steel structure or equipment foundation. The hand hole shall be reinforced concrete with galvanized steel chequered plate cover. The size of the hand hole shall be large enough to pull the cable from the conduit to the foundation.

Payment for the Contract item, "Cable Trenches", will be made on the lump sum basis at Pangtan SS and that at Bahrabise SS is deemed to be included in the bid price. Hence no separate payment for the item cable trench works for Bahrabise SS shall be made. Therefore, in the Price Schedule, such lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment and labor and all other operations related to cable trench design and construction, including but not limited to:

a) Performing detail designs and preparation of construction drawings.

b) Supplying transporting all materials to job site.

c) Excavating and backfilling for the cable trenches

d) Constructing the cable trenches with floor drains, reinforced concrete wall, base, cable tray and removable cover.

e) Providing road crossing conduit and conduit pipe at foundation block.

20. MISCELLANEOUS OUTDOOR FACILITIES.

1. General

The proposal shall include all miscellaneous outdoor facilities. The miscellaneous outdoor facilities shall comprise of switchyard fence with entrance gate, access and internal roads.

Prior to execution of the works, the Contractor shall prepare and submit design and detailed drawings of such works to Employer for approval. All works shall be executed in accordance with the stipulations of the relevant articles of the Specifications.

2. PLINTH PROTECTION

750 mm wide and 50 mm thick plain cement concrete 1:2:4 (1 cement:2 sand:4 graded 20 mm nominal size stone aggregate) shall be laid over 75 mm thick dry stone aggregates well rammed and consolidated with interstices filled with local sand including smooth finishing top. Cost of plinth protection works is deemed to be included in the LS cost of individual building as stated earlier and hence no separate payment of plinth protection shall be made to the contractor.

1. General

The proposal shall include upgradation of road as the road width is insufficient at various locations (approx 15 km) for ease of transportation of equipment/material up to SS site and protection of SS where applicable and as per decision of the Employer.

2. Survey Works

As the road condition is poor and width to Substation site inadequate in certain places, NEA has envisaged excavation, stone soling and gabion/stone masonary protection works for ease of transportation of various equipments at site. The contractor shall conduct detail survey, study and recommend/specify the exact location for requirement of excavation volume and type of protection required. The contractor shall propose the type of protection required. Prior to execution of the works, the Contractor shall prepare and submit design and detailed drawings of such protection works to Employer for approval.

Payment for survey works shall be done in km basis and excavation/protection works in accordance to the measured volume. Therefore, in the Price Schedule, the bid price shall include full compensation for all costs incurred in furnishing all material, equipment and labor and other operations related to the scope of work.

3. M20 Concrete Nominal Mix

Concrete Works for the protection works shall be performed as per Article 8.0 “Foundation /RCC construction” excluding steel reinforcement. The concrete mix shall be M20 Nominal Mix 1:1.5:3 as mentioned in BOQ. Admixture and additives as per article 9.10. Complete Form Work shall be performed as per Article 10.0 “Form work”.

Measurement for payment of M20 Concrete Nominal Mix 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 labors, equipment, materials and all other cost necessary for the performance and completion of the works.

4. Reinforcement Bars

Complete steel reinforcement work for the protection works shall be performed as per Article 9.0 “Reinforcement” of this Chapter.

Measurement for payment of Reinforcement Bars shall be made on the basis of actual placed weight of bars in Kg. Payment shall be made for the total weight measured as provided at the unit price specified in the schedule. The unit price shall include all labors, equipment, materials and all other cost necessary for the performance and completion of the works.

5. Gabion Wall

The standard type gabion (Maccaferi) shall be a flexible hot dip galvanized gabion of the type and size specified below. It is made of wire mesh of the type and size and selvedge as specified in the following:

-The mesh shall be hexagonal woven mesh, with the joints formed by twisting each pair of wires through three and half turns.

-The size of mesh shall not be less than 100mm.

-All wires used in the fabrication of the gabions shall be galvanized "Mild steel wire", having average tensile strength of 44 kg/sq.mm.

-The diameter of the wire used in the fabrication of the netting shall be at least 3.0 mm depending on the design requirement.

-The selvedge and mesh wire shall have a diameter of 3.9 mm 3.0 mm respectively

The gabion wall shall be filled with quarry stone as approved by the Employer. The rock shall be of compact, firmly bound and uniformly grain texture and absolutely weather-resistance.

Sufficient lacing and connecting wires of 2.4 mm diameter shall be supplied with the gabions, for all the wiring operations to be carried out in the construction of the gabion work.

Payment

Measurement for payment of gabion works for the protection works shall be made on the basis of actual placed volume of gabions 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 labors, equipment, materials and all other cost necessary for the performance and completion of the works.

6. Earthwork in excavation

Earthwork in excavation for the protection work shall be performed as per Article 4.4 "Excavation and Backfill" of this Chapter. Earthwork in filling along with compaction shall be as per article 4.5 "Compaction".

Payment

Contract item "Earthwork in excavation" includes both earthwork in excavation and earthwork in filling along with compaction, for the protection works. Payment shall be made on the basis of actual volume of earthwork 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 labor, equipment, materials and all other cost necessary for the performance and completion of excavation and filling the works. Hence no separate payment for filling work which may be required at site shall be made.

7. Stone soling and compaction work

Stone for and soling work shall be of the best of its kind. It shall be strong, angular, and free from flakes & must be of quality approved by the site Engineer. Earthy or diced, weather or water worn shall not be used. Stone in foundation shall be from local quarries or from any other place as approved by the Site Engineer. Stone for the stone soling work shall be hard, regular, sound, durable, and free from decay and weathering. Stone with round surface shall not be used. Before starting of work, the contractor shall get the sample of the stone approved by the site Engineer regarding its size and quality.

Payment

Measurement for payment of soling works and stone masonry for the protection works shall be made on the basis of actual placed volume of stone in cubic meters. Payment shall be made for the number of cubic meters measured as provided at the unit prices specified in the schedule. The unit price shall include all labors, equipment, materials and all other cost necessary for the performance and completion of the specified works.

8. Stone Masonry

Stone masonry work shall include stone work for slope protection in SS premises and access road. 500 mm thick Random Rubble stone masonry layer shall be also used as slope protection for the portion of 1:1 slope within the Substation premises (refer Drawing No. DWG 009). The quality of stones other materials shall be as follows.

The stones shall be sound, hard, durable and fairly regular in shape. Quarry stone shall be used. Rounded boulders shall not be allowed. The size of stone shall be of around 450mm with minimum weight of 35 kg. The quality and size of stone shall be approved by the Employer prior to commencement of work. The area to be pitched shall be trimmed and compacted to accommodate the stone work. A bed of well graded gravel filter shall be placed on sloping surface to prevent leaching of the soil through the voids of stone pitching as well to allow free movement of water to minimize uplift on stone pitching The stones

shall be set on edge with their largest dimension at right angle to the slope unless such dimension exceeds that of the required thickness of the stone pitching. The stones shall be securely rammed into the surface to be protected. The stones shall be fitted together so as to leave only minimum of interstices, which shall be fitted with suitably shaped and tightly wedged spalls. The top of the pitching shall be finished flush with the adjacent material. Suitable number of weep holes by providing 100mm PVC pipes with suitable at regular spacing in filter bed shall be provided. Stone masonry should be laid in accurately spaced courses, level, plumb and true to line and finished properly with adequate slopes for efficient drainage of sub soil / rain water to toe drain.

Payment

Measurements for payment for the Contract item "Stone Masonry " shall be made in cubic meter. Payment for the Contract item "Stone Masonry " will be made at the unit price for cubic meter and the quoted unit price shall include full compensation for all costs incurred procurement, compaction, PVC pipes and all other operations , tools & tackles, complete for finished item of work.

9. Gravel Laying and Compaction

Pavement Materials

Sub-base

Sub-base shall be a non-plastic, sandy, granular material with a C.B.R. value greater than 15. It shall be free of deleterious material and subjected to the Employer's approval. Thickness of sub-base course shall be 30cm compacted.

Base course

Base shall be of WBM (water bound macadam) using crushed aggregate with a CBR value greater than 80. The filler material for WBM shall be stone dust. It shall be free of deleterious material and subjected to the Employer's approval. Thickness of base course shall be 15cm compacted.

It shall conform to following gradation:

Sieve size	Percentage passing
1 1"/2	100
3/4"	90 - 100
3/8"	50 - 80
No.4	35 - 55
No.30	10 - 30
No.200	2 - 9

Measurement for payment of Gravel Laying Works shall be made on the basis of actual placed compacted volume of gravel in cubic meters as specified above. 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 labors, equipment, materials and all other cost necessary for the performance and completion of the works.

25.18 PAYMENTS

25.18.1 Payment for Control Building, Staff Quarters and Guard house.

Payment for the lump sum items shall be paid on in accordance with the progress of work in site.

1. Foundation work up to DPC- 10% of payment shall be made as a running bill.
2. Super structure all complete– 30% of payment shall be made as a running bill.
3. Plastering (internal and external all complete) – 10 % of payment shall be made as a running bill.
4. Painting, flooring works, doors and windows, electrical works, false ceiling, water supply & sanitary works and all finishing works – 30% of payment shall be made as a running bill.
5. Furniture and miscellaneous work- remaining 20% of payment

Payment will be made after detail progress of the completed item for the specified work have been submitted and accepted by the Employer.

25.18.2 Payment for Civil Works

Payment for the civil works shall be made on the basis of actual quantity approved by Employer as shown on approved drawings. The method of measurement shall be of required accuracy and shall be approved by Employer.

Payments will be made in the following manner:

a) Payment for the items that can be measured shall be made on **monthly progress basis** according to the unit cost quoted in the Price Schedule.

b) i) Payment against unit price for foundation work shall be made upon completion of each foundation including setting, excavation, reinforcement concrete works and backfilling complete.

ii) Payment against unit price for foundation work for slope protection works (gabion, stone masonry etc.) shall be made upon completion of each foundation including setting, excavation, reinforcement concrete, plain cement concrete works and backfilling all complete.

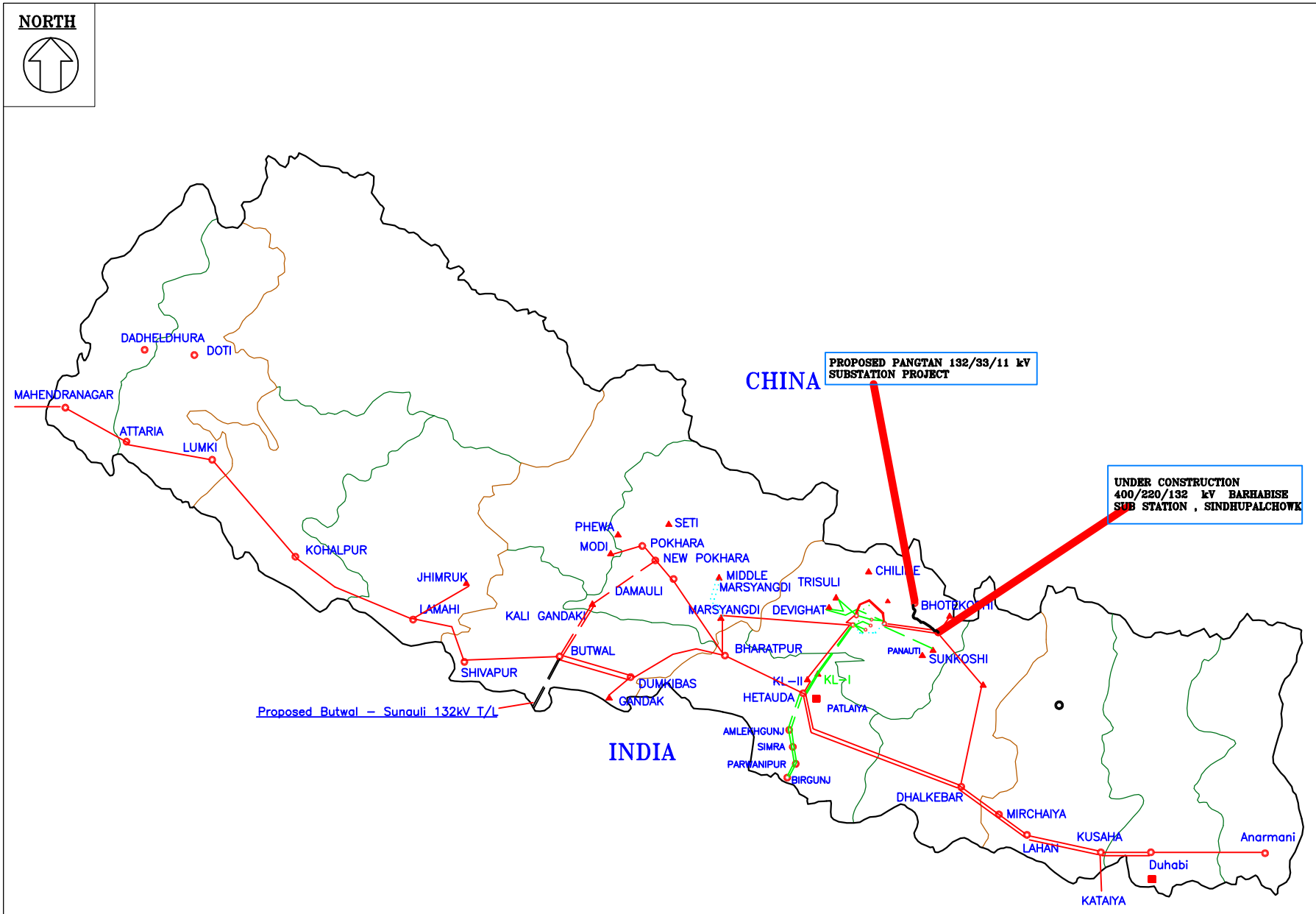
c) Payment for the lump sum items shall be paid on in accordance with the progress of work in site.

25.18.3 Payment for Installation Work of the Equipment

a) Payment against unit price basis will be made upon completion of installation of each-equipment including setting, adjusting and individual test.

b) Payment against lump sum basis will be made three times (each not less than 30%) in accordance with the progress work which will be judged by the Employer.

c) Payment against field test will be made after the whole test reports have been submitted and accepted by the Employer.



LEGENDS

- EXISTING 132kV & 66kV T/L
- PROPOSED 132kV T/L
- GRID SUBSTATION
- HYDRO–POWRE PLANT
- DIESEL–POWER STATION

REFERENCE :

DRAWING NO. 1 OF NEPAL POWER SYSTEM WITH PROPOSED BALEFI CORRIDOR TRANSMISSION LINE

FOR TENDER PURPOSE ONLY

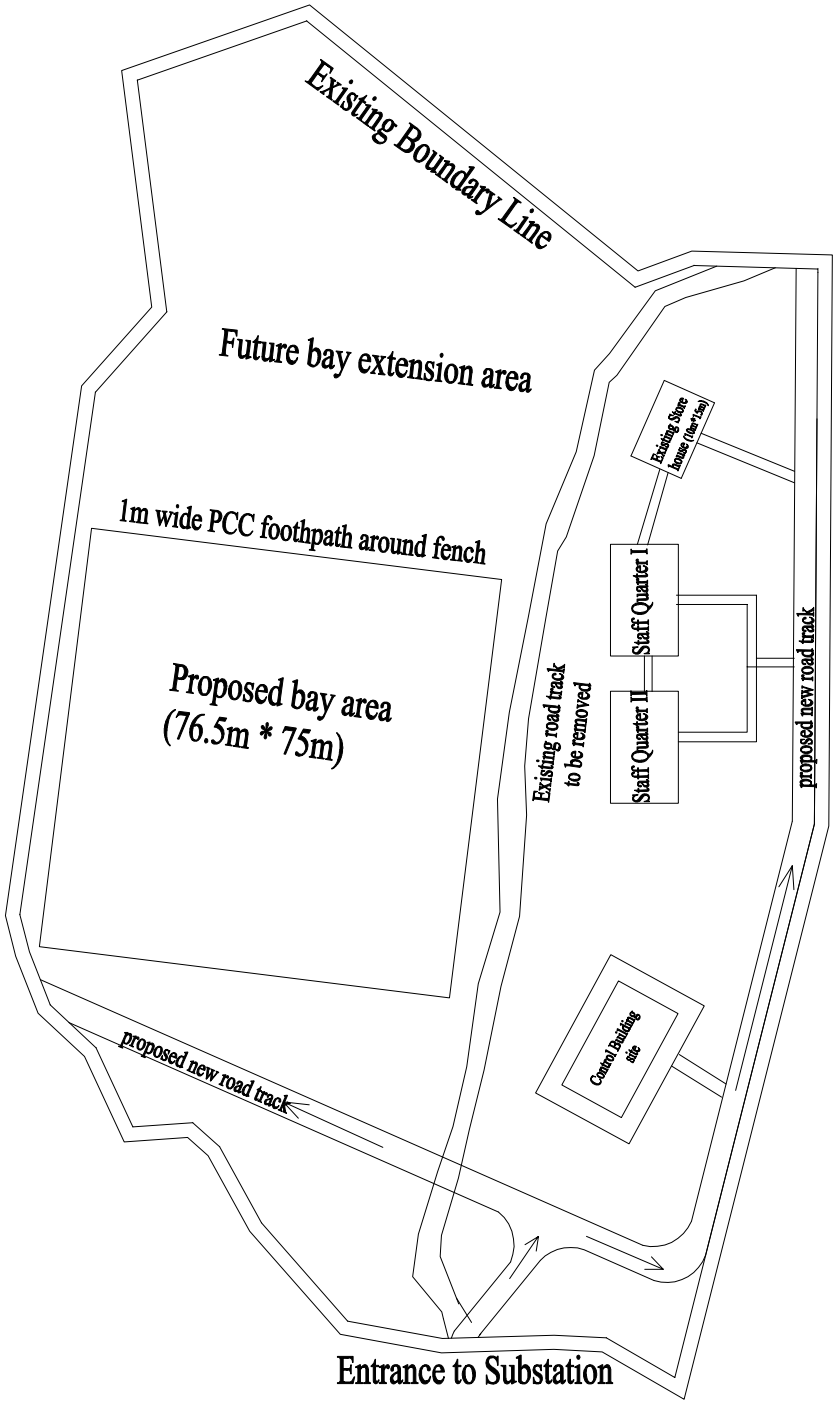
NEPAL ELECTRICITY AUTHORITY
(A Government Of Nepal Undertaking)

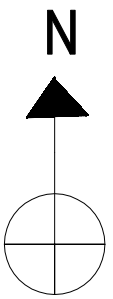
CONTRACT NO :		
PREPARED	NAME	DATE
DRAWN BY		
DESIGNED BY		
CHECKED BY		
APPROVED BY		
SHEET SIZE		
SCALE	NOT IN SCALE	

PROJECT : PANGTAN 132/33/11 kV SUBSTATION PROJECT

DRAWING TITLE : LOCATION MAP OF 132/33/11kV PANGTAN SUB-STATION

DRAWING NO : DWG 001 | REV. | SHEET 1





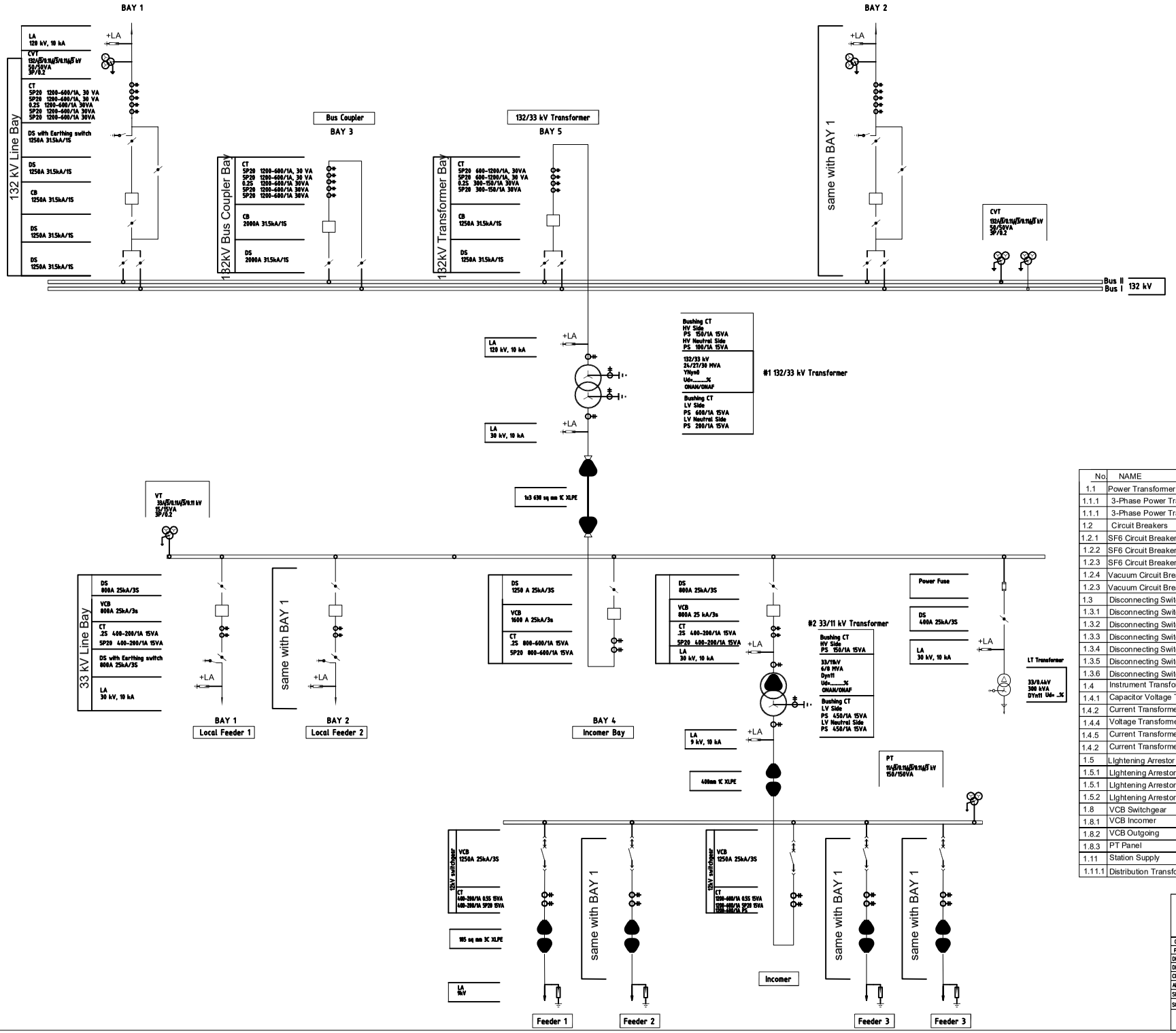
NOTES:–

1.THE LAYOUT PLAN IS INDICATIVE FOR REFERENCE OF THE BIDDER. BIDDER SHALL PREPARE OPTIMIZED LAYOUT AND SUBMIT WITH BID.
3. ALL THE EQUIPMENT & BUSES INSIDE THE SUBSTATION WILL BE PROTECTED FROM LIGHTNING MAST (LM). LM LOCATION SHALL BE AS PER DSLP CALCULATION.

FOR TENDER PURPOSE ONLY

NEPAL ELECTRICITY AUTHORITY
(A Government Of Nepal Undertaking)

CONTRACT NO :			PROJECT :	PANGTAN 132/33/11 kV SUBSTATION PROJECT	
PREPARED	NAME	DATE			
DRAWN BY					
DESIGNED BY			DRAWING TITLE :	CONSTRUCTION LAYOUT MAP OF 132/33/11kV PANGTAN SUB-STATION	
CHECKED BY					
APPROVED BY					
SHEET SIZE			DRAWING NO :	DWG 002	REV. / SHEET 1
SCALE	NOT IN SCALE				



NOTES:–

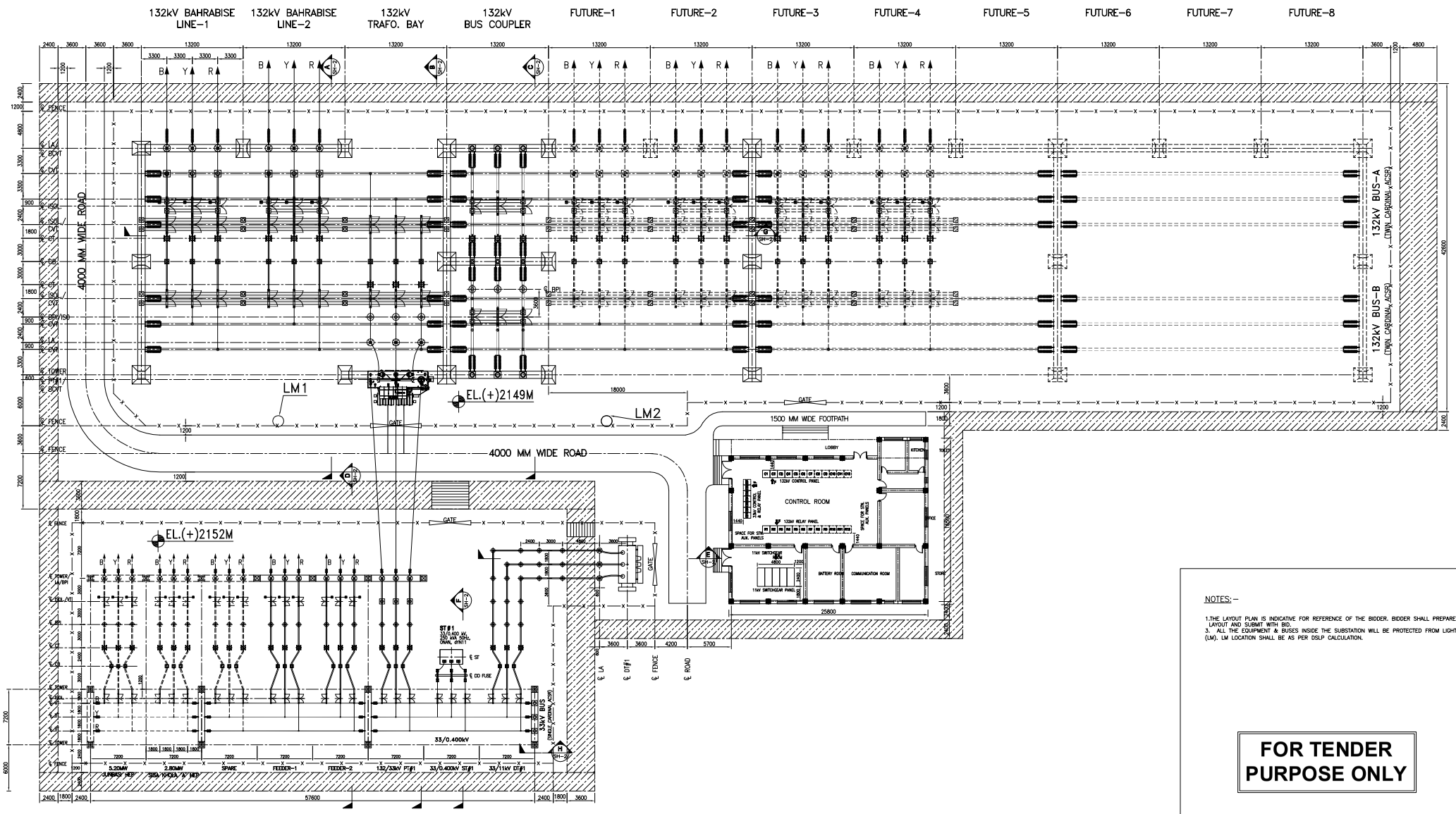
1. THE SINGLE LINE DIAGRAM IS CONCEPTUAL AND WILL BE FURTHER DEVELOPED DURING EXECUTION STAGE OF THE PROJECT.
2. THE ARRANGEMENT & EQUIPMENT OF ALL FUTURE BAYS WHICH IS UNDER THE SCOPE OF IPP, WILL BE SAME AS THAT OF THE EXISTING BAYS.

MATERIAL LIST

No.	NAME	TYPE	SYMBOL	UNIT	QTY	BOQ
1.1	Power Transformer					
1.1.1	3-Phase Power Transformer	132/33 kV, 24/27/30 MVA,		set	1	1
1.1.1	3-Phase Power Transformer	33/11 kV,6/8 MVA,		set	1	1
1.2	Circuit Breakers					
1.2.1	SF6 Circuit Breaker	145kV, 1250 A, 1 Pole Operation		set	2	2
1.2.2	SF6 Circuit Breaker	145kV, 2000 A, 3 Pole Operation		set	1	1
1.2.3	SF6 Circuit Breaker	145kV, 2000 A, 3 Pole Operation		set	1	1
1.2.4	Vacuum Circuit Breaker	36 kV, 2000 A, 3 Pole Operation		set	1	1
1.2.3	Vacuum Circuit Breaker	36 kV, 1250 A, 3 Pole Operation		set	2	2
1.3	Disconnecting Switches					
1.3.1	Disconnecting Switch with ES	145kV, 1250A		set	2	2
1.3.2	Disconnecting Switch	145kV, 2000A		set	2	2
1.3.3	Disconnecting Switch	145kV, 1250A		set	10	10
1.3.4	Disconnecting Switch with ES	36 kV, 800A		set	2	2
1.3.5	Disconnecting Switch	36 kV, 1250A		set	1	1
1.3.6	Disconnecting Switch	36 kV, 1250A		set	4	4
1.4	Instrument Transformer					
1.4.1	Capacitor Voltage Transformer	145kV, 50VA, $\sqrt{3}$2/ 3/$\sqrt{3}$.11/ 3		Nos	12	12
1.4.2	Current Transformer	145kV, 30VA, 5 Core		Nos	9	9
1.4.4	Voltage Transformer	36kV, 30VA, $\sqrt{3}$/ 3/0$\sqrt{3}$11/ 3		Nos	3	3
1.4.5	Current Transformer	36kV, 15VA, 2 Core		Nos	12	12
1.4.2	Current Transformer	145kV, 30VA, 4 Core		Nos	3	3
1.5	LIghtening Arrestor					
1.5.1	LIghtening Arrestor	120kV, 10kA		Nos	9	9
1.5.1	LIghtening Arrestor	30 kV, 10kA		Nos	6	6
1.5.2	LIghtening Arrestor	9kV, 10 kA		Nos	9	9
1.8	VCB Switchgear					
1.8.1	VCB Incomer	11kV, 1250A		set	1	1
1.8.2	VCB Outgoing	11kV, 800A		set	4	4
1.8.3	PT Panel	12 kV,		set	1	1
1.11	Station Supply					
1.11.1	Distribution Transformer	300 kVA, 33/0.4 kV		set	1	1

NEPAL ELECTRICITY AUTHORITY
(A Government Of Nepal Undertaking)

CONTRACT NO :		PROJECT :	PANGTAN 132/33/11 kV SUBSTATION PROJECT
PREPARED	NAME / DATE		
DRAWN BY		DRAWING TITLE :	SINGLE LINE DIAGRAM OF 132/33/11kV PANGTAN SUB-STATION
DESIGNED BY			
CHECKED BY			
APPROVED BY			
SHEET SIZE		DRAWING NO :	DWG 003
SCALE	N.T.S.	REV.	
		SHEET	1



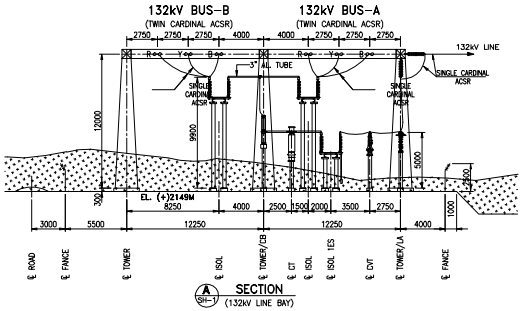
NOTES:-

1.THE LAYOUT PLAN IS INDICATIVE FOR REFERENCE OF THE BIDDER. BIDDER SHALL PREPARE OPTIMIZED LAYOUT AND SUBMIT WITH BID.
3. ALL THE EQUIPMENT & BUSES INSIDE THE SUBSTATION WILL BE PROTECTED FROM LIGHTNING MAST (LM). LM LOCATION SHALL BE AS PER DSLP CALCULATION.

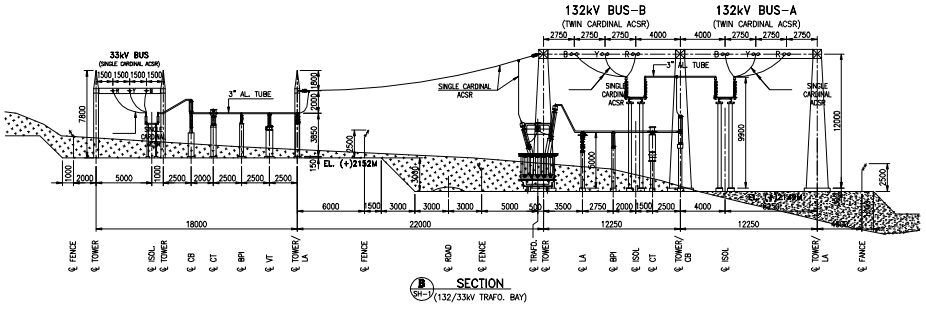
FOR TENDER PURPOSE ONLY

NEPAL ELECTRICITY AUTHORITY
(A Government Of Nepal Undertaking)

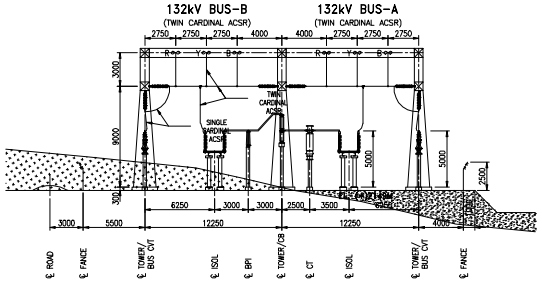
CONTRACT NO :			PROJECT : PANGTAN 132/33/11 kV SUBSTATION PROJECT
PREPARED	NAME	DATE	
DRAWN BY			
DESIGNED BY			DRAWING TITLE : LAYOUT PLAN & SECTION OF 132/33/11kV PANGTAN SUB-STATION
CHECKED BY			
APPROVED BY			
SHEET SIZE			DRAWING NO : DWG 004 / REV. / SHEET 1 OF 2
SCALE	NOT IN SCALE		



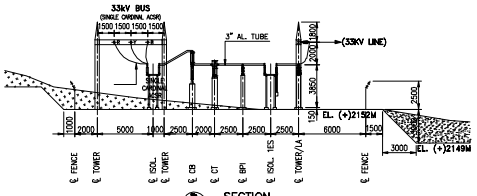
A SH-1 SECTION
(132kV LINE BAY)



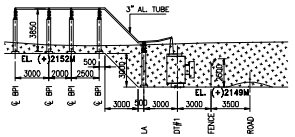
B SH-1 SECTION
(132/33kV TRAFO. BAY)



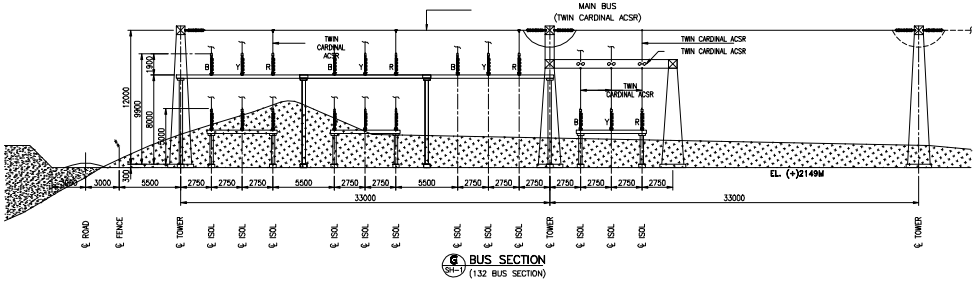
C SH-1 SECTION
(132kV BUS COUPLER BAY)



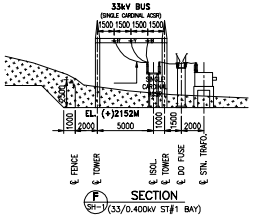
D SH-1 SECTION
(33kV FEEDER BAY)



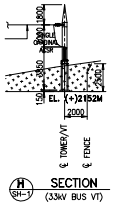
E SH-1 SECTION
(33/11kV DTF1 BAY)



G SH-1 BUS SECTION
(132 BUS SECTION)



F SH-1 SECTION
(33/0.400kV STN#1 BAY)



H SH-1 SECTION
(33kV BUS VT)

NOTES:-

1.ALL DIMENSIONS ARE IN MILLIMETER UNLESS OTHERWISE SPECIFIED.

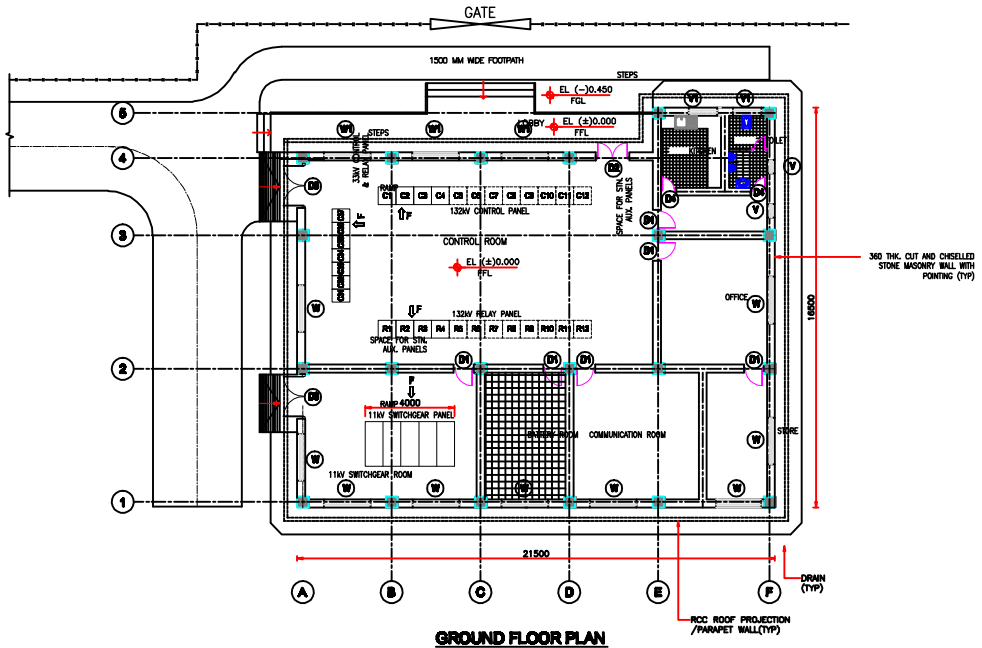
CUTTING

FILLING

FOR TENDER PURPOSE ONLY

NEPAL ELECTRICITY AUTHORITY
(A Government Of Nepal Undertaking)

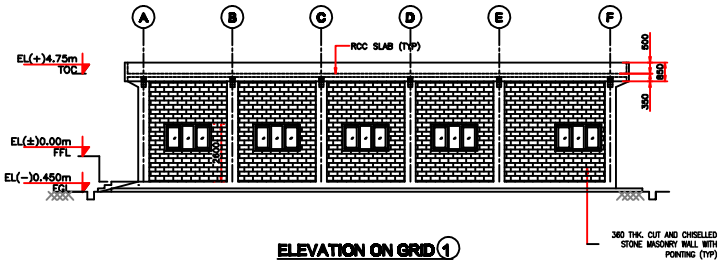
CONTRACT NO :			PROJECT : PANGTAN 132/33/11 kV SUBSTATION PROJECT
PREPARED	NAME	DATE	
DRAWN BY			
DESIGNED BY			DRAWING TITLE : LAYOUT SECTION OF 132/33/11kV PANGTAN SUB-STATION
CHECKED BY			
APPROVED BY			
SHEET SIZE			DRAWING NO : DWG 005 / REV. / SHEET 1
SCALE	NOT IN SCALE		



GROUND FLOOR PLAN

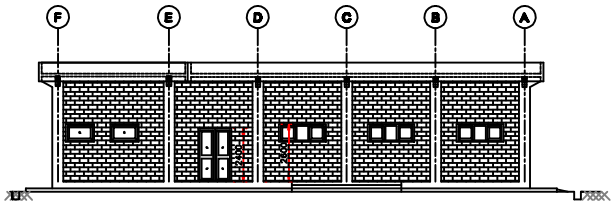
1:100

OPENING SCHEDULE				
	DESCRIPTION	SN	NO	SIZE
	1	D1	6	900X2100
	2	D2	1	1500X2100
	3	D3	2	2000X2500
	4	D4	2	700X2100
	5	W	9	2100X1200
	6	W1	3	2100X800
	7	V	2	600X800
	8	V1	2	1300X800



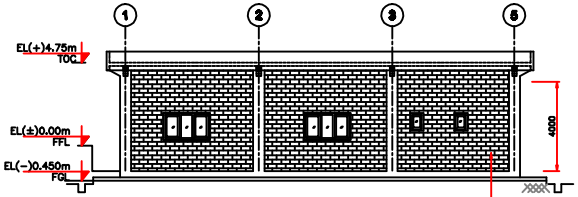
ELEVATION ON GRID 1

1:100



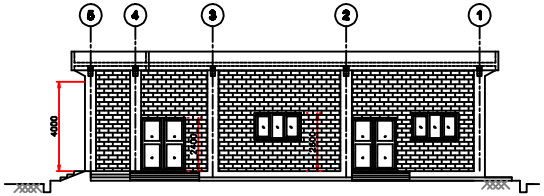
ELEVATION ON GRID 4 & 5

1:100



ELEVATION ON GRID F

1:100



ELEVATION ON GRID A

1:100

NOTES

1 (±) 0.000m CORRESPONDS TO FFL OF GROUND FLOOR OF THIS BUILDING

LEGENDS

FFL – FINISHED FLOOR LEVEL
FGL – FINISHED GROUND LEVEL
TOC – TOP OF CONCRETE
EL – ELEVATION
TYP – TYPICAL
W – WINDOW
D – DOOR
V – VENTILATOR
– STONE WALL
– RCC IN WALLS/COLS/PEDESTALS

REFERENCE DRAWINGS

DRAWING TITLE	DRAWING NO.

FOR TENDER PURPOSE ONLY

NEPAL ELECTRICITY AUTHORITY
(A Government Of Nepal Undertaking)

PANAUTI 132/33/11 kV SUBSTATION PROJECT

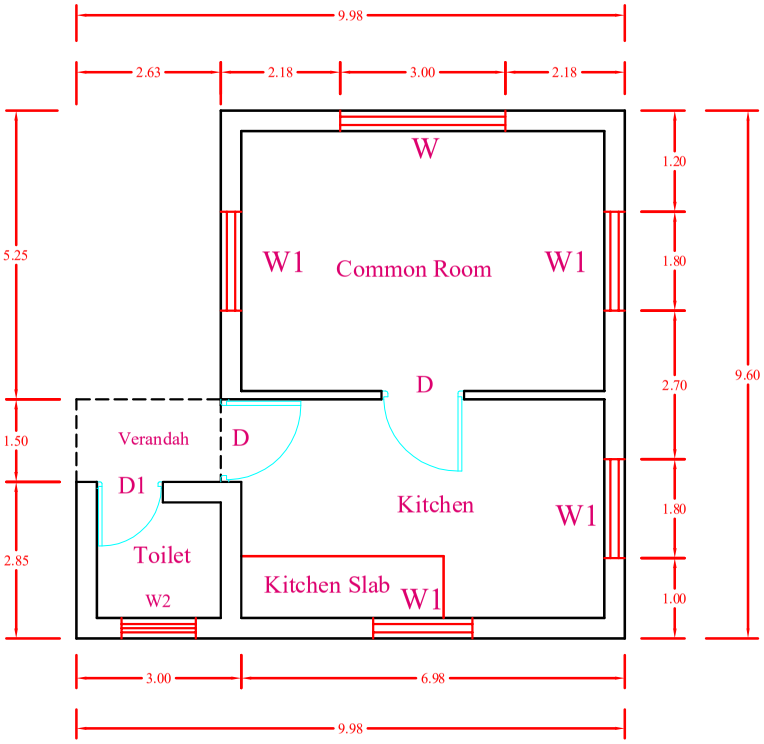
ARCHITECTURAL DRAWING
OF CONTROL BUILDING

DWG 006

REV.

SHEET

SCALE NOT IN SCALE



This drawing is for tender purpose only and contractor may submit drawing with some modifications acceptable to employer.

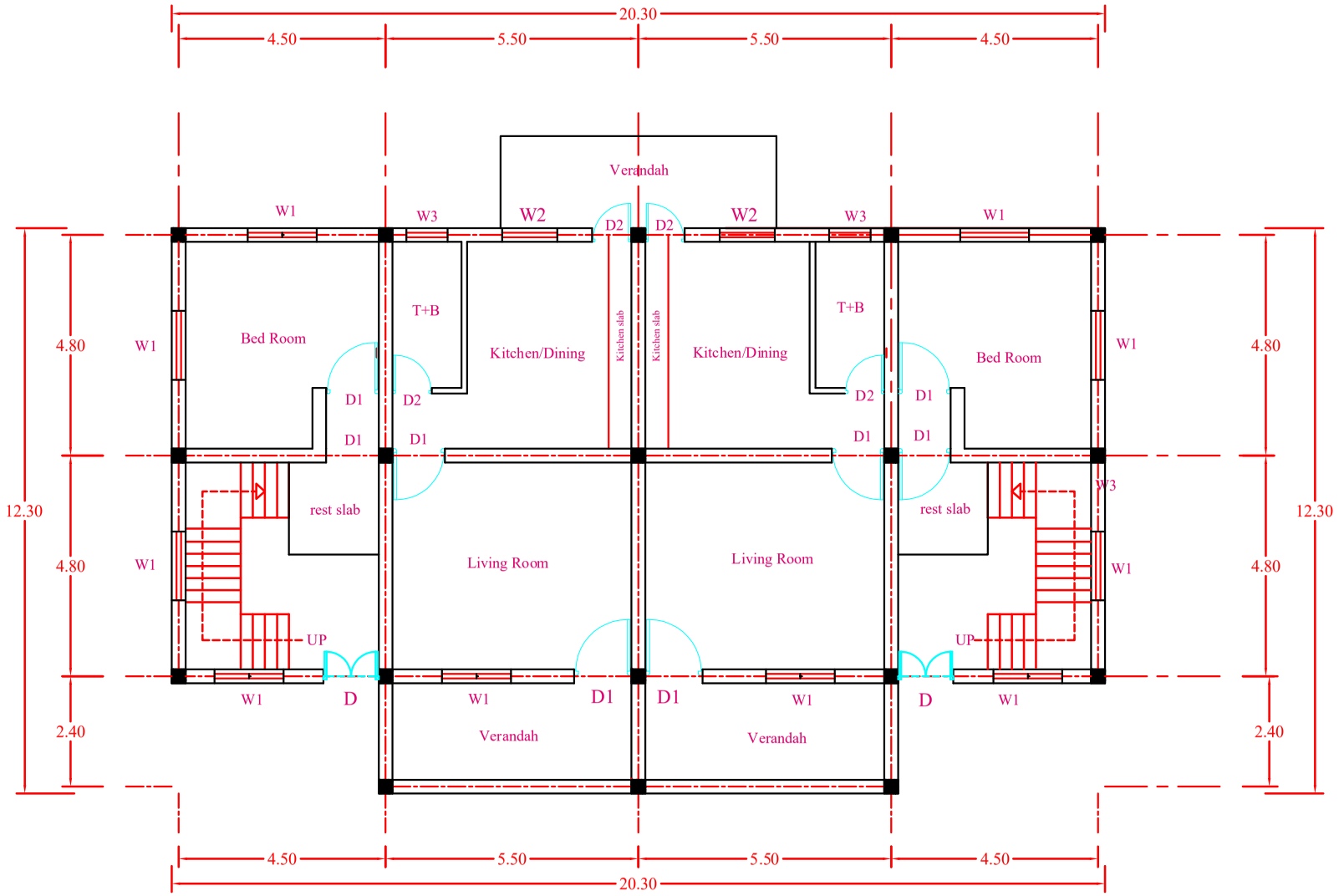
OPENING SCHEDULE

S.No.	Description	Qty.	Dimension	Remarks
1	Window W	1	2x1.2	Shill Ht.=0.9
2	Window W1	4	1.2x1.2	
3	Window W2	3	0.9x1.2	
4	DOOR D	2	1.00x2.25	
5	DOOR D1	1	0.8x1.9	

DESIGN OF DOORS AND WINDOWS WILL BE AS PER SITE CONDITION OR AS PER ORDER OF ENGINEER

NEPAL ELECTRICITY AUTHORITY
(A Government Of Nepal Undertaking)

CONTRACT NO :		PROJECT :	PANGTAN 132/33/11 kV SUBSTATION PROJECT
PREPARED	NAME DATE		
DRAWN BY			
DESIGNED BY		DRAWING TITLE :	LAYOUT FOR GUARD HOUSE
CHECKED BY			
APPROVED BY			
SHEET SIZE		DRAWING NO :	DWG 007_2
SCALE	NOT IN SCALE	REV.	SHEET 1



GROUND FLOOR PLAN

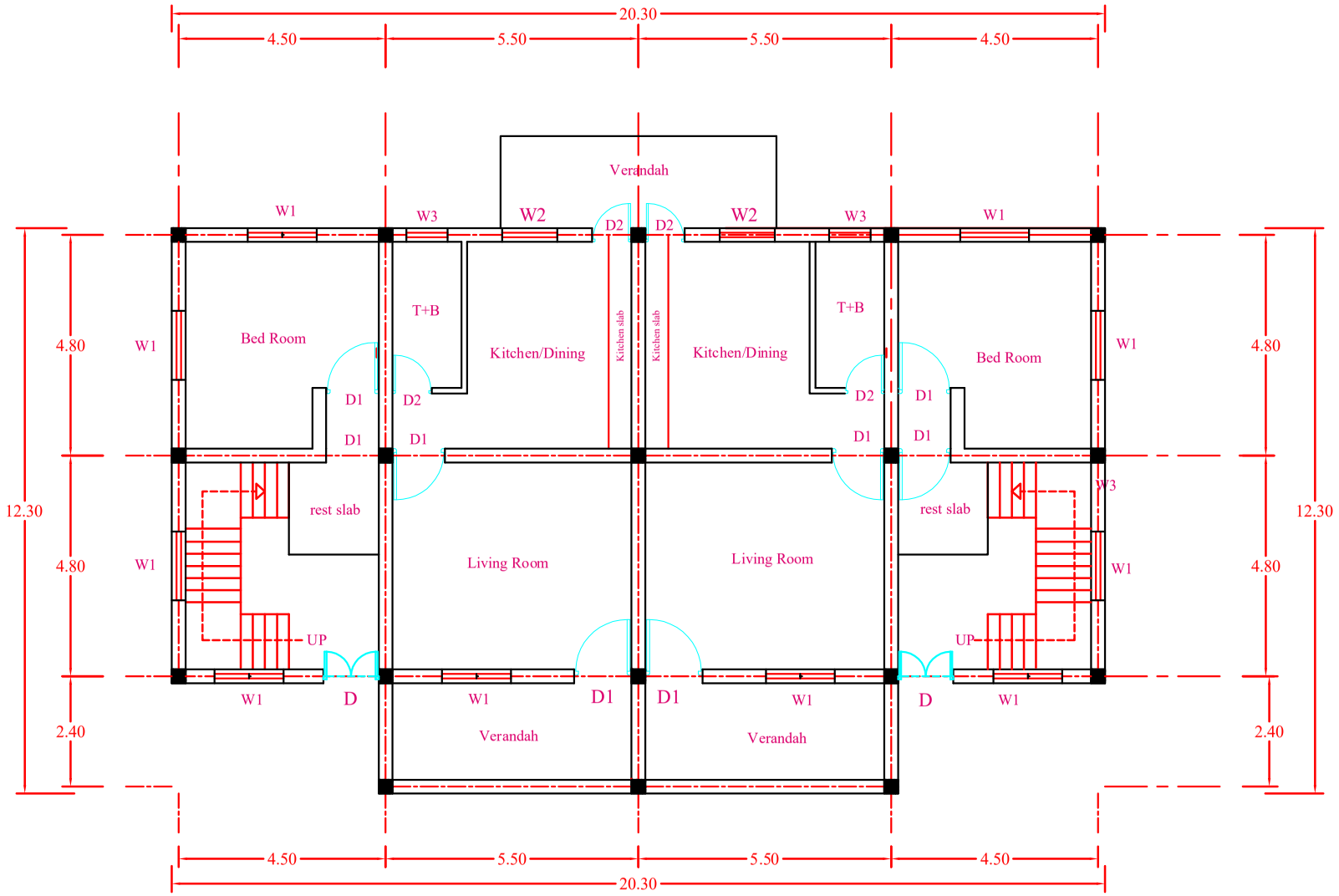
OPENING SCHEDULE

S.No.	Description	Qty.	Dimension	Remarks
1	Window W1	10	1.5x1.5	
3	Window W2	2	1.2x1.2	
4	Window W3	2	0.90x0.90	
5	DOOR D	2	1.2x2.40	Double shutter
6	DOOR D1	8	1.00x2.20	Single shutter
7	DOOR D2	4	0.80x2.20	Single shutter

NOTE :- DESIGN OF DOORS AND WINDOWS WILL BE AS PER SITE CONDITION OR AS PER ORDER OF ENGINEER

NEPAL ELECTRICITY AUTHORITY
(A Government Of Nepal Undertaking)

CONTRACT NO :		PROJECT :	PANGTAN 132/33/11 kV SUBSTATION PROJECT
PREPARED	NAME / DATE		
DRAWN BY			
DESIGNED BY		DRAWING TITLE :	LAYOUT FOR STAFF QUARTER
CHECKED BY			
APPROVED BY			
SHEET SIZE		DRAWING NO :	DWG 007_2
SCALE	NOT IN SCALE	REV.	SHEET 1 OF 3



FIRST FLOOR PLAN

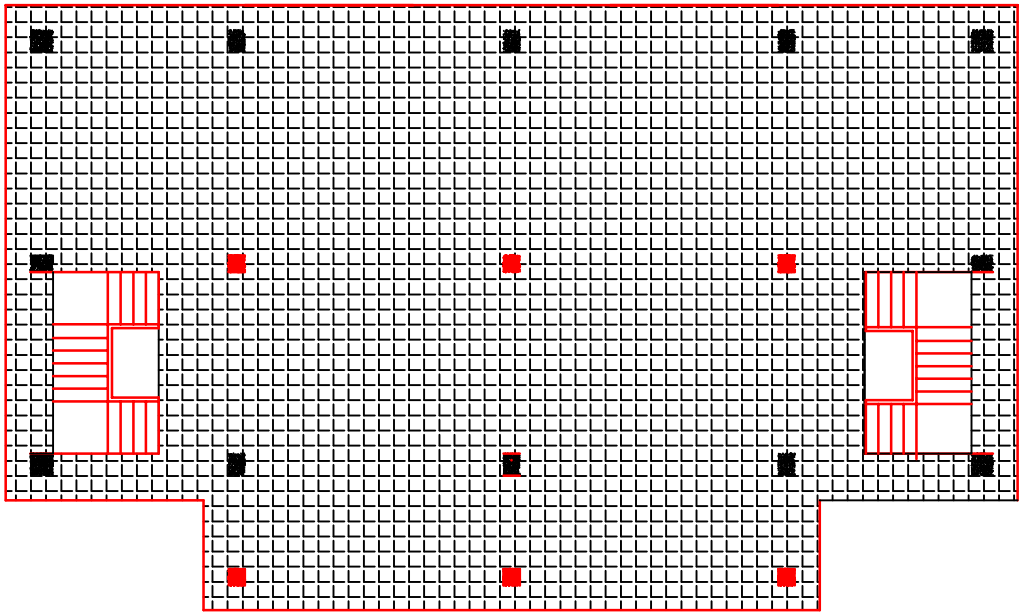
OPENING SCHEDULE

S.No.	Description	Qty.	Dimension	Remarks
1	Window W1	10	1.5x1.5	
3	Window W2	2	1.2x1.2	
4	Window W3	2	0.90x0.90	
5	DOOR D	2	1.2x2.40	Double shutter
6	DOOR D1	8	1.00x2.20	Single shutter
7	DOOR D2	4	0.80x2.20	Single shutter

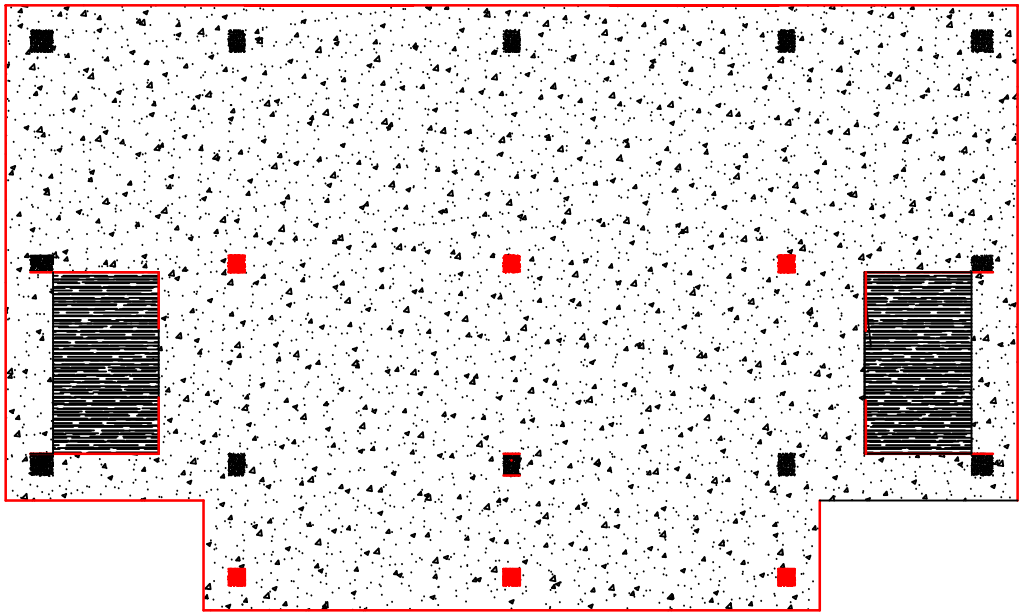
NOTE :- DESIGN OF DOORS AND WINDOWS WILL BE AS PER SITE CONDITION OR AS PER ORDER OF ENGINEER

NEPAL ELECTRICITY AUTHORITY
(A Government Of Nepal Undertaking)

CONTRACT NO :		PROJECT :	PANGTAN 132/33/11 kV SUBSTATION PROJECT
PREPARED	NAME	DATE	
DRAWN BY			
DESIGNED BY		DRAWING TITLE :	LAYOUT FOR STAFF QUARTER
CHECKED BY			
APPROVED BY			
SHEET SIZE		DRAWING NO :	DWG 007_2
SCALE	NOT IN SCALE	REV.	SHEET 2 OF 3



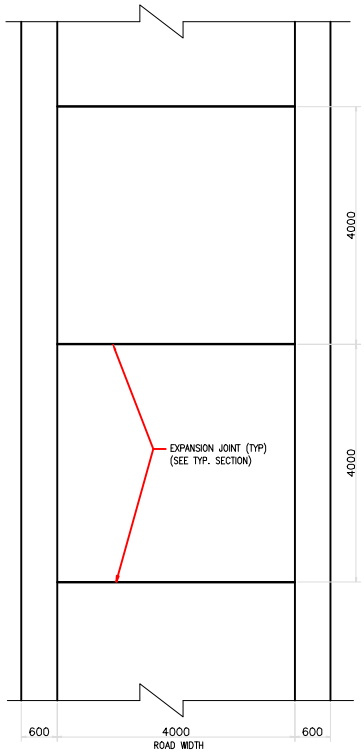
ROOF PLAN GROUND & FIRST FLOOR

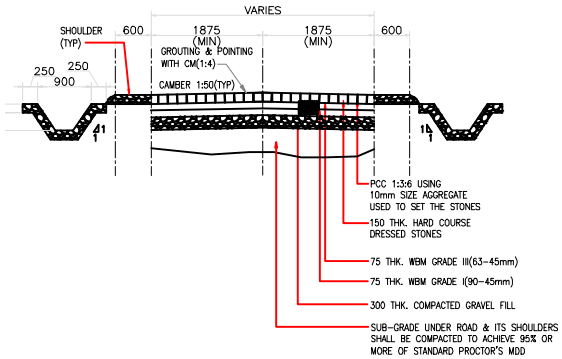


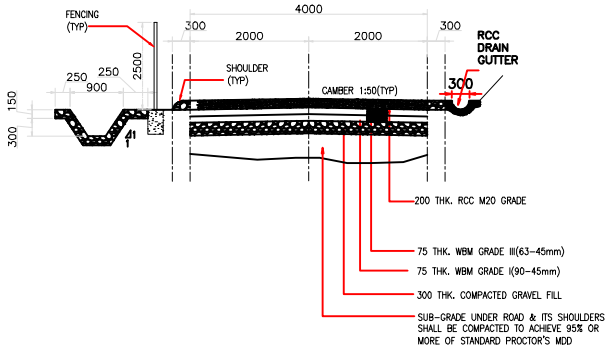
TOP PLAN

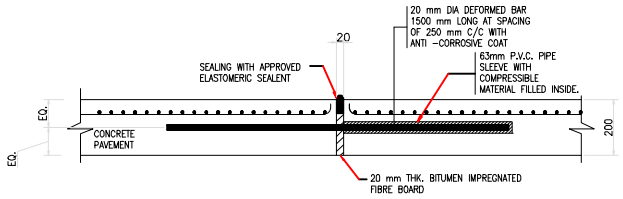
NEPAL ELECTRICITY AUTHORITY
(A Government Of Nepal Undertaking)

CONTRACT NO :			PROJECT :	PANGTAN 132/33/11 kV SUBSTATION PROJECT
PREPARED	NAME	DATE		
DRAWN BY				
DESIGNED BY			DRAWING TITLE :	LAYOUT FOR STAFF QUARTER
CHECKED BY				
APPROVED BY				
SHEET SIZE			DRAWING NO :	DWG 007_2
SCALE	NOT IN SCALE		REV.	SHEET 3 OF 3









NOTES

1) ALL RCC USED SHALL BE OF GRADE M20.
2) ALL REINFORCEMENT STEEL SHALL BE HYSD(Fe500) CONFORMING TO IS:1786/TMT BARS (EQUIVALENT GRADE).

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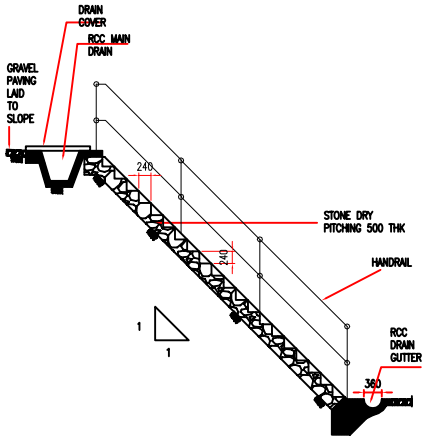
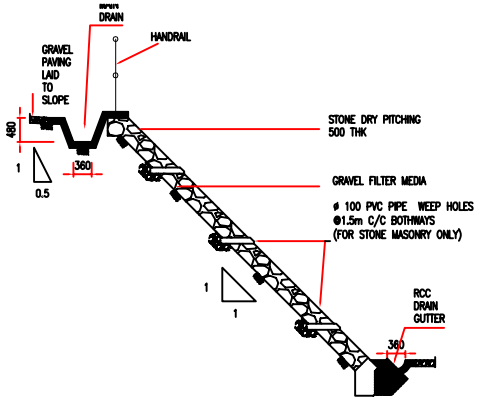
NEPAL ELECTRICITY AUTHORITY
(A Government Of Nepal Undertaking)

CONTRACT NO :			PROJECT :	PANGTAN 132/33/11 kV SUBSTATION PROJECT
PREPARED	NAME	DATE		
DRAWN BY				
DESIGNED BY			DRAWING TITLE :	INTERNAL AND ACCESS ROAD DETAILS
CHECKED BY				
APPROVED BY				
SHEET SIZE			DRAWING NO : DWG 008	REV. / SHEET 1
SCALE	NOT IN SCALE			

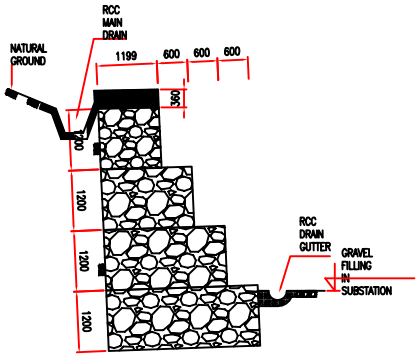


SECTION THROUGH SLOPES SHOWING STEPS

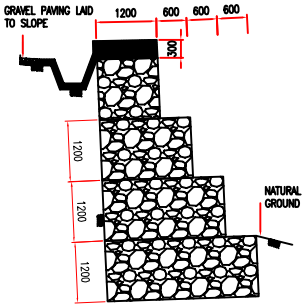


SECTION THROUGH SLOPE BETWEEN SUBSTATION LEVELS

DETAILS OF SLOPE PROTECTION WITHIN SUBSTATION



GABION WALL - NATURAL GROUND
OUTSIDE S/S SLOPING UPWARDS (TYP)



GABION WALL - NATURAL GROUND
OUTSIDE S/S SLOPING DOWN (TYP)

FOR MISCELLANEOUSE CIVIL WORKS AND S/S AS PER REQUIREMENT

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES & LEVELS ARE IN METRES UNLESS NOTED OTHERWISE.
2. (±) 0.000m CORRESPONDS TO FFL OF GROUND FLOOR OF THIS BUILDING WHICH CORRESPONDS TO RL. xxx.xxxm.

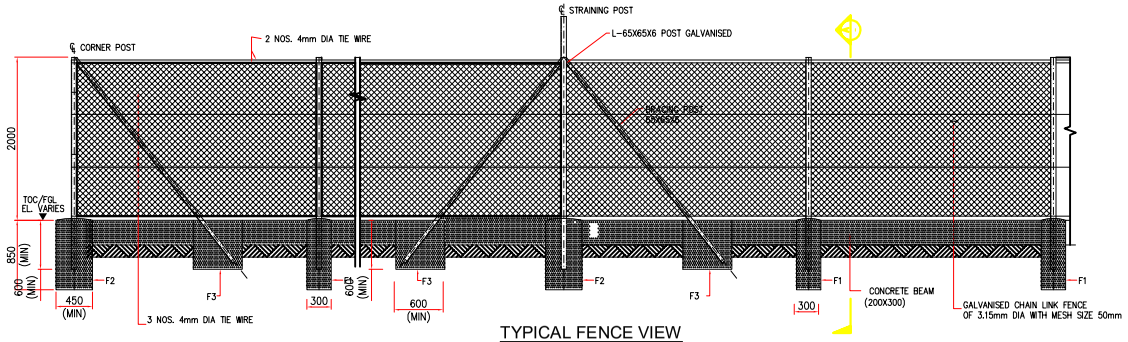
FOR TENDER PURPOSE ONLY

NEPAL ELECTRICITY AUTHORITY
(A Government Of Nepal Undertaking)

PANGTAN 132/33/11 kV SUBSTATION PROJECT

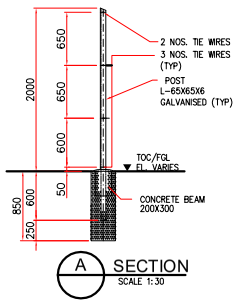
SECTIONAL DRAWINGS AT RETAINING WALL / SLOPE PROTECTION AND DRAINS

SCALE	NOT IN SCALE	DWG 009	REV.	SHEET 1



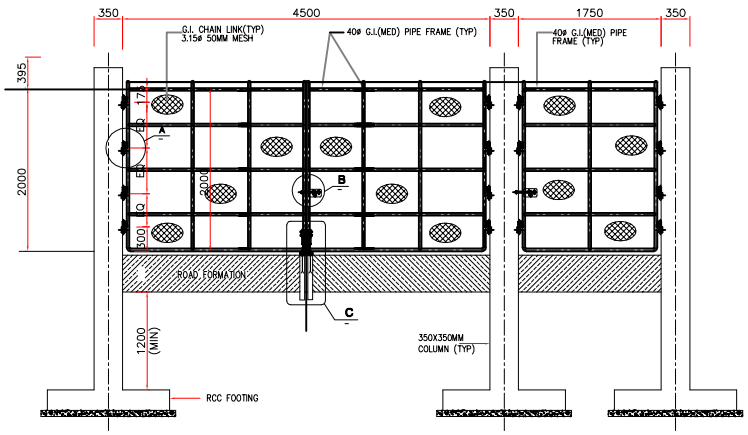
TYPICAL FENCE VIEW

SCALE 1:30



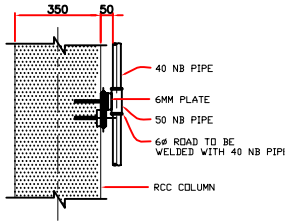
A SECTION

SCALE 1:30



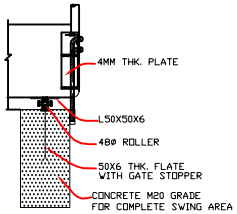
FRONT ELEVATION OF GATE

(4.5 WIDE GATE + 1.75 WIDE WICKET GATE)



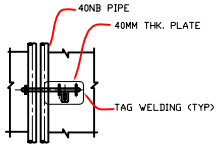
DETAIL - A

1:10



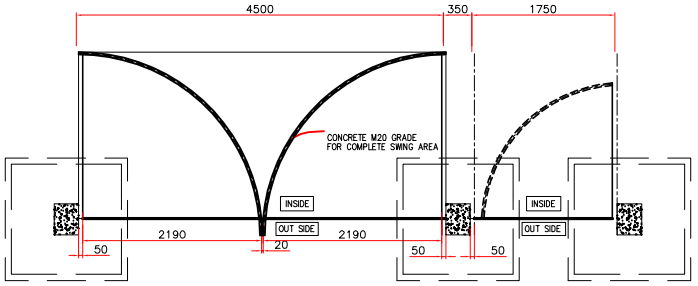
DETAIL - C

1:10



DETAIL - B

1:10



PLAN

FOR TENDER PURPOSE ONLY

LEGENDS

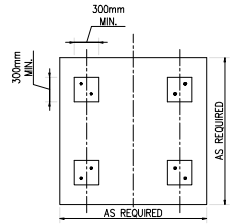
FFL	–	FINISHED FLOOR LEVEL
FGL	–	FINISHED GROUND LEVEL
TOC	–	TOP OF CONCRETE
EL	–	ELEVATION
TYP	–	TYPICAL
THK.	–	THICK

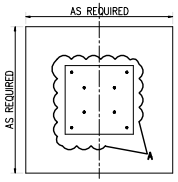
NEPAL ELECTRICITY AUTHORITY
(A Government Of Nepal Undertaking)

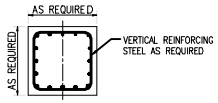
SOLU CORRIDOR 132kV TRANSMISSION LINE PROJECT

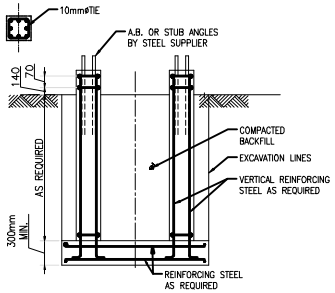
CHAIN LINK FENCE AND GATE DETAILS

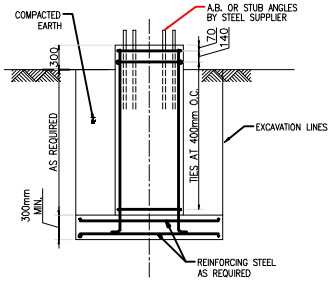
SCALE: NOT IN SCALE | DWG 010 | REV. | SHEET 1 OF 1

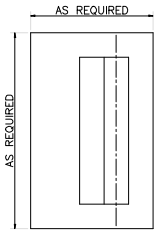


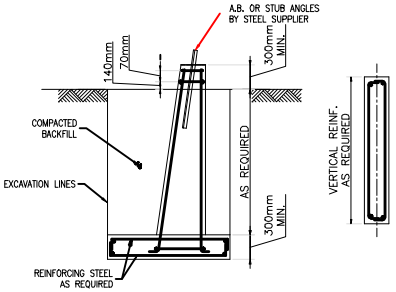


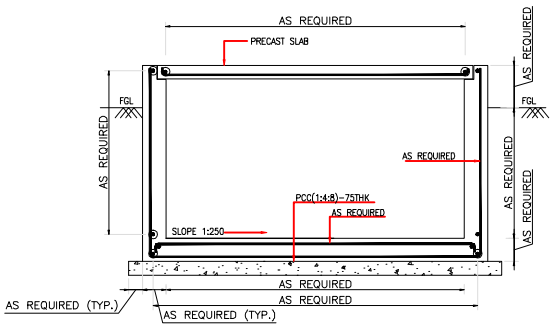


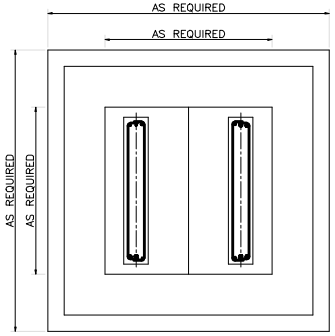


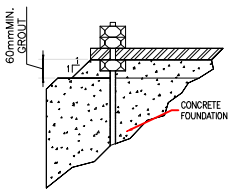


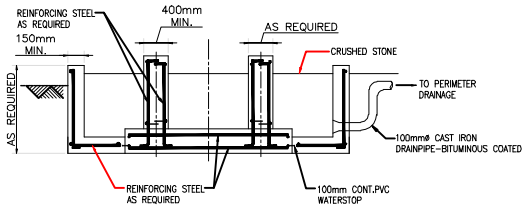












NOTES

1) ALL DIMENSIONS ARE IN MM.
2) ALL RCC USED SHALL BE OF GRADE M20.
3) ALL REINFORCEMENT STEEL SHALL BE HYSD(Fe500) CONFORMING TO IS:1786/TMT BARS (EQUIVALENT
4) ALL WELDS ARE 6mm THK. FILLET WELDS.

FOR TENDER PURPOSE ONLY

NEPAL ELECTRICITY AUTHORITY
(A Government Of Nepal Undertaking)

CONTRACT NO :		PROJECT :	PANCHAN 132/33/11 kV SUBSTATION PROJECT
PREPARED	NAME / DATE		
DRAWN BY			
DESIGNED BY		DRAWING TITLE :	EQUIPMENT FOUNDATION
CHECKED BY			
APPROVED BY			
SHEET SIZE		DRAWING NO :	DWG 011
SCALE	N.T.S.	SHEET	01 OF 1