NEPAL ELECTRICITY AUTHORITY

(An Undertaking of Government of Nepal)
Project Management Directorate

MULPANI SUBSTATION CONSTRUCTION PROJECT

A component of
Electricity Grid Modernization Project

BIDDING DOCUMENT
FOR

Design, Supply, Installation, Testing and Commissioning of Mulpani 132/11kV GIS Substation

(Procurement of Plant)

Single-Stage, Two-Envelope
Bidding Procedure

Issued on:	**11 August 2021**
Invitation for Bids No.:	**PMD/EGMP/MSCP-077/78-01**
OCB No.:	**PMD/EGMP/MSCP-077/78-01**
Employer:	**Nepal Electricity Authority**
Country:	**Nepal**

VOLUME –II OF III

Mulpani Substation Construction Project
Project Management Directorate
Kharipati, Bhaktapur, Nepal
Telephone: +977 1-6615457

CHAPTER 1 – PROJECT SPECIFICATION REQUIREMENT (PSR)

FOR

Mulpani 132/11 kV Substation

CHAPTER 1-Project Specification Requirement

1. GENERAL

Nepal Electricity Authority is establishing new 132/11kV Gas Insulated substation at Mulpani, Kathmandu. It will be connected to Chapali – Bhaktapur 132kV DC line in LILO.

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.

2. INTENT OF SPECIFICATION

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

Mulpani Substation

The complete 132kV switchyard including indoor SF6 gas insulated metal enclosed switchgear (GIS), 132kV, 11 kV Indoor/outdoor equipments, 132/11 kV, 45MVA 3 ph Transformer, associated civil works, internal roads, drains, necessary switchyard buildings etc, 132kV GIS ducts for making connections with outdoor Transformers and 132kV over-head lines, Control & protection, Digital protection Coupler, FO based communication system and, other electrical and mechanical auxiliary systems and construction of residential buildings on turnkey basis.

1.2 The new substation at Changunarayan is to be constructed along the existing 132kV DC transmission Lines which is under operation which passes through the proposed site. The Contractor is require to design and construct the substation as per the site condition based on the indicative layout drawings provided in **Annexure I**.

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

2.3 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.

2,4 The detailed scope of work is brought out in subsequent clauses of this section.

Civil Works	External electrical Works	Transformers	Switchgear	Design and Integration
Substation Compound and access road. Transformer bays.	All equipment necessary to connect the new substation to the 32kV supply	132/11 kV 45MVA applicable to both secondary voltages.	132kV GIS switchboard as described in the specification	The substation shall be designed by the contractor and shall follow NEA requirements.

220kV or 132kV GIS Switchroom				All equipment and protection shall be integrated by the contractor and commissioned in conjunction with NEA.
11kV Switchroom		Local transformer 11/0.4kV	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. 132/11 kV Mulpani Substation with the following bays (132 kV GIS and 11 kV Inddor) as per Single Line Diagram & as indicated in BPS:.

- 2 nos. 132 KV bays for **1 x 31.5/45 MVA**, 132/11 kV, 3 Phase Transformers
- 4 nos. 132kV bays for termination of 132kV Transmission line

- 01 no. 132kV Bus Coupler bay.
- MV Indoor Switchyard Panels for 8 nos line bays, 2 nos Transformer bays, 2 nos LT Transformer bays and 1 Bus section Bay.
- Other associated equipments

4.0 DETAILED SCOPE OF WORK

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

4.1 145 kV GIS System:

The 145kV 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, **2000A, 31.5kA for 1 Sec**, SF_6 gas-insulated metal enclosed **bus bar module,** each comprising of :

a) Bus bars enclosures running across the length of the switch gear to inter connect each of the circuit breaker bay modules in double main bus system.

b) Three nos. 1-phase inductive potential transformers, complete with isolator switch suitable for double bus arrangement.

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

d) Gas monitoring devices, barriers, pressure switches, UHF based Partial Discharge measurement Sensors etc. as required.

e) Local Control Cubicle (if required separately)

f) **End Piece with the test link** for Future extension of Bus bar module . As 145kV GIS is likely to be extended in future, the contractor shall make available all details such as cross section, gas pressure etc. required to design adopted in future for extension of GIS, during detailed engineering stage.

(B) 145kV, 31.5KA for 1 second, SF6 gas-insulated metal enclosed **Bus-Coupler bay module** comprising of:-

a) One **2000A, 31.5kA,** 3-phase, SF_6 gas insulated circuit breaker, complete with operating mechanism.

b) Three Nos. 1-phase, 5-core, multi ratio, current transformers duly distributed on both sides of Circuit Breaker.

c) Two nos. 3-phase, 2000A, 31.5kA group operated isolator switches, complete with manual and motor driven operating mechanisms.

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

e) Gas monitoring devices, barriers, pressure switches, UHF based Partial Discharge measurement Sensors etc. as required

f) Local Bay Control Cubicle

(C) 145kV, 31.5KA for 1 second, SF6 gas-insulated metal enclosed **Line feeder bay module** each set comprising of :-

(a) One no. **1250A, 31.5kA**, 3-phase, SF_6 insulated circuit breaker, complete with operating mechanism.

(b) Three nos. 1-phase, 5-core, multi ratio, current transformers duly distributed on both side of Circuit Breaker.

(c) Three nos. 3-phase, 1250A, 31.5kA group operated isolator switches, complete with manual and motor driven operating mechanisms.

(d) Three (3) numbers of 1-phase potential transformers.

(e) Two nos. 3-phases, group operated safety grounding switches, complete with manual and motor driven operating mechanisms.

(f) One no. 3-phase, high speed fault make grounding switch, complete with group operated manual and motor driven operating mechanisms.

(g) Three (3) numbers of 1-phase Lightning arrestors.

(h) SF6 ducts inside GIS hall (up to the outer edge of wall)

a) Gas monitoring devices, barriers, pressure switches UHF based Partial Discharge measurement Sensors etc as required.

(i) Local Bay Control Cubicle

(D) 145kV, 31.5kA for 1 sec, SF6 gas insulated **ICT feeder bay module** each comprising of (for three phase transformer):-

a) One no. **1250 A, 31.5kA**, 3-phase, SF_6 gas insulated circuit breaker, complete with operating mechanism.

b) Three Nos. 1-phase, 5-core, multi ratio, current transformers duly distributed on both sides of Circuit Breaker.

c) Three nos. 3-phase, 1250A, 31.5kA group operated isolator switches complete with manual and motor driven operating mechanisms.

d) Three nos. 3-phases, group operated safety grounding switches complete with manual and motor driven operating mechanisms.

e) Three (3) numbers of 1-phase Lightning arrestors.

f) SF6 ducts inside GIS hall (up to the outer edge of wall)

g) Gas monitoring devices, barriers, pressure switches, UHF based Partial Discharge measurement Sensors etc. as required.

h) Local Bay control cubicle

(E) 145kV, 1250A, 31.5kA for 1Sec, **SF6 Gas insulated Bus Duct** (GIB) for Line/Transformer feeder modules outside GIS hall (i.e. wall surface) with support structure (along with Gas monitoring devices, barriers, pressure switches, UHF based Partial Discharge measurement Sensors etc. as required) and SF6/Air bushing for interconnecting it with respective over head gantry/ equipment. SF6 gas ducts, where required inside GIS hall are part of GIS module.

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

a) 145kV, 1250A, 1-phase SF_6 to air bushings for outdoor overhead connections. The cantilever strength of the 145kV SF_6 to air bushings shall be of minimum 8kN.

A tentative layout / GA drawing of the switchyard is enclosed with this specification for 132/11kV 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.

4.1.1 **a. 31.5/45 MVA, 132/11kV**, 3-Phase Power Transformer including all materials / fittings / accessories/ MB/Cables including special cable (if any),etc.

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

4.1.3 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.

4.1.4 One nos. 630 KVA, 11/0.400 kV, LT Transformers along with associated 11 kV equipments. 630 KVA, 11/0.400kV auxiliary transformer shall be located in LT station area and HT side shall be connected with the 11 kV bay in the Indoor Switchgear through 11 kV cable.

4.1.5 MV Indoor Switchgear for 2 no. Transformer Incomer bay 132/11kV, 13 nos. Feeders bays, 1 no. Bus section or as per BPS).

The indoor Switchgear shall be kept in the control room Building or can be installed in separate 11kV switchgear building. The BPS specifie separate building for control room, 132kV GIS and 11kV Switchgear. The buildings may be constructed separately or in combination which will be decided during dtail engineering and soil test.

4.1.6 Complete relay and protection system as per section –Control and Relay panels including Bus Bar Protection for 132 kV Double Bus Bar Switching Scheme.

4.1.7 Fire Protection System for all Building and transformers as per technical specification. HVW spray system is envisaged for 132/11 kV Transformer.

4.1.8 Lattice or pipe structures (galvanized): Transmission line Dead end tower Towers, Beams, LMs and equipment support structure shall be provided as per design and drawings to be developed by the Contractor.

4.1.9 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.

4.1.10 Air Conditioning System for control room cum administrative building, panel room of GIS hall

4.1.11 Ventilation system for GIS hall.

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

4.1.13 100 KVA Silent type outdoor DG Set with acoustic enclosure.

4.1.14 Batteries & Battery Chargers.

4.1.15 1.1 kV grade Power & Control cables along with complete accessories, including Cable for oil filtration units.

4.1.16 11kV HT cable along with jointing Kit and other accessories for connection of LT Transformers and interconnection of LV side of 132/11 kV Transformer to Indoor LT Panel.

4.1.17 132kV XLPE Cu Cables shall be supplied with all accessories, termination arrangement for connection of overhead lines to the GIS switchgears. The termination arrangement shall be mounted on the specially designed tower along with Lightning arrestors. Please note, the existing building layout is below the existing line, therefore the bypassing arrangement might be required using the cables, before construction of the building is started.

4.1.18 Complete indoor & outdoor lighting and illumination of the switchyard including DG set area, street lighting, GIS Buildings, Control Room cum administrative Building, Fire Fighting Pump House, Auxiliary building for LT switchgear, Township etc.

4.1.19 Complete Earth mat inside the GIS building and outdoor yard. Earthing of all outdoor equipments including Transformers. Measurement of earth resistivity is in the scope of Contractor.

4.1.20 Cranes for GIS Hall

4.1.21 Digital protection Coupler (suitable for interfacing with E1 port of SDH equipment) and associated power cables,Communucation & control cables between DPC and relay Panel for both ends of 132 kV Lines.The specification of Digital Protection coupler is attached as Annexure-III.

4.1.22 AIS CVT and LA (will be deleted if not required)

4.1.23 FOTS based Telecommunication system

4.1.24 Visual Monitoring System for watch and ward of present scope as per **Annexure-IV**. The design of the system shall be such that the common system shall be able to accommodate for all feeders/equipments including future 132 kV system.

4.1.25 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.

4.1.26 Design, engineering, manufacture, testing, supply including transportation, insurance & storage at site of **mandatory spare**s as per **Annexure-I**

4.1.27 ***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***

The soil investigation report indicates liquification upto 11.5 m and the field has low bearing capcity. Therefore, the contractor is required to design and implement the works for soil bearing capacity improvement.

(a) Drawings of Master/General Layout Plan, Earthworks (cutting and filling), Gabion/Retaining Wall and partial drawing of control room building & Security room has been prepared. Employer will provide such drawings for reference only.

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

(c) Construction of switch yard buildings : Fire Fighting pump house building, fire water tank and Auxiliary building for LT switchgear.

(d) Construction of Security Room at Main Gate of sub station boundary wall

(e) Construction of septic tank & soak pit for control Room building, security room,

(f) Foundation for structures of LM, 132kV Towers, equipment support structures ,11 kV double pole structure and other equipments.

(g) Foundation for Auxiliary LT transformers, DG set

(h) 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.

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

(j) Switch yard Roads: All roads shall be RCC Roads as shown in GA drawing including culverts.

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

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

(m) Switch yard Chain link fencing and gates.

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

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

(p) GIS Buildings including control room cum administrative building. The GIS hall shall be suitable for mounting of EOT crane. The control room building shall be RCC structure following Nepalese architectural design and GIS Hall shall be Pre-Engineered steel structure as per Section “Civil”.

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

(r) 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.

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

(t) External water supply arrangement for control room cum administrative building, Fire fighting tank ,township quarters & Transit camp. Underground water tank

(u) External sewerage system for control room cum administrative building, township quarters & Transit Camp.

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

(w) Soil investigation has been carried out. NEA will provide Geotechnical Investigation Report of the substation area for reference. However contractor

shall carry out any Soil investigation(tests) for confirmation. The cost for such test shall be included in respective item in price schedule.

(x) Contouring and site leveling works: The finished ground level has been finalized and FGL of switchyard area has been achieved. However, the Contractor may have to carry out minor countouring and site leveling works (if required) to complete the scope of works. The cost for such works shall be included in bid prices elsewhere in price schedule and no separate payment will be made for such works.Construction of random rubble stone masonry wall and gabion wall

(y) Pumps: Dewatering Pumps, booster pump for underground water tank of township.

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

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

(bb) Doors and windows of front face shall be wooden(carved). TS for door and windowshas been attached in Annexure….

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

4 SPECIFIC EXCLUSIONS

i) Employer's site office.

5 PHYSICAL AND OTHER PARAMETERS

Location of the Substations –

a. Mulpan) Substations is located in Katmandu and is located 6 Km from Existing Bhaktapur Substation and 7.5 Km from Chapali Substation.

The substations of Nepal Electricity Authority are in the North-Eastern part of Kathmandu Valley

a) Altitude above sea level :

1420m from MSL

b) Ambient Air Temperature :

45ºC(max)/ 0 ºC(min)

c) Average Humidity (in %) :

95 (max), 40(min)

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

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

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

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

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

S.NO.	Voltage Level	Fault Level Changunarayan	Fault Level Lapsephedi
1	220kV		40kA for 1 Sec
2	132kV	31.5kA for 1 Sec	31.5kA for 1 Sec
3	11kV	25kA, 3 sec	25kA, 3 sec

7. 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.
The detailed bill of quantities of the mandatory spares for which break up is not given in the bid price Schedules are indicated at **Annexure-1.I** of this part.
Bidder should include all such items in the bid proposal sheets, which are not specifically mentioned but are essential for the execution of the contract. Item which explicitly may not appear in various schedules and required for successful commissioning of substation shall be included in the bid price and shall be provided at no extra cost to Owner.

8.0 BASIC REFERENCE DRAWINGS

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

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

The enclosed drawings give the basic scheme, layout of substation, substation buildings, associated services etc. In case of any discrepancy between the drawings and text of specification, the requirements of text shall prevail in general. However, the Bidder is advised to get these clarified from Owner.

8.3 The auxiliary transformers shall be used to feed the substation auxiliaries. HT side of auxiliary transformer shall be connected through 11 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.

9.0 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.

1)	Chapter 1 : Project Specification Requirement	Rev 00
2)	Chapter 2 : General Technical Requirement	Rev 00
3)	Chapter 3 : Switchgear	Rev00
4)	Chapter 4 : LT Switchgear	Rev.00
5)	Chapter 5 : Battery & Battery Charger	Rev.00
6)	Chapter 6 : Lighting System	Rev.00
7)	Chapter 7 : LT Transformer	Rev.00
8)	Chapter 8 : Fire Protection System	Rev.00
9)	Chapter 9 : Power & Control Cable	Rev.00
10)	Chapter 10 : Air Conditioning System	Rev.00
11)	Chapter 11 : DG Set	Rev.00
12)	Chapter 12 : Switchyard Erection	Rev.00
13)	Chapter 13 : Structure	Rev.00
14)	Chapter 14: Civil Works	Rev.00
15)	Chapter 15 : Control & Relay Panels	Rev.00
16)	Chapter 16 : PLCC	Rev.00
17)	Chapter 17 : Substation Automation System	Rev.00
18)	Chapter 18: Fibre Optics Based Communication Equipments	Rev.00
19)	Chapter-19 : GIS	Rev.00
20)	Chapter-20-Transformer	Rev.00
21	Chapter 22-Indoor Switchyard Equipment	Rev 00
22	Chapter 23- EHV Cable	Rev 00
23	Chapter 24- Technical Data sheet	Rev 00

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.

10. 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.

11. 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.

12. 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.

13.0 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 132/11kV bays under present scope at the substations shall be integrated by the contractor into existing SCADA system of Siemens 'SINAUT Spectrum"(version 4.3.2) installed at Master Station i.e. Nepal Electricity Authority Load Dispatch Centre (located in Siuchatar, Kathmandu). The integration shall include all hardware and software required at the Control Centre as well as necessary data base, display generation and upgrades for proposed control and monitoring of station and Network Analysis. The manufacturers of the existing SCADA system are:-
LDC facilities: Siemens Germany

The existing communication protocol used for SCADA at LDC Kathmandu is IEC 101/104. For the present scope of work no RTU is envisaged and the Data for SCADA purpose shall be obtained from the Substation Automation System

(based on IEC 61850) using Gateway port with communication protocol IEC 101/104 as per requirement being provided under present contract.

d) One set ½C x 300 Sq. mm XLPE power cable for oil filtration units of transformers shall be provided along with 250Amps, TPN MCCB receptacles at Lapsephedi & Changunarayan. The cable shall be terminated at 250A MCCB receptacle at one point near Transformer in the yard.

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

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

g) The Contractor shall impart the necessary training to 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 @ as per NEA Financial Regulation 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. (3Nos. Trainees or as per BPS)
2. GIS: 5 Days. (3 Nos or Trainees as per BPS)
3. Telecommunication Equipment (SDH, MUX & NMS (Craft Terminal)) and DPC: 5 Days. (3 Nos. Trainees as per BPS)
4. Transformer: 5 Days. (3 Nos. Trainees as per BPS)

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 contractor shall bear the per diem expense @ NRs. 1000.00 per person.

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

1. Control & Protection: 5 Days. or as per BPS
2. Substation Automation System including integration aspect of existing SCADA (of Siemens supplied SINAUT spectrum) at Load Dispatch Centre: 5 days. or as per BPS
3. GIS: 5 days. or as per BPS
4. Telecommunication Equipment (SDH, MUX & NMS (Craft Terminal)) and

DPC: 5 Days or as per BPS

5. Transformers - 5 days or as per BPS

h). 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.

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

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

k. One number each Energy meter for the record and revenue purpose is to be provided for each 132/11V bays (Bus coupler bays to be excluded) at Lapsephedi and Changunarayan substations under present scope of contract, meeting the requirement as specified at **Annexure – V**.

l. 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.

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

n) The layout drawing for connection arrangement of 220/132 kV Transformer at Lapsephedi 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 upto 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

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

p) 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 132kV in respective GIS hall(s). 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.

q) 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.

r) 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 132kV 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.

s) 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 & reactors for all the stages from the manufacturer's work to site.

t) 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, without any extra cost to NEA (If not mentioned specifically in the BPS). The contractor shall carry out the route survey along with the transporter and submit the detail proposal and methodology for transportation of transformers & reactors within three months from the date of award.

w) The specification of PABX is attached at Annexure-**VI**.

x) Specification of 11 kV outdoor equipments is attached at **Annexure-VII**

y) For Mulpani 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.

z) The indoor switchgear shall be kept in control room building.

14. PRECOMMISSIONING, COMMISSIONING, TRIAL-RUN & COMPLETION

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

(i) Pre commissioning**:** As per relevant Chapters

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

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

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

15. Considerations for public health and social measures in the workplace in the context of COVID-19

Bidder shall submit a Health and Safety COVID-19 Plan (HS-C19 Plan), in accordance with the government regulations and guidelines on COVID-19 prevention and controls, as well as workplace safety requirements, or in the absence thereof, to international good practice guidelines [such as World Health Organization. 2020. Considerations for public health and social measures in the workplace in the context of COVID-19. Geneva. Available here: https://www.who.int/publications-detail/considerations-for-public-health-and-social-measures-in-the-workplace-in-the-context-of-covid-19. Also refer to ADB SDCC's advisory in relation to COVID-19 health and safety and international good practices.]
The Plan should be fit for purpose for the particular construction works of this contract. The bidder should demonstrate in the Plan the health and safety measures they will put in place on site in relation to COVID-19 prevention and controls, including but not limited to, PPE requirements, site set up, training, induction and mobilization of new personnel, equipment and plants cleaning and other hazard management measures while undertaking site work activities, site visitors health and safety protocols, as well as the approach to the monitoring and reporting of the Plan.

The local guidelines on COVID-19 prevention and control, Considerations for public health and social measures in the workplace in the context of COVID-19 (WHO, Geneva) and ADB SDCC's advisory in relation to COVID-19 health and safety are attached herewith.

Annexure - VIII

Local guidelines on COVID-19 prevention and control
https://nmc.org.np/files/4/Nepal%20medical%20council%20interim%20guidance%20for%20infection%20prevention%20and%20control%20when%20COVID-19%20is%20suspected.pdf

Annexure-IX

Considerations for public health and social measures in the workplace in the context of COVID-19 (WHO, Geneva)
https://www.who.int/publications/i/item/considerations-for-public-health-and-social-measures-in-the-workplace-in-the-context-of-covid-19

Annexure-X

Sample Standard Operating Procedure (SOP) for Work Procedure for COVID-19 Risk Management at Workplaces

Bidder shall go through the above appendices on health and social measures in the workplace in the context of COVID-19 and shall prepare and submit **COVID-19 specific Site Health and Safety Management Plan** (HS-C19 Plan) and the submitted plan will be subjected to approval of the Employer before commencing any work at site.

16. Social Safeguard and Environment and Management Plan

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

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

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

Among others topics addressed should also include the following:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Upon completion of the underground cable installation, the trenches should be resealed and the pavement repaired as soon as possible, to ensure its durability and the absence of irregularities that may present a traffic hazard.

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

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

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

17. Safety of Personnel

The maximum safety consistent with good erection practices in the case of work above ground must be afforded to personnel directly engaged under this contract. Reasonable measures shall be taken to afford adequate protection against material falling from a higher level onto personnel below.

ANNEXURE- II

LIST OF PREFERED (SHORTLISTED) MAKE

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

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

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

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

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

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

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

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

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

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

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

Annexure-III

SPECIFICATION FOR DIGITIAL PROTECTION COUPLER

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

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

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

1.2 Principle of operation

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

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

1.3 Loop testing

An automatic loop testing routine shall check the teleprotection channel.

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

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

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

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

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

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

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

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

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

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

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

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

a) Power supply variations
b) Interruptions
c) LF disturbance emission

d) Reverse polarity

iii) Tele-protection system performance tests

a) Security
b) Dependability
c) Jitter
d) Recovery time
e) Transmission time
f) Alarm functions
g) Temperature and Humidity tests (As per IEC 68-2)

- Dry heat test (50°C for 8 hours)
- Low temperature test (-5°C for 8 hours)
- Damp heat test (40°C/95%RH for 8 hours)

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

iv) Relays

a) Impulse voltage withstand test as per IEC 60255.

b) High frequency disturbance test as per IEC 60255.

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

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

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

1.4 Major technical Particulars

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

i) Power supply 48V DC +10%, -10%
ii) Number of commands 4 (four)
iii) Operating time <7 ms
iv) Back to back operate time without propagation delay ≤ 8 ms
v) Interface to Protection relays

		Input:	Contact Rating:	
		Rated voltage	:	250 volts DC
		Maximum current rating:	5 amps	
	Output:	Contact Rating:		
		Rated voltage	:	250 volts DC
		Rated current	:	0.1 A DC
		Other parameters :	As per IEC-255-0-20	
vi)	Alarm contact			
		Rated voltage	:	250 volts DC
		Rated current	:	0.1 A DC
		Other parameters :	As per IEC-255-0-20	

vii) Digital communication interface: G 703(E1)

Technical Specification for Visual Monitoring System

Visual monitoring system for watch and ward of Substation premises:

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

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

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

1. The operation of each and every isolator pole of the complete yard in case of AIS Sub-station.
2. The Operation of each bay bays of GIS Hall as Applicable.
3. All the Transformer and Reactors All the Entrance doors of Control Room Building and Fire-fighting Pump House, 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.

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 colour cameras installed at different locations, process them for viewing on workstations/monitors in the control Room and simultaneously record all the cameras after compression using H 264/MPEG 4 or better standard. Mouse/Joystick-Keyboard controllers shall be used for Pan, Tilt, Zoom, and other functions of desired cameras.

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.

System requirements:

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

b) All cameras may be connected through a suitable LAN which shall be able to perform in 765kV class sub-station environment without fail.

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

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

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

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

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

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

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

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

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

1. Electrical Fast Transient (Level 4) – As per IEC 61000-4-4
2. Damped Oscillatory (1 MHz and 100 KHz) (level 3) – As per IEC 61000-4-
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.

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.

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.

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 ~ +50℃
14.	Operating Humidity	10 ~ 90%

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

1.	Image sensor	1/3 type Solid State Progressive Scan CCD,WDR(High Definition)
2.	Security	Multiple user access with password protection
3.	Effective Pixels	(PAL): Main Stream：1280x720 Sub Stream：640x360、320x280 selectable
4.	Compression	Dual Stream H.264 and MPEG 4 user selectable
5.	Signal System	50 Hz
6.	S/N (signal to noise) Ratio	Better than 50 dB
7.	Electronic Shutter	1/60 ~ 1/10,000 sec. automatic or better
8.	Scanning System	Progressive/interlace
9.	Low Light Sensitivity (lux)	Color: 0.5 Lux; B&W:0.02 Lux
10.	Lens	Minimum 10x (minimum) optical in High Definition (The system shall be able to zoom the images on the monitor without any distortion to the maximum level of optical zoom)
11.	Lens Size	Minimum 4.1~73.8 mm
12.	Lens Aperture	F1.6(wide)~F2.8(tele), f=4.1~41.0mm, 10X Zoom, Video Auto Focus Angle of View Horizontal : 52°(wide) , 2.8°(tele)
13.	PTZ Data Transfer Baud/Bit Rates Supported	Selectable 2400 bps / 4800 bps / 9600 bps
14.	Panning Range	Complete 360 degrees (horizontal)
15.	Pan Speed	Adjustable, 0.1 degrees / second ~ 250 degrees / second
16.	Tilting Range	Minimum 180° Tilt Rotation
17.	Tilt Speed	Adjustable, 0.1 degrees / second ~ 150 degrees / second
18.	In Built Storage	Camera should have inbuilt storage TF or SD format for recording and storing Pictures
19.	IP Class	IP66 Standard
20.	Working temperature	-0 ~ +50
21.	Working Humidity	10 ~ 90%

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

Specification for Revenue Meter & Metering (Instrument) Transformer

General

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

Energy Meter

The Energy Meter shall have the following minimum requirement

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

TECHNICAL SPECIFICATION OF PABX EQUIPMENT

1.1 General

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

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

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

The following are the minimum requirements for PABX system.

1.2 Technical Requirement

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

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

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

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

(a) SPC (Stored Program Control) type
(b) 100% non blocking switch with PCM-TDM
(c) Redundant processors or distributed processing architecture

(d) 2 Wire interfaces for local subscribers & remote subscriber
(e) 4 Wire E&M interfaces for two way trunks
(f) Extensions should be extendable over a distance of 300meters
(g) E1 Interface using Electrical (through copper cable) connection to existing SDH equipments.
(h) Provision of suitable interface for VOIP connectivity (50 Nos)
(i) Printer interface
(j) Extensions shall support DTMF & Pulse dial phones
(k) Extensions shall support analog phones/fax machines
(l) Ringer/Tone card for different tones and ring generation
(m) DID (Direct Inward dialing)
(n) DOD(Direct Outward dialing))
(o) Executive Override enabled
(p) Provision of Voice mail
(q) Call forwarding and Call pickup
(r) Circular hunting within a defined group
(s) Automatic call back
(t) Calling Line Identification Presentation (CLIP) support
(u) Howler tone for receiver-not-on-hook warning

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

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

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

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

1.4 Testing & Inspection:

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

1.5 Factory Acceptance Tests

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

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

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

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

1.6 Production Testing

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

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

1.7 Site Acceptance Tests (SAT)

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

ANNEXURE – VII

I. 11kV ISOLATOR

C11.1	Type	Outdoor (Double Break) without E/S
C11.3	Standard	IEC 2271-102
C11.4	Number of terminals in control cabinet (Interpole cabling shall be Supplied by contractor)	All contacts and control circuits are to be wired upto control cabinet plus 24 terminals exclusively for Owner's use.
C11.5	Rated current	400A.
C11.6	Rated short time withstand current of isolator and earthswitch	25 kA for 3 Sec
C11.7	Rated dynamic short circuit withstand current of isolator and earth switch	As per IEC
C11.8	Operating mechanism for Isolator and Earth switch	Manual
C11.9	No. of auxiliary contacts on each isolator	5 NO + 5 NC contacts, wired to terminal block exclusively for Owner's use in future.
C11.10	No. of auxiliary contacts on each earthing switch	3 NO + 3 NC contacts wired to terminal block exclusively for Owner's use in future.

ANNEXURE- VIII

Nepal Medical Council Interim Guidance for Infection Prevention and Control When COVID-19 Is Suspected

NEPAL MEDICAL COUNCIL

(JUNE 2020)

PREPARED BY:

NEPAL MEDICAL COUNCIL COVID-19 TREATMENT GUIDANCE COMMITTEE

SUPPORTED BY:

NEPAL MEDICAL ASSOCIATION
SOCIETY OF INTERNAL MEDICINE OF NEPAL
NEPALESE SOCIETY OF CRITICAL CARE MEDICINE
GENERAL PRACTITIONERS ASSOCIATION OF NEPAL

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Nepal Medical Council

Interim Guidance for Infection Prevention and Control When COVID-19 Is Suspected

I. PURPOSE OF THE GUIDELINES

The purpose of this document is to help physicians, nurses, other healthcare workers and healthcare institutions to apply appropriate principles of Infection Prevention and Control while providing care in healthcare institutions for patients with suspected or proven COVID-19. COVID-19 (Coronavirus Infectious Disease 2019) is a respiratory tract infection caused by the betacoronavirus SARS CoV-2 (SARS coronavirus type-2). These guidelines are based on current knowledge in the available literature, expert consultations, and recommendations from WHO, CDC and other authorities. These guidelines are not meant to replace clinical judgment based on individual patient needs and do not exclude expert consultation and are subject to change based on new knowledge.

II. TRANSMISSION CHARACTERISTICS OF COVID-19

Person-to-person transmission of COVID-19 occurs mainly through respiratory droplets released when an infected person coughs, talks or sneezes, and through contact with contaminated surfaces followed by touching one's eyes, nose or mouth. In experimental conditions, viable SARS-CoV-2 virus was detected on different types of surfaces for up to 2-3 days, and in aerosols up to 3 hours after aerosol-generating procedures. However, the evidence so far suggests that airborne transmission is probably not a major driver of transmission. Apart from upper and lower respiratory tract secretions, live virus has also been occasionally detected in faeces and blood of infected patients. However, fecal-oral route does not appear to be a driver of transmission. There is no evidence for sexual or vertical transmission of SARS-CoV-2 so far, and the virus RNA has not been detected in breastmilk.

The incubation period has been reported to be 2-14 days (median 4-5 days). The median time from the onset of symptoms to recovery in patients of COVID-19 is approximately 2 weeks for mild cases and 3-6 weeks for severe or critical cases. The peak viral shedding and risk of transmitting infections appears to be in the presymptomatic stage, around 24 hours before the onset of symptoms. One representative study among those studying the transmission of SARS-CoV-2 showed that presymptomatic individuals are sources of transmission for around 46% of the infected cases of SARS-CoV-2 in the community, currently symptomatic individuals are responsible for 38%, and asymptomatic persons who never show symptoms are responsible for only around 10% of the total transmission burden.

III. ORGANIZATIONAL PREPAREDNESS FOR PREVENTING AND CONTROLLING COVID-19

Each healthcare facility should adopt measures that facilitate

- Early assessment / triaging of cases of COVID-19
- Early identification / reporting of cases of COVID-19
- Education of staff, patients and visitors about standard and transmission-based infection control precautions
- Implementation of transmission-based precaution measures
- Restriction of access to ill visitors

- Implementation of sound occupational health policies for pre- COVID-19-surge and surge settings

Please refer to *Interim Clinical Guidance for Care of Patients with COVID-19 in Healthcare Settings* by the Nepal Medical Council for recommendations in triaging and early identification of COVID-19 cases.

IV. INFECTION PREVENTION AND CONTROL PRECAUTIONS

1. STANDARD INFECTION CONTROL PRECAUTIONS

Standard infection control precautions include the basic measures such as hand hygiene, respiratory hygiene, appropriate environmental cleaning, proper waste management, etc. that should be used by all staff at all times for all patients. They are by far the most effective protection against COVID-19 infection, more so than contact and droplet transmission precautions. Standard precaution measures are the only measures that will protect from transmission from asymptomatic or pre-symptomatic carriers of SARS-CoV-2.

Healthcare facilities should ensure that their healthcare providers and other staff members have access to handwashing facilities with adequate clean water and soap, or given adequate supplies of alcohol-based hand sanitizers.

All staff should be trained on the appropriate methods for hand-washing and using alcohol-based hand sanitizer. All staff should be advised to perform hand hygiene strictly, as advised in WHO's "my 5 moments of hand-hygiene" approach.

- Before touching the patient
- Before clean / aseptic procedures
- After body fluid exposure risk
- After touching the patient
- After touching the patient's surroundings

Good respiratory and cough hygiene measures should be adopted by all staff, patients and visitors. These include cleaning hands using soap and water after coughing, sneezing, and wiping or blowing the nose, keeping hands away from eyes, mouth and nose.

2. TRANSMISSION BASED PRECAUTIONS

For patients known or suspected to be infected with SARS-CoV-2, additional measures need to be implemented. These are

- Contact precautions
- Droplet precautions
- Airborne precautions (for aerosol generating procedures)

Based on the best practices in healthcare centers in Southeast Asia that have demonstrated very low rates of nosocomial transmission of COVID-19, the following additional measures are recommended in all healthcare centers in Nepal during the COVID-19 pandemic.

- **Universal masking: Everyone visiting or working at a healthcare facility must wear a facemask at all times except for reasonable situations such as while eating when the masks can be taken off maintaining safe distance from others.**
  - **Exception from prolonged facemask use can be made for patients who may not tolerate prolonged mask use due to certain medical conditions.**
  - **For visitors or patients, cloth mask covering both mouth and nose is acceptable.**
  - **Masks with exhaust valves should not be allowed.**
- **Arrangements should be made to facilitate and enforce physical distance of 2 metres (6-foot) between individuals as much as possible.**
- **In the outpatient clinics, surface disinfection of tabletop, chair armrests, bed, and other high touch surfaces such as the door handle, etc. with an approved disinfectant for COVID-19 should be performed ideally after each patient.**
- **Arrangements should be made to help avoid group meetings or face-to-face encounters between staff members or other individuals as much as possible.**
- **All employees, patients, and visitors should be screened daily for symptoms suggestive of COVID-19 and get daily temperature checks.**

- As noted in section V below, all medical personnel will follow droplet and contact precaution guidelines (surgical mask, goggles or face visor, gown, gloves) while assessing or managing the patient, with additional airborne precautions (N-95 masks) for aerosol-generating procedures.

  Aerosol-generating procedures include:
  - Cardio-pulmonary resuscitation
  - Intubation, extubation and related procedures
  - Manual ventilation
  - Tracheostomy / tracheostomy procedures
  - Bronchoscopy
  - Open suctioning
  - Non-invasive ventilation
  - Nebulization therapy (“Dry nebulization” is a non-aerosol-generating alternative.)
  - High flow nasal oxygen
  - Sputum induction
  - Obtaining nasopharyngeal or oropharyngeal swab
  - Dental procedures
  - Otorhinolaryngology procedures
  - Upper gastrointestinal endoscopy

- For patients with suspected or confirmed COVID-19, these potentially aerosol-generating procedures should only be performed when essential.

- Patients should be placed in adequately ventilated single rooms, and where available, preferably in rooms with negative pressure with air in the room delivered directly to the atmosphere (See appendix 1), or recirculated into the building after filtration through high-efficiency particulate air (HEPA) filters, with minimum of 12 air exchanges per hour.

- When single rooms are not available, patients with confirmed COVID-19 should be grouped together. Their beds should be placed at least 6 feet apart, ideally with a barrier placed between two suspected cases when possible.
- Suspected (but not confirmed) patients with COVID-19 should *not* be cohorted with other patients with suspected or confirmed COVID-19.
- Each single-patient isolation room or each bed in the isolation ward should have the following instruments for each patient:
    - Stethoscope (dedicated to the patient)
    - BP cuff (dedicated to the patient)
    - Thermometer (dedicated to the patient)
    - Surgical masks
    - Goggles or visors or face shields (reusable after disinfection)
    - Non-sterile gloves
    - Disposable gowns, or clean reusable gowns made of water-resistant fabric
    - Receptacle (bin) for waste disposal
- If equipment needs to be shared between patients, they should be cleaned and disinfected between use for each individual patient.
- Hospitals should implement staffing policies to minimize the number of healthcare providers who enter the room. They should consider providing care for these patients with dedicated providers (not more than one doctor and one nurse for a patient during a shift if possible) to minimize risk of transmission and exposure to other patients and other healthcare providers.
- Hospitals should keep a log of all persons who care for or enter the rooms or care area of these patients.
- Standard precautions should be applied at all times.
- Additional contact and droplet precautions should continue until EITHER the time-based criteria alone OR (for special populations) both time-based AND test-based criteria, are met.

    i. **Time-based criteria alone**:

    Resolution of fever >72 hours without antipyretics, AND improvement in respiratory signs and symptoms (cough, shortness of breath and oxygen requirement) (in **symptomatic** COVID-19 infection)
    OR
    No symptoms have developed subsequent to the first positive COVID-19 diagnostic test (in **asymptomatic** COVID-19 infection)

    AND

    At least 14 days have passed since the initial onset of symptoms (in **symptomatic** COVID-19)
    OR
    14 days since the first positive COVID-19 diagnostic test (in **asymptomatic** COVID-19)

    ii. **Both time-based AND test-based criteria (for essential workers including healthcare workers)**:

    Time-based criteria same as above except duration 10 days only (i.e., 10 days after symptom onset or 10 days after first positive test)

AND

Negative results on COVID-19 nucleic acid-based testing from at least 2 respiratory tract specimens collected ≥ 24 hours apart

iii. **Both time-based AND test-based criteria (for those with severely immunocompromising condition)**

Criteria same as above for essential workers except that the duration is 14 days after symptom onset or 14 days after first positive test

Note:

The isolation precautions in the hospital can therefore be discontinued

a) before 14 days if both the time-based and test-based criteria above are met

OR

b) after 14 days even if only the time-based criteria are met, i.e. even if RT-PCR remains positive. If RT-PCR test for SARS-CoV-2 is still positive at 14 days, further follow up RT-PCR testing is not recommended.

Note: There have been reports of prolonged detection of RNA without direct correlation to viral culture. Detecting viral RNA via PCR does not necessarily mean that a person is infectious

V. PERSONAL PROTECTIVE EQUIPMENT (PPE) WHILE TAKING CARE OF PATIENTS WITH SUSPECTED OR CONFIRMED COVID-19

1. **All healthcare providers and other staff should have access to appropriate personal protective equipment for them to carry out their professional work.**
2. **As noted in the Nepal Medical Council's Professional Ethics Guidelines for COVID-19 (March 2020), the country and the healthcare institutions have an obligation to provide necessary equipment including appropriate Personal Protective Equipment (PPE) to the healthcare workers (HCWs) for their personal protection as well as to minimize transmission of infection between infected and non-infected individuals.**
3. All staff should be trained on the appropriate methods for putting on and removing ("donning" and "doffing") PPE, including leak test for N-95 masks. (See poster in **Appendix 2**)
4. The general principles that help determine the types of PPE appropriate for specific settings are as follows:
    1. Use of facemask at all times, and by everyone including healthcare workers and other staff members, patients and other visitors in healthcare facilities
    2. N-95 masks for aerosol generating procedures, and if adequate supplies can be ensured, during all activities involving direct care of suspected or confirmed COVID-19 patients
    3. Eye-cover and gown, with or without head or foot cover, when having direct contact with patients or when risk of splash of secretions

5. All patients with suspected COVID-19 should be given surgical masks as soon as they arrive at the facility and asked to put them on throughout their stay in the hospital until 2019-SARS-CoV-2 acute respiratory disease is ruled out, unless they are placed in a negative pressure room.

6. Place surgical mask over oxygen delivery devices such as oxygen cannula, non-rebreather mask or nebulizer mask, in patients requiring the use of such devices.

7. When supplies of N-95 masks are severely limited during a pandemic, hospitals should implement:

    - staffing policies aimed at minimizing the number of individuals needing N-95 masks
    - allowing extended use and/or limited reuse of N-95 masks, when acceptable
    - prioritize the use of N-95 for the staff members at the highest risk of acquiring the infection or risk of having serious complications from it.

8. We recommend that a healthcare worker participating in the care of a patient with suspected or confirmed COVID-19 should be observed by a trained observer carrying an appropriate checklist (see example in **Appendix 3**) while putting on (donning) or taking off (doffing) head-to-toe personal protective equipment. This not only minimizes the stress on the healthcare worker but also reduces the chances of errors leading to infection in healthcare workers and nosocomial transmission to others.

9. Please see **Appendix 5** for suggestions on extended use or re-use of PPE.

10. **PPE for healthcare workers involved in aerosol-generating procedures**:

    a. N-95 mask
    b. Goggles or face-shield
    c. Gloves (double layer) (non-sterile)
    d. Disposable gowns, or clean reusable gowns made of water-resistant fabric
    e. Cap (regular disposable)
    f. Disposable, or clean reusable, shoe covers

    When supplies of N-95 masks are limited, airborne precautions with N-95 mask can be discontinued after 3 hours in the room after an aerosol-generating procedure is performed, unless it is performed in a negative-pressure room, where airborne precautions can be discontinued after 1 hour (while droplet and contact precautions are continued).

11. **PPE for healthcare workers providing direct routine care for suspected or confirmed COVID-19 patients, including those at "Fever/Influenza-like Illness Clinic":**

    a. N-95 masks when available, otherwise surgical mask
    b. Goggles or face-shield
    c. Gloves (non-sterile)
    d. Disposable gowns, or clean reusable gowns made of water-resistant fabric
    e. Cap (regular disposable)

    Those only collecting personal identification information or demographic or triage questionnaire data should maintain a distance of minimum 2 metres from the patient.

12. **PPE for escorts in hospitals or drivers of ambulances or transport vehicles:**
    a. Surgical masks
    b. Gloves (non-sterile)
    c. If physical contact is expected, depending on circumstances, a gown PLUS goggles or face-shield are also recommended, otherwise need to maintain minimum 2-metre distance from the patient.
    d. The patient should be given a facemask and instructed to perform hand-hygiene.

13. **PPE for laboratory staff processing specimen from suspected COVID-19 patients:**
    a. Surgical masks
    b. Disposable gowns, or clean reusable gowns made of water-resistant fabric
    c. Gloves (non-sterile)
    d. Goggles or face-shield (if risk of splash)
    e. Cap, disposable (if risk of splash)

14. **PPE for staff handling linens, waste and dead body:**
    a. Surgical mask
    b. Goggles or face-shield
    c. Heavy duty gloves
    d. Disposable gowns, or clean reusable gowns made of water-resistant fabric
    e. Cap (regular disposable)
    f. Boots or closed work shoes

15. **PPE for all other staff** (including health care workers involved in any activity that does not involve contact with suspected or confirmed COVID-19 patients and working in other areas of patient transit such as wards, corridors):
    - Surgical mask
    - Standard precautions including hand hygiene should be strictly followed.
    - Maintain spatial distance of at least 2 metres.

VI. MANAGEMENT OF VISITORS

- Restrict visitors from entering the room of known or suspected COVID-19 patients. Alternative mechanisms for patient and visitor interactions, such as video-call applications on cell phones or tablets should be explored.
- Hospitals can consider exceptions based on end-of-life situations or when a visitor is essential for the patient's emotional well-being and care.
- Hospitals should provide instruction, before visitors enter patients' rooms, on hand hygiene, limiting surfaces touched, and use of PPE according to current facility policy while in the patient's room.
- Hospitals should maintain a record (e.g., log book) of all visitors who enter patient rooms.
- Visitors should not be present during aerosol-generating procedures.
- Visitors should be instructed to limit their movement within the facility.
- Exposed visitors (e.g., contact with a symptomatic COVID-19 patient prior to admission) should be assessed by contact-tracing team and be tested / quarantined according to the existing public

health policy. They should be monitored for any signs and symptoms of acute illness for a period of at least 14 days after the last known exposure to the patient.

- All visitors must wear facemasks at all times while in the common areas of the facility.

VII. MANAGEMENT OF THE EQUIPMENT AND THE CARE ENVIRONMENT

- Routine cleaning and disinfection procedures are appropriate for SARS-CoV-2 in healthcare settings, including those patient-care areas in which aerosol-generating procedures are performed.
- 70% ethyl alcohol can be used to disinfect small areas between use, such as reusable dedicated equipment (for example, thermometers)
- For surfaces contaminated with SARS-CoV-2, WHO recommends chlorine-based disinfectants. A 0.1% hypochlorite solution (or 1000 ppm) will inactivate SARS-CoV-2 and vast majority of other pathogens that may be present in the health-care setting. However, for blood and body fluids spills of more than about 10mL, a 0.5% hypochlorite solution (or 5000 ppm) is recommended.
- The floor should be cleaned with 0.1% chlorine-based solution or equivalent disinfectant at least every 8 hours in noncritical areas and every 4 hours in critical areas.
- All high touch surfaces (such as handles, light switches, bed and handrails, toilet bowl, tap knobs, etc.) in the patient's room should be cleaned at least every 3-4 hours with 0.1% chlorine-based solution or equivalent disinfectant.
- Surface disinfection of tabletops, countertops, furniture surfaces and stethoscope, flash-light, knee hammer, or other used clinical instruments with 0.1% chlorine-based solution or equivalent disinfectant should be performed between all patient consults in outpatient departments. Surfaces that do not tolerate sodium hypochlorite may be cleaned with a neutral detergent, followed by a 70% concentration of ethanol.
- Spillage of blood or body fluids should be managed by carefully covering the spill with disinfecting wipes with 0.5% chlorine-based solution or equivalent disinfectant over it for at least 10 minutes, then removing the spillage carefully with the disinfecting wipes, followed by cleaning and disinfection with 0.1% chlorine-based solution or equivalent disinfectant.
- Utility gloves or heavy duty, reusable plastic aprons used by the cleaning staff should be cleaned with soap and water and then decontaminated with 0.5% chlorine-based solution after each use.

VIII. LAUNDRY

- All linen used in the care of suspected or confirmed COVID-19 patients should be managed as "infectious" linen and must be handled accordingly.
- Soiled laundry should be placed in clearly labeled, leak-proof bags or containers, after removing solid excrement if any.
- Linens can be machine washed with warm water at 60-90^{o}C (140–194^{o}F) with laundry detergent.
- If machine washing is not an option, laundry should be soaked in hot water and soap in a large drum using a stick to stir, while taking precautions to avoid splashing. Then the drum should be emptied and the laundry soaked in 0.05% chlorine-based solution for 30 minutes. The linens should finally be rinsed with clean water and fully dried in sunlight.

IX. WASTE MANAGEMENT

- The management of various types of waste produced during the care of suspected or confirmed COVID-19 should be done according to the Healthcare Waste Management Guidelines (2014) published by the Ministry of Health and Population Department of Health Services.

In essence, all waste should be treated as potentially infectious waste. The management will be the same as for other patients with respiratory tract infections, with the staff members using adequate hand hygiene and personal protective equipment.

- The personnel handling health care waste should wear appropriate PPE (goggles or face shield, surgical mask, thick gloves, long-sleeved gown, thick gloves, water-resistant apron and boots).

X. HANDLING OF THE DEAD BODY

- Please refer to the separate Covid-19 Ethical Guidelines from the Ministry of Health and Population for details of infection prevention and control precautions during the handling of the dead body.

XI. OCCUPATIONAL HEALTH AND STAFF DEPLOYMENT

1. **Definition of significant exposure:**
   Significant exposure for a healthcare worker (HCW) is defined as follows:
   - **a.** Being within 2 metres of a probable or confirmed case for more than 15 minutes without wearing proper personal protective equipment; OR
   - **b.** Having unprotected direct contact with probable or infected case or contact with their infectious secretions or excretions (e.g., being coughed on, touching soiled handkerchief with a bare hand) and not washing hands immediately afterwards; OR
   - **c.** Additionally, for healthcare workers, not wearing eye protection if the person with COVID-19 was not wearing a cloth face covering or facemask, OR not wearing all recommended personal protective equipment (i.e. gown, gloves, eye protection, respirator) while performing an aerosol-generating procedure, OR
   - **d.** Other situations as indicated by local risk assessments

2. **Determining the time period when the source case could have been infectious**
   - **a. For confirmed symptomatic cases**: from 48 hours before the onset of symptoms, until 14 days after the onset of symptoms.
   - **b. For confirmed asymptomatic cases:**
     - **i.** If there is history of known exposure to a suspected or confirmed case or exposure to a situation potentially leading to the infection (such as attending a mass congregation), the period of infectivity will be considered to start at 48 hours after such exposure and end 14 days after the positive test sample was taken.
     - **ii.** If there is no known history of such exposure, the period of infectiveness to contacts will be considered to start 10 days prior to obtaining the positive test sample, and end 14 days after the sample was taken.

3. **Determining the time period when the infected HCW could be infectious to others**
   - **a. For symptomatic infected HCW**: from 48 hours before onset of symptoms, until 14 days after the onset of symptoms.
   - **b. For asymptomatic infected HCW:**
     - **i.** If source person is known, the HCW is considered to be infectious from 48 hours after the *first* exposure to the source patient, until 14 days after obtaining the positive test sample.
     - **ii.** If source person is not known, the period of infectiveness to contacts will be considered to start 10 days prior to taking the positive test sample, and end 14 days after the sample was taken.

4. Recommended work restrictions for exposed HCW[†]

Exposure	PPE Used	Work Restrictions
HCW who had significant exposure with a patient, visitor or healthcare worker with probable or confirmed COVID-19[*]	• HCW not wearing a surgical or N-95 mask • HCW not wearing eye protection if the person with COVID-19 was not wearing a cloth face covering or facemask • HCP not wearing all recommended PPE (i.e., gown, gloves, eye protection, N-95 mask) during an aerosol-generating procedure	• Exclude from work for 14 days after last exposure • HCW to self-quarantine either at home in a separate room, or if appropriate living and social arrangements are not available for self-quarantine at home, arrangements should be made for accommodation in a comfortable and safe self-quarantine facility • Advice HCW to monitor themselves for symptoms consistent with COVID-19[*] • Any HCW who develops fever or symptoms consistent with COVID-19 should immediately contact the facility's designated clinical team for medical evaluation and testing
HCW other than those with exposure risk described above	• Not applicable	• No work restrictions • Follow all recommended infection prevention and control practices, including wearing a surgical mask or N-95 mask for source control while at work, monitoring themselves for fever or symptoms consistent with COVID-19 and not reporting to work when ill, and undergoing active screening for fever or symptoms consistent with COVID-19 at the beginning of their shift. • Any HCW who develops fever or symptoms consistent with COVID-19 should immediately self-isolate and contact the facility's designated clinical team for medical evaluation and testing.

[†] Adapted from the CDC's *Interim U.S. Guidance for Risk Assessment and Work Restrictions for Healthcare Personnel with Potential Exposure to COVID-19*, May 2020.

[*]For definitions of probable and conformed cases of COVID-19, and symptoms consistent with COVID-19, please see *Nepal Medical Council Interim Clinical Guidance for Care of Patients with COVID-19 in Healthcare Settings Update 1* (June 2020)

Note: An asymptomatic HCW who has had a significant exposure to SARS-CoV-2 but is NOT known to be infected might be asked to continue to work instead of staying in self-quarantine if severe staffing shortages make it necessary to require such HCWs to continue to work. In such situation, they should:

- wear a surgical mask or N-95 mask for source control while at work

- strictly maintain appropriate hand hygiene
- monitor themselves for fever or symptoms consistent with COVID-19 and not report to work when ill
- undergo mandatory active screening for fever or symptoms consistent with COVID-19 at the beginning of their shift and every 6 hours during the shift
- if they develop fever or symptoms consistent with COVID-19, they should immediately self-isolate and contact the facility's designated clinical team for medical evaluation and testing.
- ideally be assigned to only take care of suspected or proven patients with COVID-19

5. Criteria for testing for exposed HCWs

a. Symptomatic HCW:

- Testing should be done as soon as possible in HCWs with symptoms suggestive of COVID-19, unless the HCW has already tested positive for SARS-CoV-2 earlier.
- If a HCW is tested after 1-6 days after significant exposure to the source person because of occurrence of symptoms and the report is negative, they should be tested one more time after 7-14 days from the exposure.
- Except during severe staffing shortages, HCWs with negative test results for SARS-CoV-2 should still complete 14 days of quarantine.

b. Asymptomatic HCW:

- In general, the timing of testing for exposed asymptomatic healthcare workers is dependent on the availability of testing capacity, the home situation of the HCW regarding whether the requirements of self-quarantine can be met, the pressure on the hospital or healthcare system from staffing shortage point of view, requiring an earlier return to work if possible, etc.
- As limitations in test capabilities are expected for at least several months in Nepal, we recommend testing **at least once after 7-14 days from first significant exposure to the source person**.
- Except during severe staffing shortages, HCWs with negative test results for SARS-CoV-2 should still complete 14 days of quarantine.

6. Criteria for returning to work for infected HCWs

b. HCWs with COVID-19 should be excluded from work until they meet EITHER both the time-based AND test-based criteria, OR the *modified* time-based criteria alone.

i. **Time-based criteria**:

a) Resolution of fever >72 hours without antipyretics, and improvement in respiratory signs and symptoms (cough, shortness of breath and oxygen requirement) (in case of symptomatic COVID-19 infection)
OR
No symptoms have developed subsequent to the first positive COVID-19 diagnostic test (in case of asymptomatic COVID-19 infection)

AND

b) At least 10 days have passed since the initial onset of symptoms (symptomatic COVID-19)

OR
At least 10 days have passed since the first positive COVID-19 diagnostic test (asymptomatic COVID-19)

ii. **Test-based criteria**: Negative results on COVID-19 nucleic acid-based testing from at least 2 respiratory tract specimens collected ≥ 24 hours apart

iii. ***Modified* time based-criteria** are similar to the time-based criteria above except that the duration from the initial onset of symptoms (in symptomatic COVID-19) or duration from the first positive diagnostic test (in asymptomatic COVID-19) is **14 days** instead of 10 days.

Note:
The infected HCW can therefore return to work
a) before 14 days if both the time-based and test-based criteria above are met
OR
b) after 14 days even if only the time-based criteria are met, i.e. even if RT-PCR remains positive. If RT-PCR test for SARS-CoV-2 is still positive at 14 days, further follow up RT-PCR testing is not recommended.

HCW returning to work with persistent positive RT-PCR should ideally not be assigned to work in a unit where patients with severely immunocompromising condition are managed for 2 weeks after returning to work.

c. Return to work practices and work restrictions: After returning to work, HCW should:

i. wear a surgical mask or N-95 mask for source control while at work
ii. strictly maintain appropriate hand hygiene
iii. monitor themselves for symptoms and seek medical evaluation by the facility's designated clinical team should symptoms reoccur or worsen

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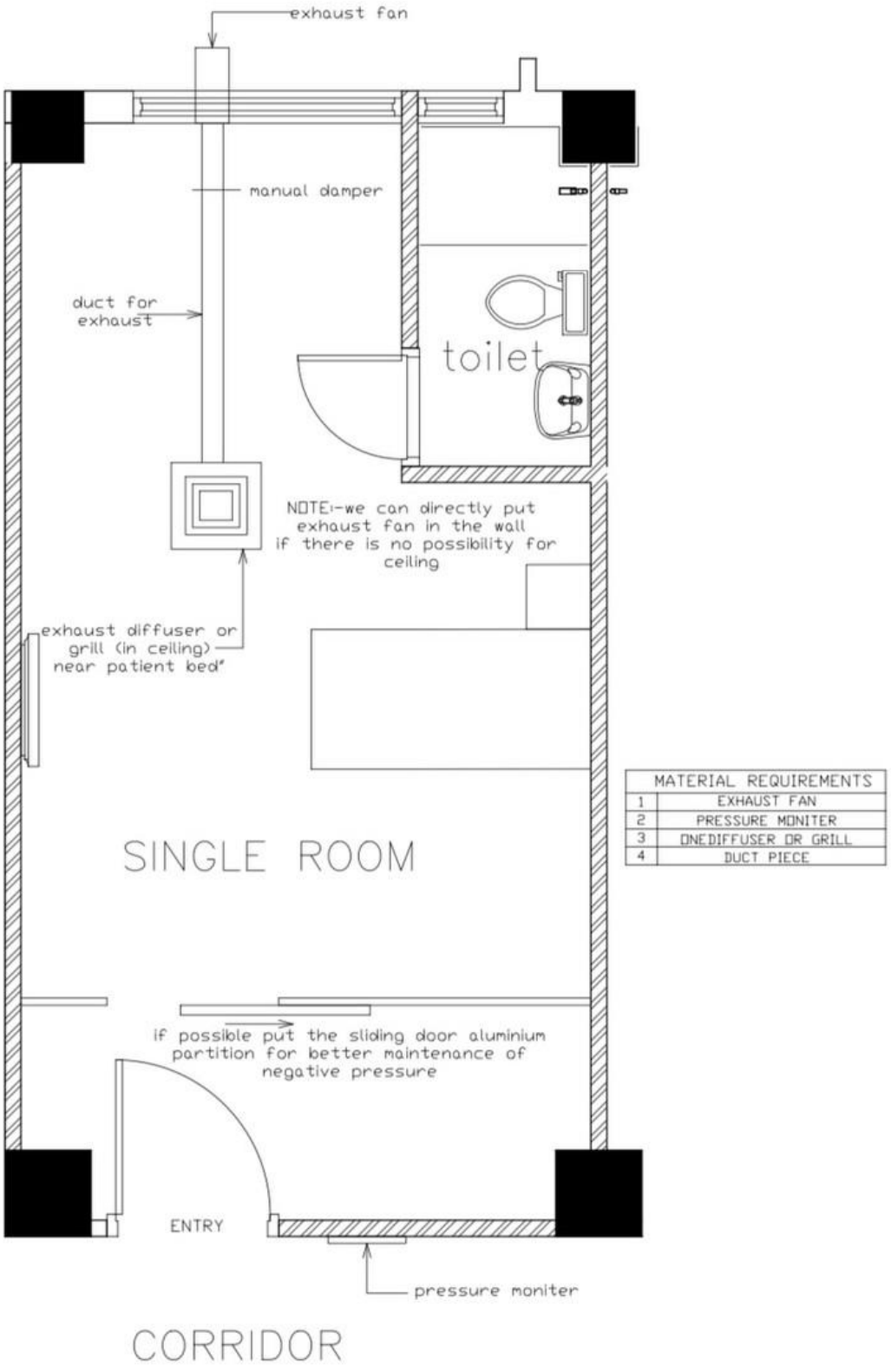
XIII. APPENDIX 1. Possible modification of existing hospital room to build negative pressure chamber



Appendix 2: Sequence for putting on and removing personal protective equipment (with Gown)

(Available at: https://www.cdc.gov/coronavirus/2019-ncov/downloads/A_FS_HCP_COVID19_PPE_11x17.pdf)

Use Personal Protective Equipment (PPE) When Caring for Patients with Confirmed or Suspected COVID-19

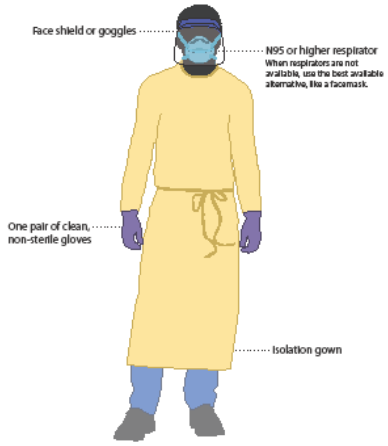
Before caring for patients with confirmed or suspected COVID-19, healthcare personnel (HCP) must:

- **Receive comprehensive training** on when and what PPE is necessary, how to don (put on) and doff (take off) PPE, limitations of PPE, and proper care, maintenance, and disposal of PPE.
- **Demonstrate competency** in performing appropriate infection control practices and procedures.

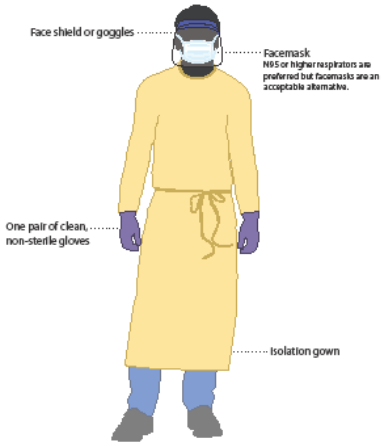
Remember:

- PPE must be donned correctly before entering the patient area (e.g., isolation room, unit if cohorting).
- PPE must remain in place and be worn correctly for the duration of work in potentially contaminated areas. PPE should not be adjusted (e.g., retying gown, adjusting respirator/facemask) during patient care.
- PPE must be removed slowly and deliberately in a sequence that prevents self-contamination. A step-by-step process should be developed and used during training and patient care.

Preferred PPE – Use N95 or Higher Respirator



Acceptable Alternative PPE – Use Facemask



Donning (putting on the gear):

More than one donning method may be acceptable. Training and practice using your healthcare facility's procedure is critical. Below is one example of donning.

1. **Identify and gather the proper PPE to don.** Ensure choice of gown size is correct (based on training).
2. **Perform hand hygiene using hand sanitizer.**
3. **Put on isolation gown.** Tie all of the ties on the gown. Assistance may be needed by another HCP.
4. **Put on NIOSH-approved N95 filtering facepiece respirator or higher (use a facemask if a respirator is not available).**
   If the respirator has a nosepiece, it should be fitted to the nose with both hands, not bent or tented. Do not pinch the nosepiece with one hand. Respirator/facemask should be extended under chin. Both your mouth and nose should be protected. Do not wear respirator/facemask under your chin or store in scrubs pocket between patients.*
   - » **Respirator:** Respirator straps should be placed on crown of head (top strap) and base of neck (bottom strap). Perform a user seal check each time you put on the respirator.
   - » **Facemask:** Mask ties should be secured on crown of head (top tie) and base of neck (bottom tie). If mask has loops, hook them appropriately around your ears.
5. **Put on face shield or goggles.** When wearing an N95 respirator or half facepiece elastomeric respirator, select the proper eye protection to ensure that the respirator does not interfere with the correct positioning of the eye protection, and the eye protection does not affect the fit or seal of the respirator. Face shields provide full face coverage. Goggles also provide excellent protection for eyes, but fogging is common.
6. **Put on gloves.** Gloves should cover the cuff (wrist) of gown.
7. **HCP may now enter patient room.**

Doffing (taking off the gear):

More than one doffing method may be acceptable. Training and practice using your healthcare facility's procedure is critical. Below is one example of doffing.

1. **Remove gloves.** Ensure glove removal does not cause additional contamination of hands. Gloves can be removed using more than one technique (e.g., glove-in-glove or bird beak).
2. **Remove gown.** Untie all ties (or unsnap all buttons). Some gown ties can be broken rather than untied. Do so in gentle manner, avoiding a forceful movement. Reach up to the shoulders and carefully pull gown down and away from the body. Rolling the gown down is an acceptable approach. Dispose in trash receptacle.*
3. **HCP may now exit patient room.**
4. **Perform hand hygiene.**
5. **Remove face shield or goggles.** Carefully remove face shield or goggles by grabbing the strap and pulling upwards and away from head. Do not touch the front of face shield or goggles.
6. **Remove and discard respirator (or facemask if used instead of respirator).*** Do not touch the front of the respirator or facemask.
   - » **Respirator:** Remove the bottom strap by touching only the strap and bring it carefully over the head. Grasp the top strap and bring it carefully over the head, and then pull the respirator away from the face without touching the front of the respirator.
   - » **Facemask:** Carefully untie (or unhook from the ears) and pull away from face without touching the front.
7. **Perform hand hygiene after removing the respirator/facemask** and before putting it on again if your workplace is practicing reuse.

**Facilities implementing reuse or extended use of PPE will need to adjust their donning and doffing procedures to accommodate those practices.*

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Appendix 3a: Example checklist for trained observer for donning of coverall suit with boots

DONNING PPE (COVERALL SUIT WITH BOOT COVERS) COMPETENCY CHECKLIST				
DATE AND TIME:				
UNIT:				
STAFF MEMBER'S NAME:		**TITLE:**		
THE PROCEDURE MUST BE CHECKED BY A TRAINED OBSERVER AND RECORD IN THE CHECKLIST BELOW				
SN	**DONNING PPE (FULL COVERALL WITH FOOT COVER)**	**YES**	**NO**	**COMMENT**
1	STAFF MEMBER HAS ATTENDED TO PERSONAL NEEDS, SUCH AS RESTROOM/HYDRATION			
2	STAFF MEMBER HAS CHANGED INTO CLEAN SURGICAL SCRUBS			
3	REMOVE WATCH AND ALL JEWELRY; SECURE HAIR			
4	ASSEMBLE ALL THE REQUIRED PPE			
5	VISUALLY INSPECT THE ASSEMBLED PPE			
6	PERFORM HAND HYGIENE			
7	WEAR THE FIRST PAIR OF GLOVES			
8	PUT ON THE COVERALL SUIT			
9	PUT ON THE BOOTS			
10	PUT ON THE BOOT COVERS			
11	PERFORM HAND HYGIENE			
12	PUT ON THE N-95 MASK			
13	PERFORM FIT TEST FOR N-95 MAKS			
14	PUT ON THE HOOD/CAP OF THE COVERALL SUIT			
15	WEAR THE ADDITIONAL PLASTIC APRON IF AVAILABLE			
16	PUT ON THE GOGGLES/FACE SHIELD			
17	PUT ON THE SECOND PAIR OF GLOVES			
18	VERIFY FULL RANGE OF MOTION WITH THE COVERALL SUIT			
19	VERIFY INTEGRITY OF THE PPE			
VERIFIED BY:				
NAME:				
DESIGNATION:				
SIGNATURE:				

Appendix 3b: Example checklist for trained observer for doffing of coverall suit with boots

DOFFING PPE (COVERALL SUIT WITH BOOT COVERS) COMPETENCY CHECKLIST				
DATE AND TIME:				
UNIT:				
NAME OF THE STAFF MEMBER:			**TITLE:**	
A TRAINED OBSERVER MUST OBSERVE THE PROCEDURE AND RECORD IN THE CHECKLIST BELOW				
SN	**DOFFING PPE (FULL COVERALL WITH FOOT COVER)**	**YES**	**NO**	**COMMENT**
1	ENTER THE DOFFING AREA WHEN THE TRAINED OBSERVER IS PRESENT			
2	INSPECT THE PPE FOR ANY RIPS, TEARS OR VISIBLE CONTAMINATION			
3	DISINFECT THE OUTER GLOVES WITH 70% ALCOHOL OR HAND SANITIZER			
4	REMOVE THE OUTER APRON IF WORN			
5	DISINFECT THE OUTER GLOVES WITH 70% ALCOHOL OR HAND SANITIZER			
6	REMOVE THE OUTER GLOVES AND DISPOSE IT IN DESIGNATED CONTAINER			
7	INSPECT THE INNER GLOVES FOR VISIBLE TEARS OR CONTAMINATION			
8	DISINFECT THE INNER GLOVES WITH 70% ALCOHOL OR SANITIZER			
9	REMOVE THE FACE SHIELD AND DISPOSE IT			
10	DISINFECT THE INNER GLOVES WITH 70% ALCOHOL OR SANITIZER			
11	REMOVE THE BOOT COVER AND DISPOSE IT			
12	DISINFECT THE INNER GLOVES WITH 70% ALCOHOL OR SANITIZER			
13	REMOVE THE BOOTS			
14	DISINFECT THE INNER GLOVES WITH 70% ALCOHOL OR SANITIZER			
15	REMOVE THE HOOD AND COVERALL SUIT			
16	DISINFECT THE INNER GLOVES WITH 70% ALCOHOL OR SANITIZER			
17	REMOVE THE MASK AND DISPOSE IT			
18	DISINFECT THE INNER GLOVES WITH 70% ALCOHOL OR SANITIZER			
19	REMOVE THE INNER GLOVES			
20	PERFORM HAND HYGIENE			
21	INSPECT THE SCRUB DRESS FOR ANY RIPS, TEARS OR CONTAMINATION			
22	LEAVE THE DOFFING AREA & TAKE A SHOWER IN THE CLOSEST BATHROOM			
VERIFIED BY:				
NAME:				
DESIGNATION:				
SIGNATURE:				

Appendix 4: Guidelines for use of personal protective equipment (Developed by the Expert Team of NMC and Government of Nepal with reference from WHO, published on March 26, 2020)

A. For Aerosol Generating procedures: Dental procedures, bronchoscopy, Upper GI Endoscopy, ENT procedures, Nebulization, Intubation of a patient, CPR, Non-invasive ventilation, endotracheal suctioning, when obtaining nasopharyngeal or oropharyngeal swab, etc. **in Covid-19 suspected or confirmed cases health personnel need to use the following protective equipment: Category I PPE:**

a. N-95 mask
b. Goggles or visor
c. Gloves (loose gloves acceptable)
d. Water resistant OR standard disposable gowns
e. Cap: Regular disposable

B. **For Non aerosol generating covid-19 suspected or confirmed patients: Health personnel need to use the following protective equipment: Category II PPE:**

a. Surgical mask (seal the top edge with tape)
b. Goggles or visor
c. Gloves (loose gloves acceptable)
d. Water resistant or standard disposable gowns
e. Cap: Regular disposable

C. For Physician/Staff running the fever/screening clinics the following PPE is recommended: Category II PPE

a. Surgical mask, (seal the top edge with a tape)
b. Goggles or visor
c. Water resistant or standard disposable gowns
d. Regular disposable Cap
e. Gloves (loose gloves acceptable)

D. For escorts or drivers, the following PPE is recommended: Category III PPE:

a. Surgical masks
b. Gloves
c. If physical contact is expected, depending on circumstances, a gown PLUS goggles or face-shield are also recommended, otherwise need to maintain minimum 6 feet distance from the patient.
d. The patient should be given surgical mask and instructed to perform hand-hygiene.

E. For Laboratory staff: category II or III PPE; depending upon the chance of splash:

a. surgical mask
b. Gown
c. Loose Gloves
d. Eye protection (if risk of splash)

F. **For all staff, including health care workers** involved in any activity that does not involve contact with COVID-19 patients and working in other areas of patient transit (e.g. wards, corridors). **No PPE required**.

For Everyone:

- ***Maintain 3-6 feet distance while visiting patients, if no need to touch the patient.***
- ***Mandatory hand-hygiene after each use of PPE and between patients.***
- ***Mandatory surface cleaning of bed or furniture with 0.5% Chlorine disinfectant (Virex* or similar) between each patient in OPD or in an inpatient setting.***

APPENDIX 5: Suggestions regarding extended use or re-use of personal protective equipment

Reuse of eye protection (disposable face shields / visors / goggles):

• Disposable face shields and non-disposable eye protection should be decontaminated and reused whenever possible provided that the integrity of the equipment remains intact and visibility is not compromised.

• Eye protection should be decontaminated when visibly soiled or each time it is removed prior to reusing it. Store in a clean paper bag or other container between use.

Steps :

1. Ensure cleaning of goggles takes place on a clean surface by disinfecting the surface before cleaning of goggles
2. Clean goggles with soap/detergent
3. Disinfect using one of the following :
    a. sodium hypochlorite 0.1% for 10 minutes, then rinse with clean water
    b. 70% alcohol wipes at least 1 minute
4. Let it completely air-dry
5. Store in a clean area to avoid recontamination

Reuse of non-disposable isolation gowns and cloth cap:

1. Washing by machine with warm water (60-90°C) and laundry detergent is recommended for reprocessing of the gown.
2. If machine washing is not possible, linen can be soaked in hot water and soap in a large drum, using a stick to stir, avoiding splashing. Then soak linen in 0.05% chlorine-based solution (e.g. hypochlorite solution) for approximately 30 minutes. Finally, rinse with clean water and let it dry fully in the sunlight
3. Routinely inspect & maintain integrity after the laundry before re-using

Extended use and reuse of N-95 mask:

- N-95 mask reprocessing:
  When severe scarcity of N-95 masks is expected, N-95 masks can be reprocessed using either vaporized hydrogen peroxide or ultraviolet germicidal irradiation, if/when such technology is available. Up to 20 cycles of reprocessing provides acceptable safety both in terms of germicidal efficacy, filtration performance and fit performance.

  Other methods of reprocessing such as microwave generated steam, microwave steam bags, moist heat incubation, or use of liquid hydrogen peroxide all have good germicidal efficacy however have not been evaluated for either or both of filtration performance or fit performance after multiple reprocessing cycles. Use of ethylene oxide gas (EtO) is not recommended because of potential harm to the wearer, because relatively long aeration cycles are needed to ensure removal of the highly toxic EtO gas.

A few centers in Nepal have UV- C wave irradiation technology available for reprocessing of N-95 masks. The specifications are: 40 W UV-C bulb (0.5–950 J/cm2), intensity 1.8mW/cm2, 245 nm with exposure 15 minute each side (total 30 minutes)

- <u>N-95 mask reuse:</u>
  When technology for reprocessing of N-95 masks is not available, the following protocol for reuse of N-95 masks is suggested.

  After using N-95 for the first time:
  1. Get a clean paper bag and write your name on it.
  2. Perform hand hygiene before removing the N-95 mask.
  3. Take the N-95 out safely without touching the inner surface of the mask.
  4. Keep the mask in a clean paper bag and staple the open end. Alternatively, can hang the used mask in a designated storage area.
  5. Perform hand hygiene.

  Reusing N-95 masks
  1. Wash your hands or use hand sanitizer.
  1. Tear the paper bag open.
  2. Take out the N-95 mask and put it on, and perform user seal check.
  3. Dispose of the paper bag.
  4. Perform hand hygiene.
  5. When removing the N95 mask, again use the process above and keep the mask safely in a new paper bag.

  Note:
  1. N-95 mask can be reused until it is physically damaged or soiled
  2. DO NOT clean N-95 masks with alcohol, chlorhexidine or any other chemicals
  3. Always use an N-95 mask along with goggles or face shield.
  4. While doing airway procedures, cover the N-95 mask with a surgical mask (which will be discarded later) to protect it from getting soiled.
  5. N-95 mask must only be used by a single user.
  6. When donning or doffing the N-95 mask, avoid touching the inside of the mask.
  7. Clean hands with soap and water or alcohol-based hand sanitizer before and after touching or adjusting the respirator, either for comfort or to maintain fit.

CONTRIBUTORS

This document was prepared by the Nepal Medical Council COVID-19 Treatment Guidance Committee.

- Dr Anup Subedee (Co-ordinator)
- Prof. Dr Subhash P Acharya (Member, and representative from Nepalese Society of Critical Care Medicine)
- Dr Prabhat Adhikari (Member)
- Asst. Prof. Dr Badri Rijal (Member, and representative from Nepal Medical Association)
- Dr Sanjeet Krishna Shrestha (Member, and representative from Society of Internal Medicine of Nepal)
- Dr Sanjeeb Tiwari (Member, and representative from General Practitioners Association of Nepal)
- Prof. Dr Janak Koirala (Invited Expert)
- Dr Rakshya Pandey (Invited Expert)
- Dr Raju Pangeni (Invited Expert)
- Prof. Dr Bhagawan Koirala (Chairman, Nepal Medical Council)

Annexure-IX

Considerations for public health and social measures in the workplace in the context of COVID-19

Annex to Considerations in adjusting public health and social measures in the context of COVID-19

10 May 2020

World Health Organization

Background

In response to COVID-19, countries across the globe have implemented a range of public health and social measures, including movement restrictions, partial closure or closure of schools and businesses, quarantine in specific geographic areas and international travel restrictions. As the local epidemiology of the disease changes, countries will adjust (i.e. loosen or reinstate) these measures accordingly. As transmission intensity declines, some countries will begin to gradually re-open workplaces to maintain economic activity. This requires establishing protective measures, including directives and capacity to promote and enable standard COVID-19 prevention in terms of physical distancing, hand washing, respiratory etiquette and, potentially, thermal monitoring, as well as monitoring compliance with these measures.[1]

On 16 April 2020, WHO published interim guidance that provides advice on adjusting PHSM,[i] while managing the risk of resurgence of cases. A series of annexes was developed to help guide countries through adjusting various public health measures in different contexts. This annex is for those involved in developing policies and standard operating procedures to prevent the transmission of COVID-19 in the workplace, including employers, workers and their representatives, labour unions and business associations, local public health and labour authorities, and occupational safety and health practitioners. This document offers general guidance for non-healthcare workplaces and workers in those settings.[ii] Additional protective measures may be necessary for specialized workplaces. Specific recommendations for protection of the health and safety of some frontline public workers are also included in the existing WHO guidance for the accommodation sector,[2] detention centers,[3] schools,[4] food businesses,[5] aviation sector,[6] water, sanitation, and waste management,[7] camps,[8] and construction.[9]

Workplace risk assessment

COVID-19 is transmitted primarily through respiratory droplets or contact with contaminated surfaces.[10] Work-related exposure can occur anytime at the workplace, during work-related travel to an area with local community transmission, as well as on the way to and from the workplace.[11]

The risk of work-related exposure to COVID-19 depends on the probability of coming into close (less than 1 metre) or frequent contact with people who may be infected with COVID-19 and through contact with contaminated surfaces and objects. The following risk levels may be useful in carrying out a workplace risk assessment for exposure to COVID-19 and planning for preventive measures in non-healthcare workplaces. In these risk categories, persons referred to as 'known to be or suspected of being infected with COVID-19' generally refers to persons who have already had a positive test or diagnosis.[iii] Although such persons should be cared for in isolation, some occupations may still have a higher risk of exposure (e.g. home care workers, personal service providers where necessary, pharmacy front-line staff).

> *Low exposure risk* – jobs or work tasks without frequent, close contact with the general public and other co-workers, visitors, clients or customers, or contractors, and that do not require contact with people known to be or suspected of being infected with COVID-19. Workers in this category have minimal occupational contact with the public and other co-workers.
>
> *Medium exposure risk* – jobs or work tasks with close, frequent contact with the general public, or other co-workers, visitors, clients or customers, or contractors, but that do not require contact with people known to be or suspected of being infected with COVID-19. In areas where COVID-19 cases continue to be reported, this risk level may be applicable to workers who have work-related frequent and close contact with the general public, visitors, or customers in high-population-density work environments (e.g. food markets, bus stations, public transport, and other work activities where physical distancing of at least 1 metre may be difficult to observe), or work tasks that require close and frequent contact between co-workers. In areas without community transmission of COVID-19, this scenario may include frequent contact with persons returning from areas with community transmission.
>
> *High exposure risk* – jobs or work tasks with high potential for close contact with people who are known or suspected of having COVID-19, as well as contact with objects and surfaces possibly contaminated with the virus. Examples of such

[i] Considerations in adjusting public health and social measures in the context of COVID-19 (Interim Guidance) (WHO 2020).

[iii] For the purposes of this guidance the term "workplace" covers all places where workers need to be or to go by reason of their work.

[iii] While the general public may include pre-symptomatic or asymptomatic persons who may be infected but have not (yet) developed obvious signs or symptoms. In this case, the likelihood of exposure of a worker will very much depend on the local COVID-19 situation. Physical distancing measures in the workplace therefore protect workers from direct contact any person who may or may not have COVID-19, whether they are aware of it or not.

exposure scenarios outside of health facilities include the transportation of persons known or suspected to have COVID-19 in enclosed vehicles without separation between the driver and the passenger, providing domestic services or home care for people with COVID-19, and contact with dead bodies of persons who were known or suspected of having COVID-19 at the time of their death.

In the same work setting there may be jobs with different levels of risk, and different jobs or work tasks may have similar levels of exposure. Therefore, the risk assessment should be carried out for each specific work setting and each job or group of jobs. For each risk assessment, it is prudent to consider the environment, the task, the threat, if any (e.g. for frontline staff), and resources available, such as personal protective equipment.

Some workers may be at higher risk of developing severe COVID-19 illness because of age or pre-existing medical conditions; this should be considered in the risk assessment for individuals. Essential public services, such as security and police, food retail, accommodation, public transport, deliveries, water and sanitation, and frontline workers may be at an increased risk of exposure to occupational hazards for health and safety.

Employers and managers, in consultation with workers, should carry out and regularly update the risk assessment for work-related exposure to COVID-19, preferably with support of occupational health services.

Preventive measures

Decisions on closing or re-opening of workplaces and suspension or downscaling of work activities should be made in light of the risk assessment, the capacity to implement preventive measures, and recommendations of national authorities for adjusting public health and social measures in the context of COVID-19.

Measures for all workplaces

Universal measures for preventing transmission of COVID-19 that apply to all workplaces and all people at the workplace, such as employers, managers, workers, contractors, customers and visitors, include the following:

Hand hygiene

- Regular and thorough handwashing with soap and water or hand hygiene with alcohol-based hand-rub before starting work, before eating, frequently during the work shift, especially after contact with co-workers or customers, after going to the bathroom, after contact with secretions, excretions and body fluids, after contact with potentially contaminated objects (gloves, clothing, masks, used tissues, waste), and immediately after removing gloves and other protective equipment but before touching eyes, nose, or mouth.
- Hand hygiene stations, such as hand washing and hand rub dispensers, should be put in prominent places around the workplace and be made accessible to all staff, contractors, clients or customers, and visitors along with communication materials to promote hand hygiene.[12]

Respiratory hygiene

- Promote respiratory etiquette by all people at the workplace. Ensure that medical face masks and paper tissues are available at the workplace, for those who develop a runny nose or cough at work, along with bins with lids for hygienic disposal.[13]
- Develop a policy on wearing a mask or a face covering in line with national or local guidance. Masks may carry some risks if not used properly.[14] If a worker is sick, they should not come to work. If a member of staff or a worker feels unwell while at work, provide a medical mask so that they may get home safely. Where masks are used, whether in line with government policy or by personal choice, it is very important to ensure safe and proper use, care and disposal.

Physical distancing

- Introduce measures to keep a distance of at least 1 metre between people and avoid direct physical contact with other persons (i.e. hugging, touching, shaking hands), strict control over external access, queue management (marking on the floor, barriers)
- Reduce density of people in the building (no more than 1 person per every 10 square metres),[15,iv]physical spacing at least 1 metre apart for work stations and common spaces, such as entrances/exits, lifts, pantries/canteens, stairs, where congregation or queuing of employees or visitors/clients might occur.
- Minimize the need for physical meetings, e.g. by using teleconferencing facilities
- Avoid crowding by staggering working hours to reduce congregation of employees at common spaces such as entrances or exits
- Implement or enhance shift or split-team arrangements, or teleworking

[iv] If a person observes the WHO recommended at least 1-meter physical distance from others, this converts to approximately 10 square meter area around them.

- Defer or suspend workplace events that involve close and prolonged contact among participants, including social gatherings.

Reduce and manage work-related travels

- Cancel or postpone non-essential travel to areas with community transmission of COVID-19, provide hand sanitizer to workers who must travel, advise workers to comply with instructions from local authorities where they are travelling, as well as information on whom to contact if they feel ill while travelling.
- Workers returning from an area where COVID-19 transmission is occurring should monitor themselves for symptoms for 14 days and take their temperature twice a day; if they are feeling unwell, they should stay at home, self-isolate, and contact a medical professional.

Regular environmental cleaning and disinfection

- Cleaning, using soap or a neutral detergent, water, and mechanical action (brushing, scrubbing) removes dirt, debris, and other materials from surfaces. After the cleaning process is completed, disinfection is used to inactivate (i.e. kill) pathogens and other microorganisms on surfaces.
- Selection of disinfectants[v] should align with the local authorities' requirements for market approval, including any regulations applicable to specific sectors.
- High-touch surfaces should be identified for priority disinfection (commonly used areas, door and window handles, light switches, kitchen and food preparation areas, bathroom surfaces, toilets and taps, touchscreen personal devices, personal computer keyboards, and work surfaces).
- Disinfectant solutions must always be prepared and used according to the manufacturer's instructions, including instructions to protect the safety and health of disinfection workers, use of personal protective equipment, and avoiding mixing different chemical disinfectants.
- In indoor workplaces, routine application of disinfectants to environmental surfaces via spraying or fogging is generally not recommended because it is ineffective at removing contaminants outside of direct spray zones and can cause eye, respiratory, and skin irritation and other toxic effects.
- In outdoor workplaces, there is currently insufficient evidence to support recommendations for large-scale spraying or fumigation.
- Spraying of people with disinfectants (such as in a tunnel, cabinet, or chamber) is not recommended under any circumstances.[16]

Risk communication, training, and education

- Provide posters, videos, and electronic message boards to increase awareness of COVID-19 among workers and promote safe individual practices at the workplace, engage workers in providing feedback on the preventive measures and their effectiveness.
- Provide regular information about the risk of COVID-19 using official sources, such as government agencies and WHO, and emphasize the effectiveness of adopting protective measures and counteracting rumours and misinformation.[17]
- Special attention should be given to reaching out to and engaging vulnerable and marginalized groups of workers, such as those in the informal economy and migrant workers, domestic workers, subcontracted and self-employed workers, and those working under digital labour platforms.[18]

Management of people with COVID-19 or their contacts

- Workers who are unwell or who develop symptoms consistent with COVID-19 should be urged to stay at home, self-isolate, and contact a medical professional or the local COVID-19 information line for advice on testing and referral.[19]
- Where local community transmission is high, and work continues, allow for a telemedicine consultation where available, or consider waiving the requirement for a medical note for workers who are sick so that they may stay home.
- All workers should be urged to self-monitor their health, possibly with the use of questionnaires, and take their body temperature regularly.
- Thermal screening at the workplace should be considered only in the context of a combination of measures for prevention and control of COVID-19 at the workplace and along with risk communication.
- Standard operating procedures should be prepared to manage a person who becomes sick at the workplace and is suspected of having COVID-19, including placing the person in an isolation room, limiting the number of people in contact, using personal protective equipment, and performing follow-up cleaning and disinfection.
- It is important to contact the local health authorities and to keep attendance and meeting records in order to facilitate or undertake contact-tracing.

[v] For example, sodium hypochlorite (bleach) may be used for disinfection of surfaces in workplaces at concentration 0.1% (1,000 ppm) and alcohol with at least 70% concentration for surfaces which can be damaged by sodium hypochlorite.

- People who were in close contact at the workplace with persons with laboratory-confirmed COVID-19 should be quarantined for 14 days from the last time of the contact in accordance with WHO recommendations.[20]

Specific measures for workplaces and jobs at medium risk

In addition to the above measures, for workplaces and jobs assessed to be at medium risk, the following measures should be put in place:

- Enhanced cleaning and disinfection of objects and surfaces that are touched regularly, including all shared rooms, surfaces, floors, bathrooms, and changing rooms;
- Where the physical distancing of at least 1 metre cannot be implemented in full in relation to a particular activity, workplaces should consider whether that activity needs to continue, and if so, take all the mitigating actions possible to reduce the risk of transmission between workers, clients or customers, contractors, and visitors; such as staggered activities, minimizing face-to-face and skin-to-skin contacts, placing workers to work side-by-side or facing away from each other rather than face-to-face, assign staff to the same shift teams to limit social interaction, installing plexiglass barriers at all points of regular interaction and cleaning them regularly;
- Enhanced hand hygiene – regular hand washing with soap and water or use of alcohol-based hand rub, including before entering and after leaving enclosed machinery, vehicles, confined spaces, and before putting on and after taking off personal protective equipment;
- Provide personal protective equipment and training on its proper use – e.g. masks, disposable gowns, disposable gloves or heavy-duty gloves that can be disinfected. Provide face or eye protection (medical mask, face shields, or goggles) during cleaning procedures that generate splashes (e.g. washing surfaces).
- Increased ventilation rate, through natural aeration or artificial ventilation, preferably without re-circulation of the air.

Specific measures for workplaces and jobs at high risk

In addition to the measures above, for high-risk work activities and jobs, the following measures should be implemented:

- Assess the possibility of suspending the activity;
- Adherence to hygiene before and after contact with any known or suspected case of COVID-19, before and after using PPE;
- Use of medical mask, disposable gown, gloves, and eye protection for workers who must work in the homes of people who are suspected or known to have COVID-19. Use the protective equipment when in contact with the sick person, or respiratory secretions, body fluids, and potentially contaminated waste;
- Training of workers in infection prevention and control practices and use of personal protective equipment;
- Avoid assigning tasks with high risk to workers who have pre-existing medical conditions, are pregnant, or older than 60 years of age.

Rights, duties, and responsibilities of workers and employers

Employers, workers, and their organizations should collaborate with health authorities in the prevention and control of COVID-19. The employers, in consultation with workers and their representatives, should take preventive and protective measures, such as engineering and administrative controls and provision of personal protective equipment and clothing for occupational safety and health and infection prevention and control. Such measures at the workplace must not involve any expenditure on the part of workers.

Workers shall follow established occupational safety and health and infection prevention and control procedures, avoid exposing others to health and safety risks, participate in related training provided by the employer and report immediately to their supervisor any situation which they have reasonable justification to believe presents an imminent and serious danger to their life or health.[21]

Co-operation between management and workers and their representatives must be an essential element of workplace-related prevention measures (such as through workers' safety delegates, safety and health committees, and collaboration with providing information and training) and respecting the right and duties of workers and employers in occupational safety and health.[22]

COVID-19 and other diseases, if contracted through occupational exposure, could be considered as occupational diseases.[23]

Plan of action

Workplaces should develop action plans for prevention and mitigation of COVID-19 as part of the business continuity plan and according to the results of the risks assessment and the epidemiological situation.[24] The plan should also include measures for protecting health, safety, and security in re-opening, closing, and modifying workplaces and work arrangements. Re-opening of workplaces should be carefully planned in advance and all possible risks for health and safety should be properly assessed and controlled.

The action plan and preventive measures put in place should be monitored and updated in case of changes in local epidemiological trends, new cases of COVID-19 at the workplace, or lack of compliance by workers, visitors, and clients or customers.

The large-scale public health and social measures introduced by countries in response to COVID-19 may also amplify some other risks for health, safety, and wellbeing at work due to alternative work arrangements, job insecurity, sudden loss of income, social isolation, and fear of contagion. Actions on prevention and mitigation of COVID-19 should be implemented together with actions for addressing other occupational safety and health risks such as ergonomic problems, heavy workloads and long working hours, remote working, psychosocial risks, poisonings, and others.[25] Occupational health services should strengthen their capacity to carry out risk assessment, infection prevention and control, and medical surveillance and organize mental health and psychosocial support in the context of COVID-19.

In developing and implementing action plans for prevention and mitigation of COVID-19 workers and their representatives should be properly consulted and all workers should be informed about the measures introduced, using specific risk communication and community engagement approaches.

Local authorities and local public health authorities can provide up to date information and facts, support community engagement activities, and offer specific recommendations on the prevention of COVID-19 among other groups of workers, such as domestic workers, workers in the informal economy, digital labour platforms, or others.

There must be no discrimination in the access of workers to protective measures for prevention of COVID-19. Refugee and migrant workers should have equal access to personal protective equipment as well as to COVID-19 prevention, treatment and care, referral, rehabilitation, social protection, and occupational health services, including mental health and psychosocial support.[26] Special efforts should be taken to prevent social stigma of workers suspected of being infected, infected with, or recovered from COVID-19.[27]

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Acknowledgments

This document was developed in consultation with ILO's LabAdmin/OSH Branch.

WHO continues to monitor the situation closely for any changes that may affect this interim guidance. Should any factors change, WHO will issue an update. Otherwise, this interim guidance document will expire 2 years after the date of publication.

WHO reference number: WHO/2019-nCoV/Adjusting_PH_measures/Workplaces/2020.1

Annexure-X

Sample Work Procedure for COVID-19 Risk Management at Workplaces (minimum requirement)

Standard Operating Procedure (SOP)

ADB Loan XXXX -NEP: XXXX

Contract Package: XXXX

Prepared by

XXXXXXXX (contractor's name)

September 2020

This Standard Operating Procedure (SOP) for COVID-19 Risk Management at Workplaces is prepared by contractor and approved by the borrower. The views expressed herein do not necessarily represent those of ADB's Board of Directors, Management, or staff, and may be preliminary in nature.

Table of Content (UPDATE)

I. INTRODUCTION

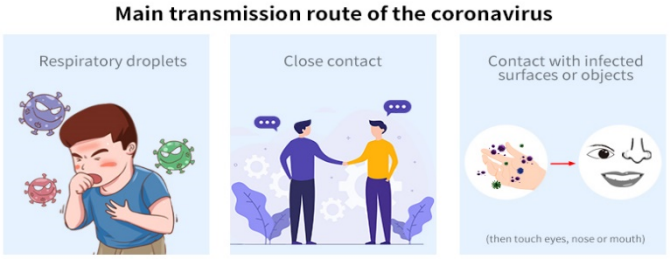
This Standard Operating Procedure (SOP) is prepared for COVID-19 Risk Management at Workplaces while resuming or initiating work as per the following:

Project	:	ADB Loan XXXXXX NEP: XXXXXX
Contract package	:	XXXXXX
Executing Agency	:	XXXXXX
Implementing Agency	:	XXXXXX
Project Management Consultant	:	XXXXXX …….
Contractor	:	XXXXXXX

The objective of this SOP is to lay down a defined and systematic prevention, detection, and emergency procedure to be followed for the COVID-19 risk management while starting and implementing work under the project.

This SOP is a supplemental document to the existing environmental management plan (EMP/SEMP) and occupational health & safety (OHS) plan. This SOP submitted by contractor will be a mandatory procedure approved by the Employer to be strictly followed while implementing the project.

- Droplets –
  - Droplets can be produced during coughing, sneezing or talking.
  - Droplets can travel about 1 m.



- Direct Contact–
  - Hugging, shaking hands and then touch eyes, nose or mouth

- Indirect Contact–
  - Touch infected door-knob, desks, tables, telephones, computers etc.
  - Touch eyes, nose or mouth by infected hand

II. OFFICE MANAGEMENT

A. PREPARATORY WORK

The contractor will organize following arrangements prior to commencing work:

- *SOP for COVID-19 Risk Management at Workplaces* is approved by the Employer
- *COVID Rapid Response Team* is established with TOR of individuals
- *Medical Center* with basic facility is established
- A fulltime Health Worker trained in COVID-19 health care is mobilized
- *COVID Marshals* appointed and oriented on their responsibilities
- Self-declaration form for COVID-19 screening is prepared
- On-line database system is prepared for recording personal, health, and contact details of each staff and worker
- *Cleaning & Disinfecting Team* with dedicated staff formed and trained on the procedure of disinfection
- List of local hospitals accredited for COVID-19 test and treatment is prepared
- Waste management system arranged complying with WHO and government guidelines
- All staff and workers are insured for COVID-19 treatment
- All staff and workers are made aware of emergency protocol & communication system

B. CLEANING AND DISINFECTING OFFICE

Following procedures will be carried out for cleaning and disinfecting office:

- Cleaning and disinfection procedures for each worksite will be prepared and Cleaning Team is trained
- Common areas and frequent touch points will be given priority for disinfection:
  - work-stations (table, chair, shelf)
  - door handles and push plates
  - handrails on staircases and corridors (if applicable)
  - lift and hoist (if applicable)
  - taps and washing facilities
  - toilet flush and seat
  - pantry and eating area
  - printer, photocopier, desktops & mouse etc.

- The team will daily disinfect office twice- before opening and in afternoon
- Record of each cleaning will be recorded in the logbook
- The *Cleaning Team* will be provided with
  - disinfectant spray gun
  - chemicals for disinfection in required quantity
  - PPE (body-cover, rubber gloves, face shield, mask and shoes)
- Personal key, telephone, mobile, keyboard will be disinfected by the staff themselves
- Heating, ventilation, and air conditioning system will be cleaned before opening the office
- One round of pest control will be carried out before resuming the office
- Automatic or foot-operated hand sanitizing stations will be located at building entrance, lobby, meeting room and dining area

- Awareness notice, pictures, posters on safety and hygiene will be pasted at visible locations
- Windows and doors will have fly net and kept open for natural ventilation and sunlight
- Waste bins with cover is placed at each workstation, meeting room, toilet and pantry
- A central collector bin is kept outside the office at safe distance for waste removal and disposal

C. OFFICE ARRANGEMENT

Following measures are undertaken for office arrangements:

- Each workstation will be reconfigured maintaining minimum 1 meter physical distance
- Workstations will be connected with highspeed internet for ease in operating virtually
- Physical interactions will be minimized by adopting remote communication means
- Visitors will be stopped from entering the office except in exceptional and urgent case
- Additional number of disinfected PPEs (mask, gloves, apron) will be kept for use by visitors
- Staff and visitors entering the office will leave their shoes outside and use personal slipper or shoe-cover which will be dropped in designated bin after use

D. STAFF MANAGEMENT

- Arrangement will be made to check temperature and recording self-certifying form by all staff confirming no symptoms or close contact with COVID-19 patient over the last 14 days
- Contact details of each person entering and leaving the site will be maintained for contact tracing in case of emergency
- Contactless attendance system will be arranged (tick-marking by guard or face-scanner, CCTV etc.)
- Staff more than 60 years and those having prior health problems will be closely monitored
- Staff will be split into work shifts to reduce number of people in office at any given time
- Lunch and tea breaks will be split in groups to reduce the number of people in common areas
- Pick-up facility will be provided for all staff and use of public vehicle will be restricted to reduce exposure
- The interior of the office vehicle will be disinfected before and after each use by the driver
- Staff will be encouraged to bring food from home or cooked in office cafeteria, and eat on their desks and dispose leftovers in plastic bag in a collector bin having foot operated cover
- Bi-weekly COVID-19 update and information will be circulated to all using electronic media
- A poster with key "*Code of Practice*" to be followed by staff will be pasted at all visible places

E. STAFF BEHAVIOR

i. Physical Distancing

Staff will be instructed to maintain physical distancing by complying the following:

- maintain a minimum 1 meter distance with each other at all times
- follow floor markings, wherever queue is needed
- adopt distant greetings and avoid shaking hands, hugging etc.

- work at their own workstation and avoid visiting or touching other's workplaces
- communicate and give approvals digitally and avoid circulation of hard copies

ii. Personal Hygiene

The H&SO officer will orient the staff regularly on the following:

- Staff will always wear face mask inside the office premises
- Staff will be encouraged to wash hands thoroughly with soap following WHO guideline or rubbing with 70% alcohol based sanitizer
- Staff will be supplied with paper napkins at workplaces to cover mouth or use elbow while sneezing and coughing
- Staff will be informed to avoid frequently touching nose, eyes, and mouth
- Arrangement will be made for proper disposal of masks as recommended by WHO
- Staff will regularly disinfect personal items like keys, mobile, keyboards, mouse etc themselves
- Staff will clean themselves the used plates and coffee mugs

iii. Meeting Etiquette

- Face-to-face meetings will be discouraged
- Digital meetings, mobile, text message and conference calls will be given preference
- Following protocols will be put in place to conduct unavoidable physical meetings:
  - meeting room will be thoroughly disinfected before and after meetings
  - windows and doors will be kept open for natural ventilation
  - restrict persons feeling unwell from attending the meeting
  - distant greeting and no physical contact
  - sensor-based or pedal operated hand sanitizer station will be placed at the entrance
  - keep at least 1 meter distance between participants at all time
  - face same direction to the extent possible
  - use facemask all the time
  - facemask will be provided to those who did not bring their own mask
  - participants will maintain respiratory etiquette by covering mouth/nose while sneezing
  - participants will be minimum essential persons, and others can join virtually
  - directly focus on agenda and discuss essential issues to keep the meeting short
  - supply onetime use paper cups and automatic hot water dispenser, tea/coffee/ creamer bags and sugar cubes, although serving tea/coffee could be avoided
  - avoid serving meals
  - clean dustbins and sanitize room immediately after meeting

iv. Visiting Site or Client's Office

Contractor will make following arrangements while visiting Client's office or work sites for monitoring:

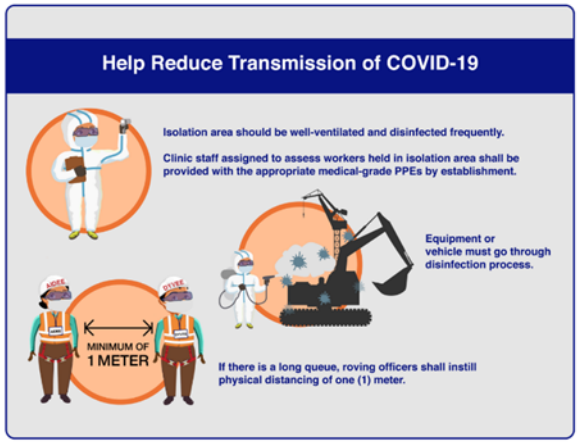
- Preparation before travelling:
  - only essential meeting and site visits will be allowed after approval of site in-charge
  - visit will be restricted in the COVID-19 hotspot areas
  - employees having higher health risk (aged, having diabetes, heart and lung disease) will not be allowed to visit the areas where COVID-19 is spreading
  - staff will carry alcohol-based hand sanitizer while visiting site for frequent sanitization

- Practice during and after visit to client's office or work site:
  - only essential staff will visit site and client's office
  - instructions by local authorities on movement or gatherings will be followed
  - disinfected company vehicle will be used for official visits
  - only 40% of the vehicle capacity used by keeping a seat left vacant in-between
  - only office staff will be allowed to enter the office vehicle
  - wear facemask or face shield at all time
  - wash or sanitize hand regularly and before and after the visit
  - maintain at least 1 meter physical distance with all persons and equipment
  - do not touch unnecessary tool, equipment, paper or other items at site
  - use own notebook, pen and mobile for photo or recording
  - do not enter labor camp and monitor from distance or by photograph
  - discuss with workers in open area and not more than 15-25 workers at a time
  - virtual monitoring will be arranged by using audio-visuals and remote monitoring such as photo and video clips, virtual site tour with help of site staff, CC camera at key areas, and use of drone, as is feasible

III. COMMENCEMENT OF WORK IN CONSTRUCTION SITES

A. PREPARATION BEFORE WORK

- Worksite and camp will be secured with gated fence, guarded 24 hours and having CC camera surveillance
- Photo Identity Card will be issued to all workers with unique identification number
- Preparation will be made for daily medical screening (thermal check and symptoms assessment) of all workers and reported to H&SO
- COVID Marshal will measure temperature by wearing facemask and gloves for their gang of workers before leaving camp



- Worker with a temperature higher than 36.6 ^{0}C will not be allowed to work. The worker will be asked to stay in quarantine in camp (for residential worker) or sent back home (non-residential worker)

COVID-19 लक्षणहरू (Symptoms)		
सबैभन्दा सामान्य लक्षणहरू (Most normal): – ज्वरो आउने (fever) – सुक्खा खोकी लाग्ने (sore throat) – थकाइ लाग्ने (weakness)	**सामान्यतया कमै देखिने लक्षणहरू (General):** – पीडा हुने वा दुख्ने (pain) – घाँटी दुख्ने (throat pain) – पखाला लाग्ने (dysentery) – आँखा पोल्ने (burning eye) – टाउको दुख्ने (headache) – स्वाद वा गन्ध थाहा नहुने (smell and taste loss) – छालामा दाग हुने वा हात वा खुट्टाका औँलाको रङ उड्ने (rash on skin)	**गम्भीर लक्षणहरू (Critical):** – सास फेर्न गाह्रो हुने वा पटकपटक सास फेर्नुपर्ने (difficulty in breathing) – छाती दुख्ने वा छातीमा दबाब पर्ने (chest pain) – बोल्न वा हिँडडुल गर्न नसक्ने (loss of voice and movement)
तपाईंमा गम्भीर लक्षणहरू देखिएमा तुरुन्तै चिकित्सा जाँच गराउनुहोस्। जहिले पनि आफ्नो डाक्टर वा स्वास्थ्य सुविधा प्रदायककहाँ जानुअघि कल गर्नुहोस् **(Please consult your doctor if you have serious symptoms)**		

- COVID Test will be conducted for all staff and workers, as agreed with Employer
- Register or on-line database for each worker will be maintained
- Quarantine at required numbers and a few isolation tents will be kept ready for emergency use. They will be located at sufficient distance from regular shelters in the camp
- Specific and separate worksite will be assigned to the new group of workers away from regular workers for a minimum of 14 days to minimize risk
- Work will be arranged in shifts to avoid crowding of workers. Teams will be divided based on (i) workers residing in the same camp (ii) workers residing outside the camp (iii) new group of workers etc.
- Consumption of liquor and chewable like Khaini, Surti, Paan etc. (those generating urge for frequent spitting) will be strictly restricted inside office and work areas

B. PROCEDURE AT ENTRY IN THE CAMP

- Guards will be oriented by the H&SO on the process of (i) checking temperature, (ii) observing health symptoms, (iii) record personal details and travel history, and (iv) taking emergency procedure, if required
- Unauthorized person and visitors will not be allowed to enter
- All personnel and visitors will compulsorily sign-in on arrival and sign-out when leaving the site (refer **Annex 1** for sample form)
- New group of workers will be mobilized only after showing COVID Test certificate from authorized government hospital issued within the last 7 days, which will be checked by the Health Worker at the Medical Center
- Guards will wear prescribed PPEs at all the times and regularly disinfect their hand
- Guard will immediately inform the Health Worker for staff and worker showing symptoms
- Personnel should maintain at least 1 m distance at all times and follow the floor-marking wherever queue is required
- Guard will direct vehicles supplying materials to go directly to the delivery zone
- Guard will inform the visitors on fulltime use of mask/face shield and hand washing/sanitizing

C. MINIMIZE WORKER AND COMMUNITY CONTACT

The Contractor will be fully responsible to ensure taking all preventive measures for possible transmission of COVID-19 risks among staff, worker and local community:

- Project Manager will work closely with the Site In-charge and Resident Engineer for planning special measures and expedite work implementation at high risk areas and areas requiring work in close proximity with the communities
- Physical barricades will be made mandatory to separate and minimize contact between workers and local people in linear type of work or work area not within a secured area

- Arrangements will be made to minimize movement of workers from barricaded work areas and camps to visit settlement areas
- Work sites will be separated into working zones to keep the groups of workers physically separated. Not more than 20 workers will be allowed to work in one group. A group leader will be identified as *COVID Marshal* who will be trained to keep close watch of workers movement and trigger emergency protocol in emergency case
- Emphasis will be given to establish sufficient size of labor camp to keep all workers inside the camp to minimize contact with community

D. TRAVEL TO WORK SITE

The contractor will arrange following arrangement for transporting workers to the worksite:

- Travel between sites and labor camps will be arranged through official vehicle
- All workers will wear facemask when travelling in a shared vehicle, including the driver who will wear mask/face shield, glove and body cover
- Driver will sanitize hand regularly and before and after every trip
- Only 40% capacity of vehicle will be used and a seat will be kept empty in between
- Windows will be opened for natural ventilation
- Workers will stay facing away from each other while in the vehicle
- Vehicle will be cleaned and disinfected thoroughly after every shift- with emphasis on handles, steering wheel, gear etc.
- All workers prior to entering the vehicle and exiting will sanitize their hands
- Prior to entering the vehicles all nonresidential staff and workers must self-certify that they do not have any COVID-19 symptoms

E. TOOLBOX TALK

The Site In-charge and/or H&SO will daily conduct toolbox talk with the workers with following:

- *Tool Box Talk* will be organized in an open space maintaining a physical distance of minimum 1 meter between each worker
- Total number of workers will not be more than 15-25 persons in a session
- Workers will stand side-to-side and face same direction
- The *Tool Box Talk* will also cover SOP related information such as (i) proper use, handling and disposal of PPEs, (ii) need of cleaning and disinfecting living areas and working tools, (iii) procedure to follow if a co-worker feels sick, and (iv) about the emergency procedure

Source of photo: SOP, NCRTC, India

F. MINIMIZE WORKERS MOVEMENT OUTSIDE THE CAMP

- Workers will be discouraged staying outside camp and take all measures to minimize movement of workers in and out of the construction site
- Transport facility will be arranged to workers who have to stay outside camp
- Existing contract will be extended to keep healthy workers at site for longer period

- Resident workers will be restricted from leaving camp for non-essential purposes
- Workers will be discouraged to meet family and friends while staying in camp. Take approval form Site In-charge if urgent to meet them using PPEs
- Local labors and resident labors will not be mixed by arranging work and area distribution
- Restriction will be put on social gathering
- All required groceries, vegetables, food items, medicine and other essentials for workers will be supplied at the labor camp. Workers will not go to market to buy these themselves
- Arrange recreation facility within camp for workers

G. DISINFECT PLANT AND MACHINERIES

- Contractor will not enter site for resuming work until Employer approves the SOP (for new contracts)
- Disinfection plan will be prepared for work area, tools and equipment, plant and machineries
- Dedicated *Cleaning Team* will be assigned to disinfect door handles, railings, ladders, switches, controls, shared tools and equipment, taps, toilets, and personal work areas at least twice a day based on established schedule
- Disinfection for plant, machineries, vehicles, and tools will be arranged. Efficiency of disinfecting tunnel will also be assessed
- Manual equipment and tools will be disinfected upon change of user
- Record of the schedule of cleaning and disinfecting will be kept for routine verification by H&SO
- Regular orientation will be provided to workers on disinfection procedure for personal belongings and room
- Awareness materials on COVID-19 safety guidelines and needed personal behaviors at work area will be pasted at all visible and common locations

H. LINEAR WORK (TRANSMISSION LINES, UNDERGROUND CABLING)

- Information on COVID spread will be collected from local authorities before planning work for Transmission Lines at particular area
- Site In-charge will group workers into small teams of not more than 15 people at each work site. Teams will be divided based on following:
  - workers residing in the same camp
  - workers residing outside the camp
  - intermittent workers
  - new workers
- Temporary hard barricade and full cover by green net will be done at work sites to minimize contact between workers and local people
- Workmen will be deployed in different locations, wherever feasible, to ensure social distancing

- Work will be divided into shifts to minimize crowding. If possible, working hours will be planned at certain hours to minimize contact with people
- Sequence of work will be followed to ensure work at stages with presence of minimal required number of workers
- Workers will be transported from their camp by office vehicle
- Workers will wear facemask/face shield, rubber glove, and safety boot at all time
- Workers will be discouraged from using other workers' phones, clothes, wallets, things or work tools and equipment
- Work will be immediately stopped and workers brought back to camp in areas where COVID-19 case is identified. Resume work after clearance by local authority
- Non-residential workers will not be mobilized. All workers will stay inside the camp
- Workers will be provided lunch, tea, water at work site
- Movable prefabricated toilets will be used at work sites
- Facility for regular handwashing using soap will be arranged at all sites
- Working tools will be disinfected before and during work at required intervals

I. WORK IN SUBSTATION

Attention will be given to the following while work involving handling of hazardous solid waste:

- The substation area will be secured and fenced with 24 hours guarding
- Workers will be tested for temperature and fill health screening form before entering the work area
- Camp will be inside substation, or adjacent, if required by leasing land so that workers do not have to commute
- No worker will be allowed to stay away from camp
- Work area will be kept well drained, dry and clean
- Workers staying in outside camp will be tested for temperature and sanitize hand before entering the substation premises
- All workers will compulsorily wear (i) facemask, face shield, (ii) rubber gloves, (iii) safety boots at all times
- Vehicles entering the site will be disinfected with spray (going through disinfecting tunnel if possible) before entering the site
- Drivers and workers will avoid contact with each other
- Safe drinking water and toilets will be provided in the work area
- Workers will be grouped to work in different shifts to minimize crowd in work area
- Work area will have handwashing and sanitizing stands
- Where possible, system of remote monitoring will be used (CC TV, drone etc.)
- Washing and changing facility will be provided within work area
- Lunch and tea will be served to workers inside the work area under open shed with clean and impervious floor
- *COVID Marshal* will closely keep an eye on fellow workers and report to Health Worker is any one falls sick or develops COVID symptoms
- Work will be stopped if any staff or worker is tested COVID positive, or any active case is identified in the area until the local authority clears to continue with work
- Awareness signboards will be places all over the work area
- Machine and tools used will be placed at a designated place for disinfection after work

J. INSTALLATION OF SMART METERS

Attention will be given to the following while installing smart meters:

- Local authority, police and public will be informed of the work area, time and preparations for COVID prevention prior to visiting private houses for installing the smart meters
- Information on any hotspot areas identified will be recorded and such areas will be avoided for work until cleared by local authorities
- The team will be provided orientation on the COVID prevention procedure to be followed as a part of installing smart meters
- The group of worker visiting the house will be kept minimal essential numbers only
- The workers will commute by disinfected vehicle to the area
- The worker will wear (i) waterproof overalls, (ii) facemasks or face shield, (iii) rubber gloves, and (iv) gumboots
- The workers group will have a *COVID Marshal* responsible to ensure full prevention practice
- The *COVID Marshal* will check temperature of the workers and household family members before starting work and sanitize hand
- The family members will be requested to stay away from work area, and if possible inside their room
- Workers team will disinfect the work area by spraying disinfectant and swapping door handles and common touch points necessary to keep on using
- Workers will maintain a minimum of 6ft from each other while working
- Expedite work without loosing time
- Disinfect the tools and equipment after completing work at one house
- Spray the area upon completion of work
- Workers sanitize their hand after completion of work
- Workers will not use toilets inside the house to the extent possible
- The workers will always avoid contact with residents
- All workers will be closely monitored daily for any symptoms.

K. MANAGE DELIVERY ZONES


ICRC

- Separate team of skilled staff will be designated to support in efficient and safe material loading & unloading in delivery zones
- Delivery vehicle will be parked at delivery zones with limited access to others
- Incoming vehicles and material will be admitted in the area after spraying disinfectant
- Delivery zones will have hand washing facility
- Material and vehicles will be disinfected with 1% sodium hypochlorite solution before handling
- designated handling zone in the project site
- Disinfected materials will remain untouched for at least 24 hours or longer before handling, to the extent possible
- Ensure drivers wash hand before entry, wear facemask and remain inside vehicle
- Workers will use full set of PPEs while handling material

- Workers will wash their hands before and after work

	Disinfectant tunnels for people don't stop Covid-19 spread but may harm people going through: Ministry of Health, Malaysia However, it could be okay for disinfecting outer surface of heavy plant, machineries and vehicles

- Do not exchange anything between the deliverer and the receiver, including documents for signing. Use own pen for signature
- Contactless delivery will be maintained where possible. Drivers and others accompanying will remain in their vehicles
- Keep informative leaflets and signboards at delivery zone

L. PERSONAL PROTECTIVE EQUIPMENT

- PPE will be supplied to all worker (free of cost) based on the nature of work
- PPEs distributed will include facemask, face shield, gloves, safety boot and body coverall, as required based on the nature of work
- *100% Gloves and Mask Policy* will be adopted on site
- *Zero Tolerance* to work without PPE will be adopted
- Cloth masks may be used if medically approved which can be reused after washing and disinfecting. PPE's will be regularly disinfected
- PPEs will be regularly inspected, maintained, and replaced, as necessary
- PPEs, mobile, utensils and working tools will not be shared between fellow workers
- PPEs left behind by out-going workers will be washed by soaking in detergent for 24 hours and kept dry for at least a week before re-use
- The cleaning team will wash and disinfect the left behind PPEs
- Ambulance equipped with necessary PPEs, first aid kits, hand sanitizers will be kept ready at all time

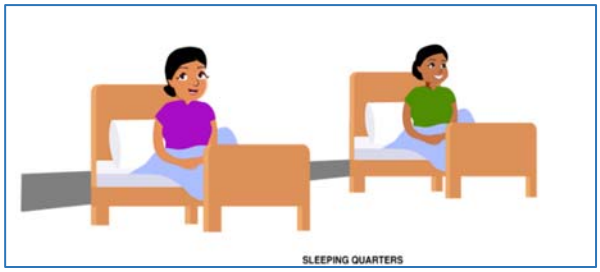
M. MANAGE WORKERS ACCOMMODATION

i. Camp Arrangement

- Labor camps will be well fenced and guarded at all time
- Keep accommodation area clean, well-drained, dry and hygienic
- Rooms designated for sleeping will have proper ventilation to ensure proper air inflow and outflow
- A minimum of 1 meter distance will always be maintained between workers
- 2 meter distance between beds will be maintained.

Tentative view of camp area

- Double bunk beds will not be used
- Separate rooms and toilet for women and male workers with families will be provided
- Camp In-charge will ensure the camps are disinfected at least twice a day and closely monitored by H&SO with help of *COVID Marshals* of the camp
- All door handles, railings, ladders, switches, controls, eating surfaces, shared tools and equipment, taps, toilets, and personal workstation areas will be cleaned and disinfected down at least twice a day. Individuals will be responsible for cleaning and disinfecting their personal space
- Each room will be ventilated for at least 3 hours in a day
- Regularly wash clothes, bed sheets, pillowcases, garments of the workers using detergent and dry in sun
- Hand washing facilities with soap will be kept at common locations in the camp with signs on maintaining good hygiene

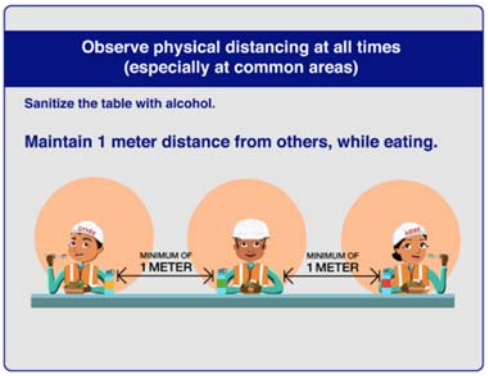

SLEEPING QUARTERS

- Intermittent, new workers and workers returning from hotspot areas will be provided separate accommodation in camps and work areas from existing workforce. As much as possible there will be little to no contact between the workers and the existing workforce for a minimum period of 14 days
- Where possible toilet and shower facilities will be separate for new workers
- Disinfect the camp area and rooms at least twice a day
- Advise workers to keep their waste in personal waste bins and dispose in a common collector bin for removal by garbage truck without entering the camp area
- Adequate number of quarantine rooms will be reserved to accommodate symptomatic workers
- Quarantine and isolation areas will be separate from the rest of the camp site with attached or separate toilet and wash facilities
- Waste disposal areas will be marked, and tightly covered bins will be provided to dispose-off waste
- Restrict access of garbage collecting tractor inside the camp area
- Regularly disinfect the waste bins by spraying disinfectant
- Pictorial posters in local language will be placed across camps to create awareness

ii. Kitchen and Dinning

- The kitchen and dining area will be kept clean, well ventilated, having natural light (sunlight) and dry and well drained impervious floor
- The dining area will be kept under clean and well ventilated area or open shed. Enclosed lunchrooms could be used only when the weather is bad
- The kitchen will be cleaned and disinfected at the end of each break and shift
- Daily screening and health check of the cooks and servers will be carried out
- Cooks and servers wear masks and gloves, and maintain physical distance while cooking and serving food
- Food delivery area will be designated, which will be frequently disinfected
- Food supply from outside the camp will be discouraged

- Number of persons eating at a time will be kept maximum 10 sitting at least 1 meter distance from each other, and stagger time for lunch to minimize people
- Chairs in the dinning will be kept not facing each other but facing the same direction
- Clean the dining tables and disinfect between each use
- Organize break times for eating in a staggered manner to avoid overcrowding
- Hand washing facilities with soap will be kept at the entrance of dinning and will be used by workers when entering and leaving the area
- Keep automatic sensor operated or foot operated water taps
- Workers will use personal plate, water bottle glass/cup and do not share with others



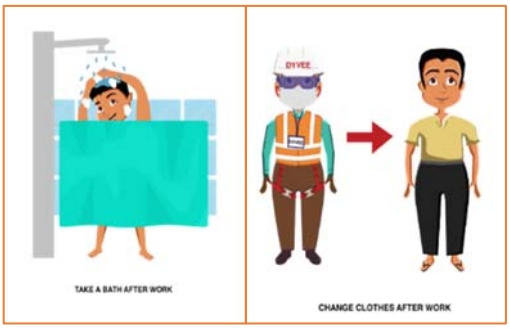
- Workers will dispose waste straight in the waste bin with lid and self-clean the plates
- Use covered and foot-pedal operated waste bins
- Collector bin will be kept at a designated area outside entrance for municipal waste collector to collect and safely dispose
- H&SO will conduct regular inspection of the kitchen/dining area

iii. Toilet

- Toilets will be cleaned, disinfected, and kept dry at least twice daily
- Sufficient toilets for male and female workers will be provided in the camp, at work sites, and for Quarantine/Isolation rooms
- Automatic or pedal operated soap and tap, hand sanitizers, hand dryer, paper towels etc. will be provided as appropriate
- Wall/ doors/ windows and all fittings in washrooms will be thoroughly cleaned each time while disinfecting
- Place enough garbage bins with regular removal and disposal arrangement
- Inspect and verify the entries in the cleaning & sanitization register by H&SO
- Keep sign boards for DO's and DON'T's

iv. Changing Facilities and Showers

- Changing and bathing room will be provided for workers to change into working attire in the morning and change back to regular cloth after work
- Changing area will be kept clean and disinfected twice daily
- Keep the used cloth soaked for washing in detergent soap



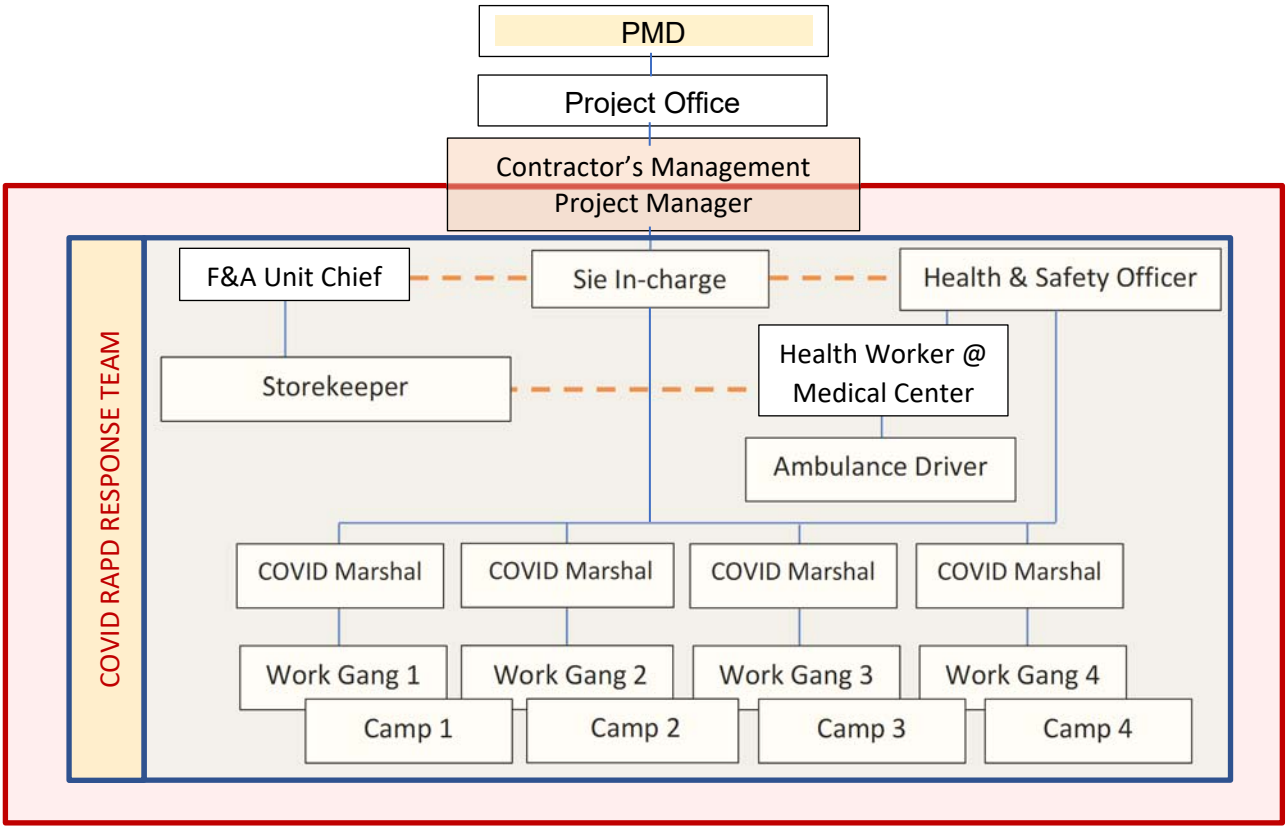
- Designated group of cleaners shall wash PPEs
- Maintain a distance of two meters while changing
- Stagger start and finish times to reduce congestion
- Dispose used PPEs in waste bin with cover, which will be transferred to collector bin for removal according to waste removal plan

IV. EMERGENCY PROTOCOL

A. EMERGENCY RESPONSE TEAM

- A *COVID Rapid Response Team* will be formed with following structure and chain of communication (refer **Annex 2** for list of responsible persons)

Figure 1. SOP Implementation and COVID Rapid Response Team



B. PREPAREDNESS FOR EMERGENCY

- A *Medical Center* of modular reusable structure, having basic medical facilities and a fulltime Health Worker will be established near the entrance. The Health Worker will be trained in handling COVID-19 case
- Full set of PPEs will be supplied to the health worker, guard at entrance, ambulance driver and waste handling staff (body cove, facemask, gloves, boot and face shield)
- A COVID Marshal will be appointed in each labor-gang of max 15-25 workers and cluster of 4 shelters in the camp. They will be oriented on their responsibility to monitor COVID symptom and urgently report to the Health Worker through hotline
- A hotline will be kept at standby to communicate emergency issues and number will be provided to each COVID Rapid Response Team Member

- Sufficient number of Quarantine (10% of total number of workers staying in camp) will be established at sufficient distance from the regular shelters in the camp
- 2 numbers of *Isolation Tents* will be placed with fencing at sufficient distance from the Quarantine and regular shelters in the camp in case of emergency need
- Arrangements in quarantine and isolation tents will be according to the quarantine management guideline of the government
- An ambulance will be kept at standby with interior partition between driver and passengers cabin and full set of medical PPE for driver and attendant
- List of local government hospitals designated for COVID treatment will be prepared with contact number and kept at all visible places
- Medicine to treat COVID patient will be kept ready in the store, in case not available in the market
- Mock drill of activating emergency protocol will be organized once in two months involving COVID Rapid Response Team, staff and workers to keep all alert and ready of their responsibility in case of real emergency situation

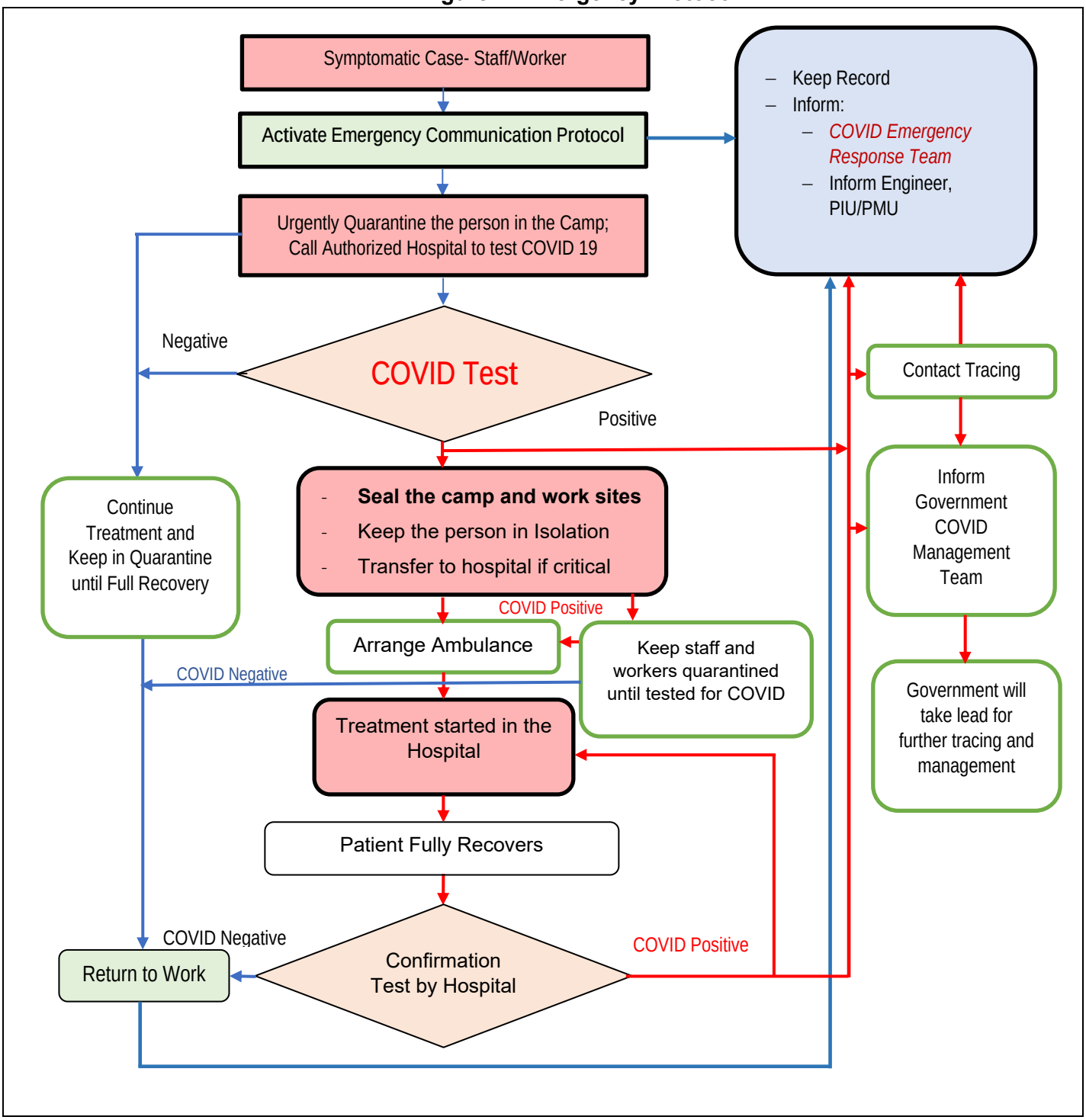
C. EMERGENCY PROTOCOL FOR SYSMPTOMATIC CASE

An emergency protocol will be triggered if a symptomatic case is encountered (refer Figure 1):

- COVID Marshal and staff will immediately contact the Medical Center in case someone becomes unwell
- The Health Worker will alert COVID Rapid Response Team through hotline and screen the sick person for COVID symptoms
- The sick person will be kept in the quarantine tent for precaution
- Worker showing mild symptoms will be made to self-isolate themselves in quarantine area and avoid being in close contact with others
- The Assistant Health Worker will monitor the health condition of the staff and worker at quarantine or isolation and discuss among the Rapid Response Team if the condition of the person does not improve
- Hospital (**Annex 4**) will be notified and arrangement will be made for swab collection of the symptomatic person for COVID test
- If the test result is fond positive, start treatment under doctor's guidance in the Isolation Area in the camp
- Seal the camp and stop all work until the situation is cleared by Hospital
- Help to trace all persons who came in contact with the sick person in last seven days in camp and immediately keep them in quarantine for at least 14 days
- Use ambulance to transfer the person to the designated hospital for treatment if conditions deteriorates critically
- Ensure ambulance is disinfected and driver and helpers use full set of medical PPE
- Disinfect the isolation area used by the infected person
- Used PPEs by infected person will be disposed as per biomedical waste disposal rule of the Government and relevant international good practice guide. PPEs will be disposed-off in a bio-hazard bag (yellow bag) with Sodium Hypochlorite (1%) sprayed inside and after tying the exterior will also be sprayed. That will be disposed- off at destination hospital or designated place for safe disposal

- Conduct COVID test for all persons having contact with the infected person, and continue to keep them in quarantine until test results are available
- A person will be allowed to return to work only after hospital confirms COVID free

Figure 2. Emergency Protocol



V. SOP IMPLEMENTATION, MONITORING AND REPORTING

The SOP implementation team will maintain SOP implementation assurance record. The project management consultant will monitor SOP implementation by using checklist supported monitoring system (**Annex 5**). The Employer will also review overall SOP implementation efficiency and performance through periodic supervision. Following will be carried out for SOP monitoring and reporting:

- Prepare standard SOP compliance monitoring checklist and health screening register
- Develop automated COVID Compliance Management Information System in coordination with the management information system of Employer (if applicable)
- Digital record of all COVID-19 management and SOP compliance activities will be maintained
- F&A, site engineer and H&SO will regularly inspect, check the register, verify compliance, ensure sufficient stock of supplies of PPE and disinfectants, and take required measures
- Ensure employees strictly follow SOP compliance requirements
- Zero tolerance will be followed to casual attitudes by workers (in terms of maintaining distance, wearing masks, maintaining hygiene and overall SOP implementation measures)
- Disciplinary actions will be taken on the worker and employees who willfully violate the prevention and precautionary norms by issuing warning and financial penalty
- A worker will be removed from work if they continue to violate rules even after second warning
- Check option of installing CC TV cameras in key work locations for distant monitoring
- Establish system of taking stagewise photo and video clips or drone visuals and submit to project management consultant to review and verify quality of compliance
- Prepare and submit bi-weekly COVID-19 SOP implementation report in the agreed format (Annex 5)
- Periodically brief the local government and government health agencies, as needed on SOP implementation

VI. AWARENESS AND TRAINING

All the staff members, COVID Rapid Response Team (CRRT) Members, Supervisor & workers will be oriented on COVID-19 risks and controls measures. The awareness program will cover the following:

- Symptoms of COVID-19
- How virus spread
- System and management of symptoms for the cases detected
- Importance of maintaining social distancing
- Importance and DO’s and DON’T's of hand washing
- Overview of the precautionary measure taken at site for COVID 19
- Roles and responsibility of workers specific to the precautions towards COVID-19
- Reporting in case of symptoms of flu
- Emergency procedure to follow during suspected cases of COVID-19
- Updates released by government and other international agencies like WHO
- Handling myths, misconceptions, misinformation and rumors related to COVID19
- Promoting self-hygiene & respiratory hygiene
- Specific roles System and management of symptoms for the cases detected
- Importance of maintaining social distancing
- Importance and DO’s and DON’T's of hand washing
- Overview of the precautionary measure taken at site for COVID-19
- Roles and responsibility of workers specific to the precautions towards COVID-19
- Reporting in case of symptoms of flu
- Emergency procedure to follow during suspected cases of COVID-19
- Updates released by government and other international agencies like WHO
- Handling myths, misconceptions, misinformation and rumors related to COVID19
- Promoting self-hygiene & respiratory hygiene
- Specific roles & responsibilities related to trigger COVID-19 emergency procedure

VII. ROLE AND RESPONSIBILITY

The following sections discuss the role and responsibility of various stakeholders in the SOP implementation and monitoring.

A. MANAGEMENT OF THE LEAD FIRM

- Take full ownership to implement the SOP
- Arrange necessary resources in agreement with Employer

B. PROJECT MANAGER

- Finalize SOP with staff, material and budget and seek PMU approval
- Establish communication with the local hospital serving COVID patients
- Collect field monitoring information and submit bi-weekly report to PMU

C. HEALTH AND SAFETY OFFICER (H&SO)

- Maintain daily labor register on health screening
- Prepare SOP monitoring checklists in collaboration with PMU
- Orient staff and workers on COVID-19 risk management
- Ensure quarantine and isolation area within camp are always in ready condition
- Prepare bi-weekly report of SOP implementation and submit to Project Manager

D. SITE IN-CHARGE AT VARIOUS WORK SITES

- Ensure all SOP requirements are fully followed by workers
- Give daily tool-box-talk to workers also informing COVID prevention
- Ensure workers are using PPEs and maintaining required behavioral practices
- Undertake emergency protocol on any suspect case
- Support H&SO to fill SOP compliance checklist for bi-weekly monitoring report

E. COVID MARSHAL (1 worker in a gang of maximum 25 persons)

- Daily monitor workers' health status and PPEs used as required
- Monitor behavioral practices are followed such as physical distancing at work
- Daily report to Site In-charge/H&SO

F. HEALTH ASSISTANT

- Routine medical screening of workers, check for symptoms and trigger emergency protocol in case of symptomatic case.

G. FINANCE AND ADMINISTRATION SECTION (F&A)

- Manage regular housekeeping, sanitization, and fumigation of office, camps and other work premises and ensure supplies are in the store.

ANNEXES

(Samples Only)

Annex 1: Sample Health Checklist 1: COVID-19 Surveillance Checklist for Workers (Sample)

Project Name:		Location	
Date:		Client Name:	
SN	Description	Yes (✓) NO (X)	Remarks
1.	Temperature (Fever)		
2.	Cold		
3.	Cough		
4.	Difficulty in Breathing		
5.	Are you having any medical illness? (BP, Sugar, Cardiovascular, lung, obesity, kidney etc.)		
6.	Is any of your family members are suffering from above symptoms.		
7.	Have you met any confirmed COVID -19 person?		
8.	Is any of your neighbors are confirmed with Covid-19?		
9.	Is your locality falls in covid-19 containment / Red zone area?		
10.	Have you done hand sanitization before entering site?		
11.	Did you travel beyond your state boundaries earlier (holidays/weekly off)		
12.	Any history of international travel		
13.	Have you received - Nose mask & Hand sanitizer		
14.	Mode of travel used to reach site.		
15.	Whether social distancing (Min-6feet) maintained in case of public transport, site related activities and site office.		
16.	Are you aware about Resilience plan, MHA (Ministry of Home Affairs) updates, and National Directives, State Govt order, Local authority order on Covid-19?		

Declaration by Employee

I _____declare that the information given by me above is true and correct to the best of my knowledge.

Signature of Staff with Date: _____

Medical Professional at site Signature of Appropriate authority or any nearby assigned government approved dispensary/hospital

Signature of Admin. with Date: _____

_____

Signature with Date

Signature of PM/TL with Date: _____

Annex 2: COVID Rapid Response Team

Contractor to fill

Annex 3: Regular Health Monitoring Template at Site XXX (Sample)

Project Name:		Location	
Name:		Client Name:	
S. No.	Description	Yes (✓) NO	Remarks
1.	Temperature (Fever)		Logbook to be maintained
2.	Cold		
3.	Cough		
4.	Difficulty in Breathing		
5.	Have you done hand sanitization before entering site?		
6.	Has the person wearing mask		

Signature of Staff with Date: _____

Signature of Admin. with Date:
_____

Annex 4: Name and Address of Hospital to Contact in Case of Emergency

Annex 5: COVID-19 Risk Management Compliance Monitoring Checklist
(Bi-weekly Report)

SN	Item	Requirements	Status with Details	Remark/Corrective Action
1	Institutional setup			
		• Organizational setup for COVID management established **(Yes/No)**		
		• Fulltime H&SO mobilized **(Yes/No)**		
		• Fulltime Health Worker mobilized **(Yes/No)**		
		• COVID Marshals (1 for max 25 workers) appointed and trained **(Yes/No)**		
		• Guards appointed (**put √ mark**)	• Main site entrance • Office gate • Camp gate • Material delivery area	
		• COVID Rapid Response Team with communication system established **(Yes/No/NA)**		
		• List of COVID Test & Treatment Hospital prepared **(Yes/No)**		
		• Cleaning (House-Keeping) team formed **(Yes/No)**		
		• Disinfecting procedure and schedule prepared **(Yes/No)**		
		• Waste management system arranged **(Yes/No)**		
		• Material handling team for delivery zone formed		
2	Facilities established			
		• Camp and work area fully fenced and guarded **(Yes/No)**		
		• Medical Facility established **(Yes/No- mention arrangement)**		
		• Hand washing or sanitizing stations established (**put √ mark**)	• Entrance Gates • Medical Center • Office • Toilets • Meeting Room • Kitchen/Dinning • Labor Camp • Material Delivery Zone	
		• Automatic or foot-pedal operated liquid soap dispenser arranged (**put √ mark**)	• Handwashing Station • Toilets	
		• Automatic or foot-pedal operated water tap arranged (**put √ mark**)	• Handwashing Station • Toilets	
		• Automatic hand dryer or paper napkin arranged in Toilet (**put √ mark**)	• Dinning • Toilets	
		• Paper napkins arranged at all handwashing stations **(Yes/No)**		
3	Workers Camp			
		• Camp fenced and guarded **(Yes/No)**		
		• Camp standard approved by the Engineer **(Yes/No)**		

SN	Item	Requirements	Status with Details	Remark/Corrective Action
		• Camp capacity to accommodate workers (**%)**		
		• Sufficient number of toilets for male **(Nos.)** and female **(Nos.)**	M ……; F ……..	
		• Camp area has separate room and toilets for female workers **(Yes/No)**		
		• Rooms are well ventilated **(Yes/No)**		
		• Camp area is well drained, dry and on impervious floor **(Yes/No)**		
		• Max number of person in a room (Nos. and distance between bed)	No……; spacing……..feet	
		• Bunk-beds are also used **(Yes/No)**		
		• Waste management system established **(Yes/No)**		
		• All food and provisions are supplied in camp **(Yes/No)**		
		• Outside visitors restricted in camp **(Yes/No)**		
		• Recreational facility inside camp **(Yes/No)**		
4	PPE and associated materials stock			
		• Disinfectant spraying gun available for room and plant & Machinery	Nos……	
		• Sufficient quantity of disinfectant supplied to office, camp, work sites **(Yes/No)**		
		• Sufficient quantity of PPEs distributed and available at stock (**put √ mark**)	• Facemask • Face Shield • Goggles • Glove • Safety boot • Body overall	
5	Cleaning & Disinfection			
		• House-Keeping team is carrying out disinfection at least twice a day (**put √ mark**)	• Office • Camp • Kitchen & Dinning • Toilets • Medical Center	
		• COVID Marshal trained and sprays disinfectant at workplace **(put √ mark)**	• Workplace • Plant & Equipment • Vehicles • Delivery good	
6	Awareness Materials			
		• Signboards, notice, brochure etc. on awareness raising, informative, and safety at all places **(Yes/No)**		
7	Thermal Measurement			
		• Sufficient no. of thermal gun available **(Yes/No)**		
		Identified thermal screening zones **(put √ mark)**	• Entrance Gate • Medical Center • Office Gate • Camp Entrance • Kitchen/Dinning • Material Delivery Zone • Other (mention)	
		• Guard trained in thermal screening		

SN	Item	Requirements	Status with Details	Remark/Corrective Action
		(Yes/No)		
		• All entering the workplace is screened during each entry **(Yes/No)**		
		• Self-evaluation form prepared **(Yes/No)**		
9	Contractor Office			
		• No of time disinfected in a day **(nos)**	…….. times	
		• Contactless attendance system established **(Yes/No)**		
		• Workstations at min 1 m spacing **(Yes/No)**		
		• Number of person in a room	Size of room: No of staff in the room:	
		• High speed internet connection at office **(Yes/No)**		
		• Meeting rooms have physical distancing, hand sanitizer, digital presentation, ventilated room **(Yes/No/NA)**		
		• Tissues and closed bins provided **(Yes/No)**		
		• Use & throw type of coffee/tea service is provided **(Yes/No)**		
		• Mosquito net is fixed and doors/windows kept open for ventilation. Use of A/C is minimized **(Yes/No)**		
9	Staff Management			
		• Office vehicle disinfected and provides pick-up and drop-off **(Yes/No/NA)**		
		• Only 40% capacity of vehicle used **(Yes/No)**		
		• Close monitoring of staff >60 years and with medical history **(Yes/No)**		
		• Staff split in to work shift **(Yes/No)**		
		• Staff brings own food from home or eats in office cafeteria **(Yes/No)**		
		• 100 ml hand sanitizer to each staff **(Yes/No)**		
10	Staff Behavior			
		• Physical distancing is followed and distant greeting **(Yes/No)**		
		• Respiratory etiquette is followed **(Yes/No)**		
		• Staff wears facemask and required PPE inside office **(Yes/No)**		
		• Staff sanitizes hand regularly **(Yes/No)**		
		• Staff uses personal cup/goods and do not share with other? **(Yes/No)**		
11	Visit Client Office			
		• Physical meeting is discouraged and organized only if absolutely necessary **(Yes/No)**		
		• Virtual meeting is encouraged **(Yes/No)**		

SN	Item	Requirements	Status with Details	Remark/Corrective Action
		• Staff use PPE while visiting Client and work site **(Yes/No)**		
		• Virtual monitoring is encouraged-CC camera, photo, video clip, skype video, drone etc. **(Yes/No)**		
		• Only essential staff visits site **(Yes/No)**		
12	Preparation before Work			
		• Confined work areas fenced **(Yes/No)**		
		• Work area hard barricaded **(Yes/No/NA)**		
		• Workers daily thermal and health screened **(Yes/No)**		
		• Workers health record established **(Yes/No)**		
		• All workers are insured for COVID **(Yes/No)**		
		• Test carried out for workers on COVID **(Give detail with reason)**		
		• Quarantine cabins established at ….% of fulltime workers	…..% of total no of workers	
		• New groups of workers are assigned separate work areas **(Yes/No)**		
		• Consumption of liquor and chewable (paan, surti etc) restricted **(Yes/No)**		
13	At Entrance to work area			
		• No outsiders will be allowed to enter work site **(Yes/No)**		
		• Workers will queue-up as per floor marking **(Yes/No)**		
		• Encourage workers to stay in camp	…. % total worker stay in camp	
		• Contactless attendance established **(Yes/No)**		
14	Minimize worker and community contact			
		• Hot spot areas avoided **(Yes/No)**		
		• Any strategy taken for expediting work in COVID high risk areas **(Yes/No)**		
		• Lunch provided to workers at site? **(Yes/No- reason)**		
		• Information disseminated regularly to community **(Yes/No- how)**		
15	Travel in office vehicle			
		• Workers provided transport facility in office vehicle to travel from camp and work area **(Yes/No)**		
		• How does the non-residential workers commute **(put √ mark)**	Walk Public vehicle Office vehicle	
		• Workers and driver wear facemask all the time during travel **(Yes/No)**		
		• Driver uses PPE during service **(Yes/No)**		
		• Only 40% of vehicle capacity is used for physical distancing **(Yes/No)**		

SN	Item	Requirements	Status with Details	Remark/Corrective Action
		• Inside of vehicle is disinfected each time after use **(Yes/No)**		
		• All persons thermal screened and provided hand sanitizer before boarding vehicle **(Yes/No)**		
		• Material transporter is checked for temperature, wash hand and use facemask before entry **(Yes/No)**		
16	Toolbox Talk			
		• Organized in open area maintaining physical distancing **(Yes/No)**		
		• Only 25 workers attend at a time **(Yes/No)**		
		• Talk also Includes COVID information **(Yes/No)**		
17	Disinfection of plant & machine			
		• Equipment & plant disinfection system prepared **(Yes/No)**		
		• Cleaning Team assigned **(Yes/No)**		
		• Vehicle sanitation tunnel established **(Yes/No/NA- alternative??)**		
		• Tools are disinfected before change of users? **(Yes/No)**		
		• Record of the disinfecting maintained and verified by H&SO **(Yes/No)**		
18	Delivery Zone			
		• Separate delivery zone designated **(Yes/No)**		
		• Special team assigned to load/unload material **(Yes/No)**		
		• Fabricated materials and supplies disinfected before handling **(Yes/No)**		
		• Driver remained in vehicle wearing facemask all the time **(Yes/No)**		
19	Kitchen/ Dinning			
		• Eating time staggered **(Yes/No)**		
		• Kitchen, Dinning Tables regularly disinfected **(Nos of time??)**	…….. times a day	
		• Max number of people eating at a time (number)	…….. number at one time	
20	Changing Facility			
		• Changing facility provided **(Yes/No/Not Needed- reason??)**		
		• Used cloth and PPE washing and disinfecting arrangements made **(Yes/No- what arrangement??)**		
21	Emergency Protocol			
		• All staff/worker knows how to trigger the emergency protocol **(Yes/No)**		
		• Quarantine and Isolation Tents are ready with disinfection arrangement **(Yes/No)**		
		• Contact no. of hospital available and pasted at visible places **(Yes/No)**		
		• Ambulance with driver wearing full PPE is at standby **(Yes/No/NA)**		
		• Mock drills carried out **(Yes/No)**		

SN	Item	Requirements	Status with Details	Remark/Corrective Action
		• Any COVID +ve case ?? **(Yes/No)**		
		• If yes, describe the emergency action taken-		
22	Training			
		• Training for staff and workers on COVID organized **(number of training)**	….. numbers	
		• Awareness materials are sufficient at site **(Yes/No)**		
23	Monitoring and Reporting			
		• Checklist based monitoring is carried out **(Yes/No)**		
		• Zero tolerance for casual attitude of workers maintained **(Yes/No- explain what action was taken)**		
		• Virtual monitoring is also used **(Yes/No)**		
		• Bi-weekly submission of checklist to employer **(Yes/No)**		

Conclusion and Recommendation for Corrective Action:

Annex 6: Example of Responsibility and Accountability Matrix for Implementation of the SOP (Sample)

SN	SOP Activities	Executing / Implementing Agency					Contractor						
		PMU/PD	F&A	PIU Chief	Site Engr	All Staff	PM	H&SO	ERT	Superv	Camp Man	Worker	Supplier
1	Conducting meeting to review preparation to resume work before starting work	A	R	R	R		R	R	R				
2	Prepare a site-specific action plan	R		R	R		A	R	R				
3	Screening of staff and workers												
4	Orientation on OHS and SOP												
5	Access control measures												
6	Disinfection												
7	Risk control in lanor camp												
	Labour register												
8	Maintaining physical distancing in work area												
9	Pre-start up check location wise												
10	Promoting self hygiene and respiratory hygiene												
11	Organizing resources for COVID-19 response												
12	Management of awareness raising displays												
	Public consultation												
13	Monitoring of compliance												
14	Reporting symptomatic case												
15	Emergency procedure												
16	Periodic review												

Note: A = Accountable; R= Responsible

Annex 7: List of Emergency Contact Person at Various Work Sites (Sample)

Name	Department	Position	Phone No.	Alternate Contact
	Safety			
	General Office			
	Clinic			
	Processing Dept.			
	Crusher and Batching Plant			
	Store			
	Workshop			
	Camp			
	Tunnel			
	Excavation			
	Tree cutting			
	Construction site			

APPENDIX XI: EMP REQUIREMENT TO BE COMPLIED BY THE CONTRACTOR DURING IMPLEMENTATION (PART OF SUPPLEMENTARY DOCUMENT IN VOLUME II)

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)			Budget/source
						Contractor / Subcontractor	
Project-wide EMP							
Detailed design and pre-construction preparations							
General							
Compliance with national regulations and international good practice guidelines.	Environment, health, and safety impacts and risks of the project in general	• NEA and Contractor to ensure compliance with national and international regulatory framework as set out in Section II of the IEE, including ADB Safeguard Policy Statement (2009), IFC EHS General Guidelines (April 2007), and IFC EHS Guidelines for Electric Power Transmission and Distribution (April 2007) plus other applicable environment, health and safety laws and regulations in force during project implementation, in addition to any further mitigation measures set out in this EMP.	No breaches of national regulations and/or international good practice guidelines.			Contractor to comply with requirements throughout contract implementation.	Part of contract cost, include costs of implementing EMP as BOQ line
Grievance Redress Mechanism (GRM).	Environment, health, and safety impacts and risks of the project on affected persons; including construction workers and affected local communities	• NEA with support of Contractor to establish multi-level GRM as per Section VII of IEE, including identification of GRM Officers at all GRM levels and Grievance Redress Committee members. • NEA and Contractor to carry out community awareness raising during community meetings and one-to-one discussions about the GRM with directly affected persons before the commencement of works including details of how to submit a grievance to either NEA and/or the Contractor, consultations are to be documented. • NEA and Contractor to disseminate GRM contact details verbally and by SMS as well as through distribution of leaflets, and prominently posting GRM arrangements on noticeboards located at the project sites and at local NEA offices, project substations, community centers etc. • Contractor to carry out awareness raising amongst workers about the GRM at the start of their employment on-site, including details of how to submit a grievance to either NEA and/or the Contractor. Disseminate GRM contact details verbally and by SMS as well as through noticeboards located at temporary construction workers camps and construction site offices. • Contractor to ensure that throughout construction, signage is prominently visible detailing site and office contacts in case of grievance. • NEA and Contractor to encourage affected persons to make use of the GRM yet clarify that this does not prevent them from pursuing any legal action, if they feel that it is needed.	GRM operationalized upon loan effectiveness, affected persons are aware of its existence and are actively using GRM to raise their grievances. 100% of grievances received are resolved in a timely manner by NEA and Contractor. Details of GRM operationalization including photos of awareness			Contractor to comply with requirements throughout contract implementation.	Part of contract cost, include costs of implementing GRM as BOQ line

APPENDIX XI: EMP REQUIREMENT TO BE COMPLIED BY THE CONTRACTOR DURING IMPLEMENTATION (PART OF SUPPLEMENTARY DOCUMENT IN VOLUME II)

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)			Budget/source
						Contractor / Subcontractor	
		• NEA and Contractor to inform communities about the ADB Accountability Mechanism and their possibility to resort to it if any of their grievance is not resolved by the project's GRM. • NEA and Contractor to keep record of grievances received and their resolution as report on these, as per Section VII of the IEE.	raising activities to be submitted in first monitoring report, records and grievances and their resolution specified in subsequent monitoring reports.				
Environment safeguards staffing – see also site-specific measures for additional staffing requirements	Environment, health, and safety impacts and risks of the project in general	**Contractor:** • Contractor to employ as part of the team delivering each package at least one suitably qualified and experienced, dedicated, environment officer and at least one suitably qualified and experienced, dedicated, health and safety officer responsible to be based on-site and monitor and supervise safeguards implementation on a day-to-day basis for the duration of the works. • Contractor to nominate a community engagement/GRM officer as part of the team delivering each package/lot to be based on-site and keep affected persons informed of the status of works and be available to receive and deal with any grievances at the project site level, for all new transmission lines this will be a dedicated officer. • Contractor's environment safeguard team to oversee EMP implementation, providing guidance on corrective action as required, and recording construction activities and environment, health, and safety conditions on-site through photos and notes. • Contractor's environment safeguard team will be based on-site. • Contractor to ensure each active construction site or team has a project manager based on-site full-time who is nominated to the role of EHS Supervisor with responsibility for ensuring EMP implementation by their site/team, acting on the advice of, and reporting to the environment safeguards team on compliance. Project manager will be supported by full time OHS steward(s) for each construction site/team who will supervise all works. • NEA and Contractor should not discriminate and should proactively encourage the employment of suitably skilled women on the project.	Contractor environment safeguards team appointed upon commencement of contract, CVs for approval of environment safeguard team submitted as part of bid or subsequently for approval of NEA before field mobilization. List of staff and copies of CVs to be submitted in first monitoring report, any updates/changes in staffing specified in subsequent monitoring reports.			Contractor to comply with requirements and appoint required staff for the duration of their contract.	Part of contract cost, include costs of safeguards staffing as BOQ line

APPENDIX XI: EMP REQUIREMENT TO BE COMPLIED BY THE CONTRACTOR DURING IMPLEMENTATION (PART OF SUPPLEMENTARY DOCUMENT IN VOLUME II)

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)			Budget/source
						Contractor / Subcontractor	
Meaningful consultations with affected people and other concerned stakeholders.	Environment, health, and safety impacts and risks of the project in general, community could be disrupted and disturbed by works hence they need to be consulted and kept well informed about the project and its progress	• NEA with the support of the PSC to prepare detailed communication/consultation plan upon loan effectiveness. • NEA will not award any contract for project components until meaningful consultation requirements are confirmed as met by ADB. • During detailed route surveys, Contractor to consult one-on-one with all affected persons within ROW of transmission lines as well as all persons occupying properties in close proximity to the substations up to 500m and within the ROW up to 50m of the transmission line alignment, to seek their views and respond to individual environment, health, and safety concerns about alignment. Obtain no objection from private landowners. • Contractor to consult with and seek the agreement of local communities on their proposed locations for any temporary construction workers camps, site offices, storage areas, and areas for waste management, etc. • Contractor to consult with and seek the agreement of local communities to temporarily use any community resources (e.g., water supplies, village ponds) during construction to identify any potential conflict, if additional demand may place stress on community resources plan for alternative sourcing for these resources for project needs. • Contractor to communicate at least four weeks (one month) prior to the commencement of works, advance notice to local communities within 500m of substations and transmission lines verbally through NEA local offices and contact with village heads and through notices, pamphlets or similar in Nepali about the agreed schedule of and details of planned construction works in their area to help manage any disruption and disturbance and potential conflicts with local communities. • Contractor to continue to undertake one-on-one consultation with affected persons, especially those within ROW of transmission lines and within at least 20m of new substations who will be most impacted to keep them fully informed of the nature of works and latest schedule, notifying them at least four weeks (one month) prior to the commencement of works of intended start date and schedule. • NEA and Contractor to ensure, in the context of the COVID-19 pandemic, that all consultations are carried out following latest national COVID-19 requirements and WHO social distancing and hygiene guidelines as detailed in Appendix 8 of the IEE. • Consultations undertaken during project implementation will be documented as reported in either final/updated IEE or attached to periodic monitoring reports.	Detailed communication/ consultation plan reflecting final EMP requirements developed upon loan effectiveness. Meaningful consultations for all project components undertaken, documented, and reported on in final IEE. Local communities and other concerned stakeholders kept informed throughout project implementation. Details of ongoing consultations, including photos and records of participants (including gender) documented and included in			Contractor to comply with requirements prior to the commencement of works, and then continue to remain actively involved with the local communities through ongoing consultations throughout contract duration. .	Part of contract cost, include costs of implementing EMP as BOQ line

APPENDIX XI: EMP REQUIREMENT TO BE COMPLIED BY THE CONTRACTOR DURING IMPLEMENTATION (PART OF SUPPLEMENTARY DOCUMENT IN VOLUME II)

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)			Budget/source
						Contractor / Subcontractor	
			monitoring reports.				
Obtain necessary national EIA/IEE/other environmental approvals, and other EHS permits and licenses	Environment, health, and safety impacts and risks of the project in general	• Contractor to comply with the conditions of the national EIA/IEE, if there is any conflict between the measures set out in this EMP and the national EIA/IEE conditions most stringent provision will take precedence. • Contractor to acquire all other national EHS permits and licenses required by national laws and regulations, ensuring that these are all obtained before start of related works, including enabling works.	100% of applicable clearances, permits and licenses obtained prior to the start of works. Copies of clearances, permits and licenses to be submitted with monitoring reports.			Contractor to comply with requirements prior to the commencement of works, and to comply with any conditions imposed throughout contract duration. .	Part of contract cost, include costs of implementing EMP as BOQ line
Update and disclose IEE prior to contract award, update as required to reflect detailed designs.	Environment, health, and safety impacts and risks of the project in general	• If a change in project scope or design occurs during project implementation or if unanticipated impacts are identified at any point during project implementation NEA to inform ADB and, if deemed appropriate, NEA will update the IEE for clearance and disclosure by ADB. Project components having associated facility unable to avoid significant irreversible impacts post-mitigation on protected areas, natural and critical habitat do not qualify for financing under this project. NEA will ensure all associated facility of the project comply with national laws and regulations, and are consistent with SPS requirements by requiring them to comply with this EMP. • NEA to locally disclose in a timely manner the final IEE, any subsequent updates to it, and other environmental safeguards documentation by posting them on the NEA website and ensuring full copies of the latest IEE and its executive summary translated into Nepali are available at all local NEA offices and project substations. Notices will also be placed on noticeboards at the project sites and local NEA offices and pamphlets should be distributed in the project areas in Nepali, informing of the main findings of the IEE and the availability of the IEE and reports with notice	Updated IEE cleared and disclosed by ADB prior to contract award. IEE updated, as required, to reflect the detailed design for all project components prior to the start of any works. Final IEE, any subsequent updates to it, and other			Contractor to immediately inform NEA if any unanticipated impacts are identified at any point and make a copy of the latest IEE available at the project sites.	Part of contract cost, include costs of implementing EMP as BOQ line

APPENDIX XI: EMP REQUIREMENT TO BE COMPLIED BY THE CONTRACTOR DURING IMPLEMENTATION (PART OF SUPPLEMENTARY DOCUMENT IN VOLUME II)

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)			Budget/source
						Contractor / Subcontractor	
		given that help with their translation into Nepali and affected persons' dialects will be extended free of charge on request.	environmental safeguards documentation are locally disclosed.				
Bidding and contract documentation, contractor, and subcontractor management.	Environment, health, and safety impacts and risks of the project in general	• Contractor will preferably have in place corporate environment, health and safety policies and corporate environment, health, and safety management system certifications, such as, ISO 14001 for environment, ISO 45001 for health and safety, or equivalents. • Contractor will comply with all relevant provisions of the final EMP and any updates to it following detailed designs or in response to any unanticipated impacts, they will be responsible for implementing and budgeting for all the measures required. • Contractor will comply with any corrective action plan required and cover the costs where corrective action is required due to non-compliance on behalf of the contractor, its subcontractors or third parties. • Contractor will ensure all its subcontractors and third parties, irrespective of being formally or informally employed, also comply with the final EMP and any updates to it, as well as their own CEMP and H&S Plan, and that this responsibility is cascaded down any chain involved. • Contractor will not engage in any activities described on the ADB Prohibited Investment Activities List in Appendix 5 of ADB's SPS (2009) • Contractor to ensure no persons under 18 are employed on the project. • Contractor will put in place appropriate incentives and/or penalties for (non-)compliance by workers related to PPE, prohibition on firewood and NTFPs collection and fishing, hunting, or poaching by workers.	Final EMP cleared by ADB and related provisions included in all bidding and signed contract documentation. No breaches of final EMP by contractor, subcontractor or third parties with prompt corrective action taken if it is required.			Contractor to comply with requirements throughout contract implementation, ensuring adequate budget for implementing final EMP is included in their contract cost.	Part of contract cost, include costs of implementing EMP as BOQ line
Trainings and awareness raising activities.	Environment, health, and safety impacts and risks of the project in general.	**<u>EHS management:</u>** • Contractor to ensure all members of its project management team, environment safeguards team, design team, construction management team, and community engagement/GRM officers attend NEA trainings. • Training of all PMD and O&M staff on the climate change impact of SF6, alternatives, H&S risks during O&M due to presence of toxic byproducts, leakage minimization, and environmentally sound and safe disposal of old equipment with SF6	Detailed training plan reflecting final EMP requirements developed upon loan effectiveness.			Contractor to comply with requirements throughout contract implementation, including conducting training sessions	

APPENDIX XI: EMP REQUIREMENT TO BE COMPLIED BY THE CONTRACTOR DURING IMPLEMENTATION (PART OF SUPPLEMENTARY DOCUMENT IN VOLUME II)

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)			Budget/source
						Contractor / Subcontractor	
		Construction workers: • Contractor to conduct training for construction management and provide all workers and visitors on-site, irrespective of them being formally or informally employed by contractor, subcontractor or third-party with an environmental, health and safety induction before being allowed on-site including do's and don'ts in relation to construction site, temporary workers camps, local communities, protected areas, etc. • Contractor to ensure topics covered by training and induction will include but not be limited to: good housekeeping at all times; environmentally sound waste management practices; hygiene and communicable disease prevention including COVID-19 and HIV/AIDS; snake and rodent bites and precautionary measures for avoidance i.e. avoid work after rain, flood, and in the crop ripening seasons, caution while putting hands in holes; sexual exploitation, abuse and harassment prevention; culturally acceptable practices; biodiversity conservation awareness; fire safety prevention; prohibition on firewood and NTFPs collection by workers; prohibition on fishing, hunting, or poaching by workers; heritage conservation awareness; chance find procedures; OHS, including use of PPE; etc. • Contractor to conduct training for construction management and regular drills involving workers irrespective of them being formally or informally employed by contractor, subcontractor or third-party on emergency preparedness and response procedures in case of an environmental or health and safety incident including spillage, fire, natural disaster, disease outbreak etc. Training for construction management will include modules on first aid and fire safety including include training on how to use first aid and firefighting equipment provided on-site and the scenario of potential or confirmed COVID-19 infection on-site. • Contractor to continue to deliver short environmental, health and safety refresher sessions to construction management and all workers on a monthly basis throughout construction period, and cover pertinent environmental, health and safety topics on daily basis in toolbox talks. • Contractor to ensure workers with a specific role have attended specialized health and safety trainings related that role e.g. first aiders, fire safety officers, as well as ensuring workers have task-specific trainings for working at height, working with electricity, etc. **Community awareness:**	Trainings and awareness raising delivered in accordance with the plan. Contractor and construction workers fully aware of their responsibilities under EMP through training. Details of training and awareness raising sessions, including photos and records of participants (including gender) documented and included in monitoring reports.			and ensuring relevant staff attendance.	

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						Contractor / Subcontractor	
		• Contractor to undertake construction safety community awareness raising activities in local affected communities within 500m of substations and transmission lines prior to construction. • NEA to undertake electrical safety community awareness raising activities in local affected communities within 500m of substations and transmission lines prior to construction, awareness raising activities to be repeated on completion of construction; to include electrocution risks, EMF, corona noise, etc.					
Detailed design.	Environment, health, and safety impacts and risks of the project in general	• NEA and Contractor to address all site-specific measures detailed in this EMP with regards biodiversity and physical cultural resources as well as other sensitive receptors during the detailed design, as well as ensuring the detailed designs reflect international engineering best practice/ good EHS practices. • Contractor's detailed designs will be reviewed by the PSC to confirm that all measures required by the final EMP have been adequately incorporated and that they reflect international engineering best practice/good EHS practice before they are approved by NEA. **Disaster risk management:** • During detailed route survey identify presence of any floodplain, waterlogged or unstable land, avoid locating any project components in such locations, including areas of the Terai that get waterlogged when temporary inundation occurs during the monsoon. • Select an appropriate foundation design for substations and towers considering climatic factors such as wind, geological factors such as seismic risk, and hydrological factors such as high groundwater table or karst in the project component locations. • Given high seismic risk across the project area, design of all substation and tower foundations and any structural components (e.g., buildings) to consider seismic zone, main frontal thrust, main boundary thrust etc. and be checked for seismic safety by the design team as well as by an independent expert, separate to the design team, to confirm that international good practice seismic design standards are met. • Buildings, transmission towers, and conductors to incorporate climate adaptation measures as per the CVRA, including to withstand extreme temperatures and gale force wind speeds, at minimum equal to upper end of gale conditions on Beaufort scale (40 knots) given 30 knots experienced during the 31 March 2019 tornado event in Nepal.	NEA approved detailed designs minimize impacts and risks on environment, health and safety during construction and operation & maintenance stages.			Contractor to comply with requirements prior to approval of detailed design.	Part of contract cost, include costs of implementing EMP as BOQ line

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		• Consider placement of equipment within substations to avoid water logging in operation & maintenance, ensure placement above the maximum flood level (allowing for climate change) and incorporate adequate drainage design to avoid waterlogging during the wet season. • Drainage will be designed so that discharge from substation site is no more than greenfield runoff rates; so as not to exacerbate flooding on land which is outside of the substation/downstream. • Set all transmission towers back by at least 100m from the edge of river banks and irrigation canals. • Detailed design to avoid locating any towers in river beds and irrigation canals, tower design at crossing locations (single wire spans) to keep tower footing away from the river and irrigation canals by 100m. • In the event towers sited in locations that get waterlogged when temporary inundation occurs during the monsoon cannot be avoided, they will be of suitable construction and raised above the high-water level. **<u>Pollution risk management:</u>** • Use of PCBs will be prohibited in all new transformers and any other project facilities or equipment provided by the project. • Equipment purchased by NEA or Contractor for use on the project is to be accompanied by letter from the manufacturer stating that it is guaranteed PCB free and to be labelled as PCB free before its installation. • Contractor to provide NEA with material data sheets for insulating oil meeting technical specifications for use in new transformers. • During detailed route survey identify presence of any surface waterbodies including rivers/ponds and groundwater sources including springs/wells/pumps/water spouts and confirm if any are used by local communities for drinking water. • Contractor to coordinate with Department of Water Resources and Irrigation and relevant irrigation authority where ROW crosses rivers and water channels to obtain their no objection. • Detailed design of substations to locate new transformers; storage areas; and septic tanks/soakaway ideally 500 m from any surface waterbodies and groundwater sources but at least 100m to reduce pollution risk. If closer placement is required due to substation's proximity to surface waterbodies and groundwater sources, further assessment to be carried out by Contractor to demonstrate using source-pathway-receptor model that there will be no adverse impact on aquatic ecology or human health.					

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						Contractor / Subcontractor	
		• Detailed design of transformers and fuel, oil chemical, and waste storage areas to incorporate impermeable concrete surface bunded to 110% volume which is not connected to the drainage system to collect spills and leaks; ideally storage areas to be 500m to water sources (surface water and groundwater wells, springs, water spouts etc.) but if this is not possible minimum distance is to be 100m. • Detailed design of fuel, oil chemical, and waste storage areas to provide for a covered storage area of sufficient size to accommodate all anticipated storage requirements, ensure storage areas have the ability to be locked, are well-ventilated and will not reach extreme temperatures. • Substation detailed design to incorporate adequate drainage; no drainage water will be permitted to discharge direct to surface water, oil interceptors are to be fitted on all drainage to catch oil spill. • Detailed design of substations to minimize cut and fill in order to reduce the extent of earthworks and thus dust generation during construction. • Detailed design of substations to ensure operation noise will be limited to the following as 1 hour LAeq: (i) 70 dB(A) at the site boundary; (ii) at residential properties, 55 (day) and 45 (night) dB(A) in urban areas and 45 (day) and 40 (night) dB(A) in rural areas as defined by Nepal regulations; and (iii) at "peace areas" such as schools as defined by Nepal regulations, 50 (day) and 40 (night) dB(A) – if these levels are already exceeded by the background, the Contractor will ensure that the noise standards are met by the project design alone and/that substation operation will not result in an increase of 3dB(A) above background levels. • Detailed design of transformers and other noise sources to locate them as far as practical from the substation site boundary since noise diminishes with distance, at minimum given transformer noise is generally in the range 60-80 dBA they are to be located at least 10m from substation site boundary – if this is not possible Contractor must carry out noise calculations (modelling) to demonstrate that site boundary levels can be met. • If any properties are within 100m of the substation site boundary then baseline measurements must be carried out during detailed design and noise calculations (modelling) considering low frequencies associated with transformer hum undertaken by the Contractor to demonstrate that these noise levels will be met. • If noise levels cannot be met through siting alone detailed design to incorporate acoustic barrier designed to international good practice					

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		around either the noise source and/or substation site boundary to attenuate noise to level such that noise levels will be met. **Health and safety:** • Use of any asbestos containing materials is prohibited. • Include in the design of all substations and transformers within the substation a secure wall or fence with lockable entry featuring written and visual warning signs to include the ISO 7010 "Hazard Type: Electrical Symbol" warning of the risk of electrocution. • Include in the design of all towers anti-climb features together with posting of written and visual warning signs to include the ISO 7010 "Hazard Type: Electrical Symbol" warning of the risk of electrocution. • Contractor to ensure detailed design of transmission lines incorporates lightening protection to minimize fire risks. • Detailed design of substations to include fire safety measures including detector, alarm, and firefighting equipment in accordance national regulations and IFC EHS Guidelines on OHS. • Indoor work areas at substations to be well ventilated and well-lit in accordance national regulations and IFC EHS Guidelines on OHS. • Detailed design of substations to ensure EMF levels within the substation boundary are within international good practice levels as per International Commission on Non-Ionizing Radiation Protection (ICNIRP https://www.icnirp.org/cms/upload/publications/ICNIRPemfgdl.pdf) (reference and peak values) for the occupational exposure; in areas where EMF levels could be exceeded posting of written and visual warning signs. • Detailed design of substations and transmission lines to ensure EMF levels at all regularly occupied properties is within international good practice levels as per International Commission on Non-Ionizing Radiation Protection (ICNIRP) (reference and peak values) applicable to the public exposure. • Use of shielding equipment/materials to decrease electromagnetic field exposure. • Establish applicable right of way and safety clearance corridor in accordance with the Electricity Rule. During detailed route survey identify the presence and use of any structures found in the (i) right of way and (ii) safety clearance corridor. Consider re-siting of angle point towers such that any structures are outside the ROW or if not possible outside the safety clearance corridor. If it is not possible to avoid regularly occupied					

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		structures in the safety clearance corridor these are to be relocated with adequate compensation in accordance with the Resettlement Plan. Such properties must be relocated, and applicable compensation provided by NEA prior to the start of any works. Consider grounding roofs and other metallic surfaces on any properties remaining within ROW to avoid induced current and electricity related accidents. • During detailed route survey identify presence of any existing utilities such as power lines, communications, streetlights, groundwater pumps, water spouts as well as through consultation with service providers (electric, water, gas, telecoms etc.) • In cases where excavation works may be needed, including drilling or open trenching for underground cables, underground utility scans using a Cable Avoidance Tool (CAT) or equivalent must be undertaken by the Contractor to identify any services. • Contractor to coordinate with operators where ROW crosses existing utilities to obtain no objection. • Detailed design to consider the risk of damage to utilities and allow for sufficient vertical and horizontal safety clearances to minimize health and safety risks as per the Electricity Rules, and crossings for communications as per Electricity Regulation 1993. • Pit latrines and disposal of untreated sanitary wastewater to surface or groundwater is prohibited. Detailed design of substations to include adequate sanitation and welfare facilities for all NEA workers to be posted at or visiting the substations including indoor kitchen, eating and sleeping facilities (if applicable) and adequate number of indoor toilets/washrooms with a hot and cold running water supply which are connected to either existing sewerage system or to septic tank with soakaway. • Disposal of worker generated waste (e.g. plastic bottles) on-site is prohibited and adequate waste storage areas to be incorporated into the detailed design. Composting of food waste may be permitted on-site if detailed design incorporates enclosed composting facilities (enclosed to avoid attraction of vermin etc.) located away from accommodation and any properties outside the site boundary. Incineration may be permitted on-site if detailed design incorporates an enclosed, small volume solid waste incinerator with stack and pollution control that is designed for residence time and temperatures that minimize incomplete combustion for waste disposal at substation, to reduce the volume of solid waste to be removed off-site given lack of suitably engineered and licensed sanitary waste facilities in rural municipalities.					

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		• Source of drinking water that meets drinking water standards to be provided to substations. If substation is in district which suffers from arsenic contamination of drinking water, groundwater must not be used, and alternative source must be identified. If any surface or groundwater sources are proposed for use in substations, Contractor is to undertake a baseline water quality sampling per EMoP (Table 10.B) to confirm its suitability for use. If drinking water standards are not met, detailed design to consider alternative source or include water treatment facilities at the substation to facilitate safe drinking water supply. • Provide a dedicated shelter to security guards, shielding them from rain, wind, and extreme (hot and cold) temperatures. **Greenhouse gas emissions:** • Use of chlorofluorocarbons (CFCs) including halon is prohibited. • Detailed design of GIS substations will comply with international norms and standards for handling, storage, and management of SF6. • SF6 insulated equipment will be tested and guaranteed by the supplier at less than 0.1% leakage rate. • SF6 emergency response plan to be prepared by contractor for construction, NEA in relation to operation to deal with event of an accidental leak.					
Planning for on-site environment, health, and safety management.	Environment, health, and safety impacts and risks of the project during construction in general.	• NEA and Contractor to address all site-specific measures detailed in this EMP with regards biodiversity and physical cultural resources as well as other sensitive receptors before commencing construction works, including any enabling works, ensuring that all pre-construction preparations reflect international engineering best practice/good EHS practices. • Contractor's pre-construction documentation will be reviewed by the PSC to confirm that all measures required by the final EMP have been adequately incorporated and that they reflect international engineering best practice/good EHS practice before they are approved by NEA. • Contractor to prepare and submit a Construction Environmental Management Plan (CEMP) to NEA for approval, for each works package. CEMP to include details on how the Contractor plans to implement the construction mitigation measures specified in the final EMP, and the relevant parts of the IFC EHS General Guidelines including the Construction and Demolition section, and IFC EHS Electric Power Transmission and Distribution Guidelines. The CEMP will also identify the	CEMP and topic- and site-specific sub-plans including CPPP, CWMP, CTMP, BMP, HMP, CFP, CHSMP, CEPRP all prepared and approved prior to any construction works, including enabling works.			Contractor to comply with requirements prior to any construction works, including enabling works.	Part of contract cost, include costs of implementing EMP as BOQ line

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		temporary construction facilities needed and their location e.g., laydown and storage areas, workers facilities, etc. • Contractor to keep CEMP as a living document, to be updated as required and re-approved by NEA if any changes in construction methods, site conditions etc. **Land take:** • Ensure relocation and compensation of any affected persons within the ROW has been paid and ensure effective relocation of any households living within the safety clearance corridor (Electricity Rules) has taken place prior to any construction work. **Biodiversity management**: • Contractor to strictly locate all temporary construction facilities outside of forest areas, all temporary workers camps unless within substation boundaries are to be located at least 500 m for forest areas. Location of related project facilities is to be identified by contractor, PSC international biodiversity expert to review if locations are suitable prior to NEA approval. • Include in CEMP or site-specific BMP emergency fauna rescue and handling procedure, including contacts of protected area management, nearest veterinary etc. **Physical cultural resources management (chance finds)**: • Contractor to strictly locate all temporary construction facilities at least 100m from any identified physical cultural resource e.g., temple. • NEA to develop a Chance Find Procedure (CFP) to be followed by contractor as part of their CEMP prior to commencement of any works, including enabling works, to address the event any physical cultural resources (including fossils) are found during works. CFP is to include the following procedures: o If suspected physical cultural resources are encountered, halt all works at the find site immediately. o The find should be assessed by a competent DOA Official, and procedures to avoid, minimize or mitigate impacts to such physical cultural resources to be agreed in writing with them. o Work will not resume until the procedures to avoid, minimize, or mitigate impacts to the physical cultural resources have					

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		been agreed with DOA and confirmed by them in writing to have been implemented in full. o If avoidance is not feasible, and no alternatives to removal of the physical cultural resources exist, thorough cost-benefit assessment need to be carried out to assess whether the project works should continue or stop at site. If the project benefits outweigh the anticipated cultural heritage loss from removal from site, following clearance of ADB the physical cultural resources are to be removed and preserved using the best available technique in accordance with relevant national heritage protection laws and regulations as well as international best archeological practice. o Records to be maintained of all finds, including chain of custody instructions for movable finds. o Construction workers must be made aware of the chance-find procedure and the types of finds (including fossils) to be reported through training and induction before the commencement of any works. **<u>Pollution risk management</u>**: • The Contractor will prepare for NEA approval a construction pollution prevention plan (CPPP) as part of the CEMP covering dust and emissions to air management, noise management, the protection of water resources and environmentally sound and safe storage, use, and disposal of all fuels, chemicals and oils used on site and an emergency preparedness and response plan in the event of any leaks or spills in accordance with national laws and regulations and the EHS General Guidelines prior to commencement of any works. • The Contractor will prepare for NEA approval a Construction Waste Management Plan (CWMP) as part of the CEMP for dealing with all solid and hazardous waste generated in an environmentally sound and safe manner in accordance with national laws and regulations and the EHS General Guidelines section on Waste Management prior to the start of any works. • Contractor to undertake air quality monitoring per the EMoP (Appendix 10, Table 10.B) to confirm current background levels in the project area at least one week prior to the commencement of any actively on-site. • Plan construction works in the vicinity of waterbodies, considering erosion issues and surface water pollution risk.					

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		• If any surface waterbodies or groundwater sources within 100m, Contractor is to undertake a baseline water quality sampling per EMoP (Table 10.B) to confirm their current water quality status at least one week prior to the commencement of any actively on-site. • Contractor to schedule, as far as practical, earthworks at substation sites and installation of towers during the dry season to minimize exposed areas subject to erosion by surface water runoff. • To inform development of the CPPP in relation to noise management, the Contractor will be required to measure and confirm the distance from their construction works to sensitive receptors during the detailed design, to confirm if the noise standards can be met based on their construction methods or temporary acoustic barriers are required. • Contractor to undertake noise monitoring per EMoP (Table 10.B) to confirm current background noise levels in the project area at least one week prior to the commencement of any actively on-site. • Construction methods to ensure construction noise will be limited to the following as 1 hour LAeq: (i) 70 dB(A) at the site boundary; (ii) at residential properties, 55 (day) and 45 (night) dB(A) in urban areas and 45 (day) and 40 (night) dB(A) in rural areas as defined by Nepal regulations; and (iii) at "peace areas" such as schools as defined by Nepal regulations, 50 (day) and 40 (night) dB(A). • If noise levels may be exceeded, Contractor to erect temporary acoustic barrier around either the noise source and/or site boundary to attenuate noise to level such that noise levels will be met. • For any sites where piling or blasting may be necessary for substation or tower foundations, Contractor to identify properties at risk of vibration damage, undertake a through structural survey, supported by photographic evidence of any properties at risk, and determine whether such buildings may require the installation of vibration monitors during construction to monitor movement. **Health and safety:** • For each contract package, the Contractor is to undertake a H&S risk assessment through a facilitated workshop to be attended by PMD, PSC and the Contractor during the detailed route survey so that it can inform both the detailed design and pre-construction preparations. H&S risk assessment to consider both occupational and community H&S risks resulting from the construction and operation & maintenance stages of the project.					

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		• Informed by the H&S risk assessment, Contractor to prepare a Construction Health and Safety Management Plan (CHSMP) for each package/lot including site-specific measures as needed for each construction site. CHSMP will address both occupational and community H&S risks and adherence to national health, safety labor laws and regulations. Measures reflected in the CHSMP will be in accordance with the EHS General Guidelines sections on Occupational and Community Health and Safety and the Electric Power Transmission and Distribution Guidelines. • Contractor to keep CHSMP as a living document, to be updated as required and re-approved by NEA if any changes in construction methods, site conditions, in response to accident, near miss etc. • In the absence of NEA records to confirm transformers are PCB free (ones installed post-1990 should have records, NEA to facilitate access to data archive) all existing transformers already in-situ must be assumed by the Contractor for health and safety purposes to contain PCBs and if needing to be disturbed by them the oil must be sampled and analyzed following UNEP Guidelines for the Identification of PCB and Materials Containing PCB and a health and safety risk assessment and plan prepared referring to the measures in UNEP (2002) PCB Transformers and Capacitors: From Management to Reclassification and Disposal. Provide workers with training on PCBs and their safe handling and disposal. • Label any equipment or container containing PCBs found in existing transformers and other project equipment and unless being retained in-situ replace it with new PCB free equipment under the project. NEA must ensure appropriate transport, storage, decontamination, and disposal of redundant contaminated units; disposal should involve facilities capable of safely transporting and disposing of hazardous waste containing PCBs. A hazardous waste management plan to be prepared for handling PCBs. • Assess surrounding soil exposed to PCB leakage from equipment removed or retained in-situ and implement appropriate removal and / or remediation. • CHSMP to include a Construction Emergency Preparedness and Response Plan (CEPRP) including communication systems and protocols to report an emergency situation (health emergency, work-related accident, traffic accident, accident involving the community, natural disaster, fire especially forest fire, virus outbreak etc.). • Contractor to set up an accident reporting system for any health and safety incidents (near miss, minor, lost time, fatal) involving workers or					

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		community to be reported to PMD within 24 hours of occurrence with a response plan detailing the incident and how its reoccurrence will be avoided. NEA to then report any lost time or fatal incidents to ADB within 48 hours. Record of all incidents and response taken should include date, time, details of incident, treatment given and outcome, and lessons learnt for the future. • CHSMP and its CEPRP are to be submitted for approval of NEA prior to commencement of any works, including enabling works • In undertaking H&S risk assessment and preparing CHSMP and CEPRP adequate attention will be given to the risks associated with COVID-19 pandemic and other communicable viral diseases. National restrictions for containing the spread of COVID-19 must be complied with and Government of Nepal (https://covid19.mohp.gov.np/) and ADB guidance (https://www.adb.org/publications/safety-well-being-workers-communities-covid-19) is to followed, as well as further guidance detailed in Appendix 8. Contractor will provide adequate sanitation and welfare facilities including hand washing and clean PPE in sufficient quantity are provided on-site and at accommodation; Contractor will also consider the ability of communities to comply with protective measures such as regular handwashing and the local health care facilities' capacity to deal with any infections agreeing with the with nearest Health Center and/or Hospital for emergency cares of workers. Particular attention must be paid to accommodation of workforce given the transient nature of work on transmission lines, to avoid spreading any virus between communities. CEPRP must include response flow chart and contact details to deal with any construction worker or community member being diagnosed with COVID-19 during the course of the works. To limit contacts and hence contamination risk, the same workers should be grouped in accommodation, transport, and work teams. Medical insurance will be provided by Contractor for all workers with sick leave allowance to ensure symptomatic workers do not attend site; Contractor will avoid no-work-no-pay policies, whereby by fear of not getting paid workers would be tempted to report to work and hide any symptoms, creating more risk for the wider workforce and community. Given the unprecedented nature of responding to COVID-19, public health officials/experts must be consulted in undertaking the risk assessment and management planning for COVID-19. **Traffic management:**					

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						Contractor / Subcontractor	
		• For all works on or adjacent to public roads, the Contractor will prepare for NEA approval a Construction Traffic Management Plan (CTMP) appropriate to the pedestrian and vehicular traffic flows on the road as part of the CEMP in consultation with relevant local authorities/traffic police to ensure proper execution of traffic controls including where temporary blockage of the road during installation is required for health and safety purposes and ensure that highly visible guides, advance warning signs or flag persons are in place to direct pedestrian and vehicular traffic. **Damage to crops, structures, and utilities:** • Contractor to maximize use of existing substation compounds for temporary construction facilities (e.g., laydown and storage areas, workers facilities etc.) • Contractor to locate temporary construction facilities as much as possible on uncultivated land (not natural habitat) to minimize disturbance to cultivated lands. • Contractor to locate temporary construction facilities (e.g., laydown and storage areas, workers facilities etc.) at least 500m away from residential areas/villages within rural areas, at least 500m from surface waterbodies, groundwater wells/springs/water spouts, and 100m from other sensitive receptors (e.g., individual houses, schools, clinics, temples, touristic areas etc.) avoiding land which is steeply sloping or in floodplain/waterlogged. • Construction methods to be selected to minimize risk of damage to roads, utilities, structures, drains etc. • For existing roads, irrigation canals, utilities, structures, drains etc. photographic and/or structural pre-condition surveys are to be completed by the Contractor and agreed with NEA and property owners prior to any works, including enabling works. These must be documented in a pre-project condition report submitted to NEA, which will serve as baseline in case any damage to property occurs • Contractor will be required to restore any property damage that is caused by their works including damage caused by heavy construction traffic using access roads to at least pre-project condition at their own cost. • Contractor to avoid piling or blasting and other vibration inducing activities as much as possible; in locations where this is unavoidable Contractor to identify properties within the zone of influence and undertake pre-construction structural surveys to identify level of risk. Risk may be high if structures previously damaged during earthquake and					

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Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)			Budget/source
						Contractor / Subcontractor	
		not repaired. If risk of structural damage to properties identified due to current condition, consider alternative construction method or temporary relocation of occupants during works if at risk. Consider need to install monitors during construction to monitor structural movement. Structural or cosmetic damage to be repaired by Contractor to at least pre-project condition at their own cost.					
Employment of staff for construction	Temporary employment opportunities, both skilled and non-skilled laborers will be required.	• Contractor to abide by the Nepal Labor Code and labor regulations • Contractor must prohibit child labor (under 18 years old). • Contractor should not discriminate in employment • Contractor should proactively encourage employment from local communities where appropriately skilled. • Contractor should proactively encourage employment of women on the project where appropriately skilled. • GRM will be available to workers for receiving and handling complaints about unfair treatment or unsafe living or working conditions, ensuring no coercion nor reprisal. • Provide health/accident insurance for all workers (formal and informal) for the duration of their contracts. • Contractor to allow a minimum number of sick leave as per Nepal law or 10 days per year, whichever is the higher.	No child labor has been recruited, as per detailed record of employment, and gender/age/origin analysis, provided in monitoring reports.			Contractor to comply with requirements throughout contract implementation.	Part of contract cost, include costs of implementing EMP as BOQ line
<u>On-site enabling works, construction works, testing and commissioning of project components</u>							
Physical Environment							
On-site pre-construction and construction activities	Changes in topography/ terrain as a result of earthworks, primarily at substations	• Comply with CEMP during construction works • Contractor to examine stability of tower locations before excavation. • Balance cut and fill in the areas where leveling of sites is required. • On completion of works re-vegetate disturbed areas to avoid soil erosion. Restore temporarily used sites to at least their pre-project condition following works.	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA and Contractor			Contractor to comply with requirements throughout construction.	Part of contract cost, include costs of implementing EMP as BOQ line

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Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)		Contractor / Subcontractor	Budget/source
			as determined through regular site checks, photographic record etc. No outstanding topography / terrain related grievances from local communities.				
On-site pre-construction and construction activities	Changes in ambient air quality - dust and suspended particulate matter from earthworks, and other pollutants from vehicular emissions, may affect ambient	• Comply with CEMP, CPPP, and the IFC EHS General Guidelines in relation to air quality and avoid the occurrence of pollution incidents as far as practicable • Require construction equipment and vehicles to meet national emissions standards, see Appendix 2 of IEE. • Perform regular checks, upkeep, and maintenance of construction equipment and vehicles to keep them in good working order as per the manufacturer's specifications to meet emission standards. Keep log of maintenance undertaken. • Sprinkle water during earthworks to avoid dust being dispersed by wind, cover with materials like gravel to minimize re-suspension of dust. • Stockpiles of spoil and other dust generating materials to be kept to a minimum necessary to undertake works for the day • Cover stockpiles with tarpaulin. Locate stockpiles at least 500m from residential property to avoid inconvenience to avoid inconvenience from fugitive dust and ensure they are enclosed by a fence or similar to minimize windblown dust. Minimize double handling and drop loads. • Trucks importing loose raw materials or removing spoil to local approved disposal sites must be covered with tarpaulin to reduce dust generation, all trucks used are to be serviced and meet Nepal emission standards and belching of black smoke prohibited. • Position any stationary emission sources (e.g., water pumps, diesel generators, compressors, etc.) as far as practical from sensitive receptors (houses, schools, clinics, temples, touristic areas etc.) • Impose speed limits on construction vehicles to minimize exhaust and dust emissions along areas where sensitive receptors are located (houses, schools, clinics, temples, touristic areas etc.).	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA and Contractor as determined through regular site checks, photographic record etc.			Contractor to comply with requirements throughout construction, keep required maintenance records and undertake ambient air quality monitoring in accordance with the EMoP	Part of contract cost, include costs of implementing EMP as BOQ line

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Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)			Budget/source
						Contractor / Subcontractor	
	air quality with impacts on the health of workers and community.	• Trucks transporting loose material will be covered. • Limit engine idling to maximum 5 minutes. • Sprinkle excavations, earthen access road, and material stockpiles with water during the construction period to mitigate dust related issues due to frequent movement of construction vehicles as necessary i.e. 2-3 times per day but more often if needed during excavations, dry and windy conditions that enable dust to be easily mobilized and the dust to be visible. Clean dust from the access road after construction work is completed. • Strictly prohibit the burning of wastes generated by project-related activities. • Ensure workers working in close proximity to or having long exposure to vehicle exhausts and earthworks are provided with clean N95 dust masks to avoid inhalation or particulate matter and other pollutants.	Monitoring confirms ambient air quality within national standards or no worsening of the baseline situation if already exceeded. No outstanding air quality-related grievances from local communities or workers.				
On-site pre-construction and construction activities	Changes in ambient noise and vibration levels - mobilization of heavy equipment and machinery, use of construct	• Comply with CEMP, CPPP, and the IFC EHS General Guidelines in relation to noise and avoid the occurrence of pollution incidents as far as practicable • Schedule construction activities so as to minimize nuisance to sensitive receptors (houses, schools, clinics, temples, touristic areas etc.) i.e., avoid works at night, on weekend, during holidays, school exam periods, etc. • Select construction techniques and low noise generating machinery and equipment e.g. less than 55dBA sound pressure level at 1m, and stage noisy works to limit their duration to minimize noise and vibration • Construction noise must be noise limited to the following as 1 hour LAeq: (i) 70 dB(A) at the site boundary; (ii) at residential properties, 55 (day) and 45 (night) dB(A) in urban areas and 45 (day) and 40 (night) dB(A) in rural areas as defined by Nepal regulations; and (iii) at "peace areas" such as schools as defined by Nepal regulations, 50 (day) and 40 (night) dB(A) – if these levels are exceeded the Contractor will be required to implement additional noise mitigation such as placing temporary acoustic barriers around the works site to ensure that the noise standards are met and/or the construction works do not result in an increase of 3dB(A) above background levels.	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA and Contractor as determined			Contractor to comply with requirements throughout construction, keep required maintenance records and undertake noise monitoring in accordance with the EMoP	Part of contract cost, include costs of implementing EMP as BOQ line

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Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)				Budget/source
							Contractor / Subcontractor	
	ion vehicles, and construction activities may increase ambient noise level. Exposure to high levels of ambient noise may affect hearing of workers or cause anxiety and disturbance to community.	• Use of piling or blasting and other vibration inducing activities are to be avoided. • Structural or cosmetic damage caused by vibration to be repaired by Contractor to at least pre-project condition at their own cost. • Require construction equipment and vehicles to meet national standards, see Appendix 2 of IEE– all trucks should carry fitness certificates issued by the Nepal Road Traffic Authority and renewed annually under the applicable regulations of Nepal. • Fit all vehicles, machinery and equipment used in construction with exhaust silencers where the manufacturer's design allows this • Perform regular checks and maintenance of construction equipment and vehicles to keep them in good working order as per the manufacturer's specifications to meet emission standards. Keep log of maintenance undertaken. • Position any stationary emission sources (e.g., water pumps, diesel generators, compressors, etc.) as far as practical from sensitive receptors (houses, schools, clinics, temples, touristic areas etc.) • Prohibit use of horn by construction vehicles • Limit vehicle movement and offloading of construction materials to daytime in areas where sensitive receptors are located (houses, schools, clinics, temples, touristic areas etc.) transport of materials and spoil by truck will be limited to the daytime without hooting. • Impose speed limits on construction vehicles to minimize noise emissions along areas where sensitive receptors are located (houses, schools, clinics, temples, touristic areas etc.). • Limit engine idling to maximum 5 minutes. • Provide appropriate PPE (acoustic ear plugs or earphones capable of reducing noise levels to 80dB(A) for hearing protection) to any workers subjected to noise levels of 80dBA for more than 8hours per day and ensure they wear it e.g. if using breakers. • No unprotected ear should be exposed to a peak sound pressure level (instantaneous) of more than 140 dB(C) or average maximum sound levels of 110dB(A). • Periodic medical hearing checks to be performed on workers exposed to high noise levels.	through regular site checks, etc. Monitoring confirms ambient noise within national standards or no worsening of the baseline situation if already exceeded. No outstanding noise or vibration-related grievances from local communities or workers.				
On-site pre-construction and construction activities	Changes in quality of surface and groundwater – due to sediment laden runoff or spills/lea	• Comply with CEMP, CPPP, and the IFC EHS General Guidelines in relation to water quality and avoid the occurrence of pollution incidents as far as practicable. • Follow General EHS Guidelines in relation to water quality for the use and storage of fuel, oil, and chemical including prevention and control of hazards associated with spill prevention, emergency response, spill clean-up and remediation. • Establish dedicated fuel, oil, and chemicals stores on impermeable bunded area of 110% volume to avoid spills and leaks contaminating soil and affecting water quality • Avoid storage of fuel, oil, and chemicals in areas within 500m to water sources (surface water and groundwater wells, springs, water spouts etc.) to avoid direct contamination or contamination through run off, if this is not possible minimum distance is to be 100m. • Place all equipment that may leak fuel or oil on drip trays it not sited on impermeable surface with 110% bunded capacity.	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA and			Contractor to comply with requirements throughout construction.	Part of contract cost, include costs of implementing EMP as BOQ line

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Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)			Budget/source
						Contractor / Subcontractor	
	ks of fuel, oil and chemicals used in construction works.	• Undertake refueling only on areas of hard protected soil, preferably bunded, at least 500m from surface water, but if this is not possible minimum distance to be 100m, with all drainage directed through oil interceptors. • Provide spill response kit with sufficient absorbent materials (e.g. sorbents, dry sand, sandbags) on-site for soaking up any fuel, oil, or chemical leaks/spills. • For transformers, follow the Spill Prevention Control and Countermeasures (SPCC) plan as recommended by United States Institute of Electrical and Electronics Engineer Inc. (IEEE) standard 908. • Undertake construction during the dry season as much as possible to minimize exposed areas subject to erosion by surface water runoff. • Works over or near watercourses will adopt protection measures to guard against loss of soil that would result in the turbidity of water. • Minimize soil erosion and surface water runoff by reducing the extent of earthworks, revegetating earthworks on completion, and covering stores of sand and spoil with tarpaulin. • Ensure sediment laden runoff shall not discharge directly to surface water but shall be discharged through sedimentation basin and oil interceptor. • If water from excavations is pumped it must either be disposed of to an adjacent defined area of ground for percolation, or to waiting tanker trucks for proper disposal, it must not be disposed of to surface water. • Do not allow washing of equipment or vehicles in surface water and ensure all washing water is discharged to sedimentation basin and oil interceptor instead of directly to surface water. • Cement will be stored in rented private storage facilities; enclosed and not exposed to the elements. • Do not undertake any concrete mixing within 500m of surface water, if this is not possible minimum distance to be 100m. • Provide portable sanitary facilities for construction workers, so as to avoid surface and ground water pollution. Locate these at least 500m away from surface waterbodies including rivers/ponds and groundwater sources including springs/wells/pumps/water spouts, away from floodplain, any waterlogged land and shallow groundwater. • Strict prohibition on open defecation and urination by construction workers; no use of pit latrines for worker camps. • Toilets and washing facilities to be connected to existing sewerage system, septic tank (with soak pit) or as portable self-contained units for disposal of wastewater off site to sewage treatment works. No untreated wastewater is to be discharged direct to surface water or the ground. • Construct adequate drainage with oil interceptors for all new substation sites according to detailed design; install adequate bunding to transformers and storage areas.	Contractor as determined through regular site checks, photographic record etc. No outstanding water quality-related grievances from local communities or workers.				

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Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)				Budget/source
							Contractor / Subcontractor	
On-site pre-construction and construction activities	Use of raw materials and generation construction waste	• Comply with CWMP and with IFC EHS General Guidelines in relation to waste management. • Import all materials from existing licensed sources and keep records of all materials used, and sources. • Storage yards will be fenced. • Prior to the start of works the contractor will ensure the waste management system is established at the construction sites and workers camps. • Separate waste containers (drums, bins, skips or bags) will be provided for different types of waste. • Sensitize workers on good housekeeping and the environmentally sound storage and disposal of construction and wastes, and importantly not to leave garbage lying around. • Collect and segregate construction wastes including scrap metal, oil, and solid waste; ensure all workers are familiar with this segregation and arrange garbage bins to collect these wastes so they are not thrown on the floor • Store all the wastes produced in an environmentally sound manner in designated, labelled area with separate waste containers (drums, bins, skips or bags) for each distinct type of waste. • Store solid waste in enclosed bins to contain leachate and avoid vermin. • Encourage recovery of recyclable wastes that could be reused or sold to recyclers, rather than disposing of it. • Prohibit use of waste (e.g. empty cement bags and containers, plastic, wooden planks) for backfilling – only inert spoil may be used for backfilling to avoid need for off-site disposal (any excess inert spoil is to be disposed of at suitably licensed waste facilities). • Prohibit burning of construction wastes. • Prohibit dumping of construction wastes on-site, into drains, rivers, in agricultural fields etc. • Provide weekly toolbox talk to remind of the importance of waste disposal, prohibition of disposal on the road, in drains etc., prohibition on burning of wastes, and open defecation and urination. Develop a procedure/system to penalize through escalating fines or similar any construction workers who breach these requirements. • Contractor may compost biodegradable kitchen scraps on site if of small volume in enclosed composting facilities (enclosed to avoid attraction of vermin etc.) located ideally 500m but at least 100m from water sources (surface water and groundwater wells, springs, water spouts etc.). • Document all wastes removed off site using transfer notes, to be taken by licensed waste contractors who should reuse/recycle or dispose of the waste to suitably licensed and engineered waste management facilities according to type – for solid waste disposal this will need to be to Kathmandu, and for hazardous waste this will need to be to a neighboring country since no such facilities currently exist in Nepal. • Excavated spoil that cannot be reused to a licensed disposal site as suitable for accepting inert wastes ensuring no solid or hazardous wastes are comingled with the inert excavated spoil • Collect solid waste and dispose of it to suitably engineered and licensed sanitary waste facilities– in Kathmandu as no such facilities are existing in rural municipalities.	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA and Contractor as determined through regular site checks, photographic record etc. No outstanding material use or waste-related grievances from local communities or workers. 100% wastes removed off site have been disposed of by licensed			Contractor to comply with requirements throughout construction, keep records in accordance with the EMoP	Part of contract cost, include costs of implementing EMP as BOQ line

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Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)		Contractor / Subcontractor	Budget/source
		• Ensure any hazardous waste such as oily rags or old drums disposed of in suitably licensed hazardous waste facilities– out of country since no such facilities in Nepal.		waste contractors who reused/recycled or disposed of it to suitably licensed waste management facility, as confirmed by documented full-cycle transfer notes.			
Socio-economic Impacts							
On-site pre-construction and construction activities	Occupational health and safety of workers at risk due to the hazards created during the construction period, e.g. movement of	• Comply with CHSMP and with IFC EHS General Guidelines in relation to occupational H&S. • Ensure health and safety supervisor is on site at all times (implies an alternate off on leave or on sick). • Require subcontractors and workers to confirm they have seen and understood the requirements of the CHSMP before proceeding with their work. • Provide worker training on H&S and daily/weekly briefings led by site-appointed Health and Safety Officer. • PPE to be provided for all workers (regardless formal and informal, directly contracted or subcontracted) in accordance with Table 2.7.1. Summary of Recommended Personal Protective Equipment According to Hazard in IFC EHS Guidelines on OHS. • Enforce disciplinary system (e.g. immediate removal from site) for non-compliance with PPE requirements and other H&S measures (e.g. social distancing for COVID-19). • Check health condition of workers on daily basis, for example, use of self-certification forms and temperature checks before being allowed on the construction site with more thorough monthly health checks by qualified medical professional. • Check the load of the vehicles before use, all drivers, and passengers to fasten seatbelt and comply with all transportation-related H&S laws and regulations • Examination of all equipment and tools' quality and the presence of operational safety features before use	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA and Contractor as determined through regular site checks, photographi			Contractor to comply with requirements throughout construction, maintain records of health and safety incidents per the EMoP and maintain copies of training records.	Part of contract cost, include costs of implementing EMP as BOQ line Budget for compensation included in Resettlement Plan and Indigenous People

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Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)		Contractor / Subcontractor	Budget/source
	heavy equipment, vehicles, and machineries, working conditions, etc. Workers may be exposed to occupational health risks and safety hazards, regarding site clearance for pre-construction and during construction relating to working with electricity and working at height, as well as from	• Implementation of safety measures while excavating to avoid collapse e.g. shoring if soil unstable • Untrained workers will not be permitted to work with live electricity or at height. • Observe IFC EHS Guideline on Electric Power Transmission and Distribution requirements for working with live power lines; only allow suitably trained workers that meet the requirements set out in above-referred IFC guideline to work on live power lines with strict adherence to safety standards including those listed in said guidelines; these workers must have training record of attending suitable training course on electrical safety and be provided with and wear the appropriate PPE for their role. • Ensure proper grounding and deactivation of any live power lines during construction work or before any work in close proximity to the lines and that this has been checked and certified by the on-site Health and Safety Officer in advance. • Measure exposure levels to electromagnetic fields (EMF) and provide workers working in zones where EMF levels are above reference levels with personal EMF monitoring device to be attached onto their PPE. • Require workers to observe the minimum approach distances for excavations, tools, vehicles, pruning, and other activities when working around power lines. • Observe IFC EHS Guideline on Electric Power Transmission and Distribution requirements for working at height; only allow suitably trained and qualified workers to work at height, these workers must have training record of attending suitable training course and be provided with and wear the appropriate PPE for their role. Require workers to test the structural integrity of towers prior to proceeding with the work. Use fall protection measures when working on towers, i.e. mobile elevated working platform, and all workers at height are required to wear body harness. Ensure sufficient harnesses and gear are available on site for all workers, that workers are trained to use such harness and are obligated to use the latter at all times when working at height. • Unless transformers have been certified PCB free workers must wear suitable chemical and/or oil resistant gloves, goggles, and protective clothing whilst working with transformers. Eye wash station and water supply to shower to be provided during works due to risk of PCB coming into contact with skin. • Ensure good housekeeping in the premises at all times, including on construction site, workers camps, storage areas, etc. Perimeter is to be kept neat and tidy, with no trip hazards on the ground e.g. open channels, materials, equipment, trash laying around. Do not leave hazardous conditions (e.g. unlit open excavations without means of escape) overnight unless no access by public can be ensured. • During construction works, ensure qualified first aider and trained fire marshal is available on-site at all times with an appropriately equipped first aid kit and appropriate fire extinguisher and other firefighting equipment immediately available for use. • Provide an ambulance for more serious cases to transport the patient to the hospital for treatment • Prepare signboards reminding of health and safety measures and procedures to follow in case of accident, including key contact details (ambulance, doctor, hospital, etc.)	c record etc. No outstanding OHS related grievances No fatalities or lost time incidents, if they do occur to be reported to NEA board and management within 24h and to ADB within 48h. 100% of H&S incidents including near miss recorded, immediately investigated, and corrective action taken to prevent repeat				

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Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)				Budget/source	
							Contractor / Subcontractor		
	handling PCBs or asbestos in upgrade works at existing substations.	• Keep a log of all incidents, near-misses and accidents and include these in monthly monitoring reports submitted to NEA and periodic monitoring reports to ADB • Temporary construction camps will include proper sanitation, alternative fuel to firewood, clean eating area, water supply, and secure storage of domestic solid wastes for disposal off site to suitably licensed waste management facilities. • Pit latrines prohibited, and adequate number (about 1 toilet per 10 workers, can refer to EBRD guidance note on workers' accommodation) of toilets and washing facility with hot and cold running water. Toilets to be connected to existing sewerage system, septic tank, or as portable self-contained units for disposal of wastewater off site to sewage treatment works to be provided. • Toilets to be equipped with soap and hand sanitizer. • There should be an indication of whether toilet and washing facility is "in use" or "vacant" if not gender segregated. • Toilets should be cleaned at least twice daily to ensure they are kept in a hygienic condition. • Prevent standing water as it may become a breeding habitat for mosquitoes etc. • Provide workers with access to a shaded rest area on-site. • Provide workers with a clean eating area for breaks and lunchtime. • Provide all construction workers will an adequate supply of potable drinking water meeting national standards. Groundwater used must be appropriately treated and only be used where it will not put stress on local water resources. Where a risk of arsenic contamination is identified, prohibit the use of groundwater as a source of the drinking water. • If ground or surface water is used for drinking water, it must first be tested to confirm it meets drinking water standards and continue to be regularly tested every week. If drinking water standards are not met, potable water shall be imported to site. • If workers are not local to the area use may be made of existing accommodation facilities but if a construction camp is provided it must be adequately equipped with sufficient toilets, hand washing facilities, showers or baths, food preparation and clean eating area, etc.						
On-site pre-construction and construction activities	Community health and safety - at increased H&S risk from communicable	• Comply with CHSMP and with IFC EHS General Guidelines in relation to community H&S. • Installation of barriers (a temporary fence ideally solid fence) at construction areas with hazard warning signs to deter people from accessing the construction site • Do not leave hazardous conditions (e.g. unfenced and unlit open excavations without means of escape) overnight unless no access by public can be ensured • Define construction schedule for sections along or crossing roads in coordination with local authorities/traffic police particularly where road closures required. • Implement CTMP during construction works with advance warning signs or flag persons to ensure traffic safety of construction workers and road users, in coordination with traffic police.	Compliance with national laws and regulations. Mitigation measures successfully implemente			Contractor to comply with requirements throughout construction, maintain records of health and safety incidents per the EMoP.		Part of contract cost, include costs of implementing EMP as BOQ line

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Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)		Contractor / Subcontractor		Budget/source
	diseases as workers coming from elsewhere, including COVID-19, social disturbances related to workers camps, traffic, electricity infrastructure etc.	• Road safety and warning signs must be posted at 500m, 100m, and immediately in advance of the works at least two weeks prior to the works commencing to inform the public of the temporary blockage. • Access to the construction site will be under traffic controls when trucks enter and exit. • Require all project drivers to abide by Nepal road safety regulations at all times. • Use of scaffold and bamboo frames to support stringing to protect structures, roads, irrigation canals, utilities etc. as well as pedestrians, vehicles, and the conductor itself. • Restore the utilities immediately after all necessary works carried out to minimize public inconvenience • Construction workers including subcontractors will be given awareness raising in HIV/AIDS, other communicable diseases including COVID-19, and sexual, exploitation, abuse and harassment with strict penalties (e.g. immediate removal from site) for any non-compliance of workers to an agreed code of practice • Avoid ponding of water during construction to avoid habitat creation of vector borne diseases e.g. malaria. • Keep a log of all incidents, near-misses and accidents and include these in monthly monitoring reports submitted to NEA and periodic monitoring reports to ADB	d by NEA and Contractor as determined through regular site checks, photographic record etc. No outstanding CHS related grievances No project-related accident reported within community - if they do occur to be reported to NEA board and management within 24h and to ADB within 48h. 100% of H&S incidents including near miss				Budget for compensation included in Resettlement Plan and Indigenous People

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Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)			Budget/source
						Contractor / Subcontractor	
			recorded, immediately investigated, and corrective action taken to prevent repeat				
On-site pre-construction and construction activities	Loss of physical cultural resources (PCR) - chance find procedures will be implemented in case of chance find (including fossils).	• Comply with CEMP and chance find procedure; implement as soon as any monuments or artefacts encountered during construction activities. • Strictly ensure no chance finds are tampered with. • Brief workers on chance find protocol and on apply penalties applying for tempering with them. • Contractor to declare a chance find to DOA and NEA within 24h of find. • PMD to report on any chance find having occurred within 48h to ADB.	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA and Contractor as determined through regular site checks, photographic record etc. No outstanding PCR related grievances 100% of chance finds were			Contractor to comply with requirements throughout construction.	Part of contract cost, include costs of implementing EMP as BOQ line Budget for compensation included in Resettlement Plan

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

APPENDIX XI: EMP REQUIREMENT TO BE COMPLIED BY THE CONTRACTOR DURING IMPLEMENTATION (PART OF SUPPLEMENTARY DOCUMENT IN VOLUME II)

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

APPENDIX XI: EMP REQUIREMENT TO BE COMPLIED BY THE CONTRACTOR DURING IMPLEMENTATION (PART OF SUPPLEMENTARY DOCUMENT IN VOLUME II)

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)		Contractor / Subcontractor	Budget/source	
Substation operation	Noise in the form of buzzing or humming can often be heard around transformers or power lines producing corona. Transformer oil spill and leakage.	• Maintain transformers and other noise generating equipment to ensure noise to be limited to the following as 1 hour LAeq: (i) 70 dB(A) at the site boundary; (ii) at residential properties, 55 (day) and 45 (night) dB(A) in urban areas and 45 (day) and 40 (night) dB(A) in rural areas as defined by Nepal regulations; and (iii) at "peace areas" such as schools as defined by Nepal regulations, 50 (day) and 40 (night) dB(A). • Transformers to be routinely inspected and maintained to avoid spills and leakage. • Collect and segregate O&M wastes including scrap metal, oil, and solid waste; ensure all workers are familiar with this segregation. • Store all the wastes produced in an environmentally sound manner in designated, labelled area with separate waste containers (drums, bins, skips or bags) for each distinct type of waste. • Store solid waste in enclosed bins to contain leachate and avoid vermin. • Encourage recovery of recyclable wastes that could be reused or sold to recyclers, rather than disposing of it. • Prohibit open/uncontrolled burning of wastes. • Prohibit dumping of O&M wastes on-site, into drains, rivers, in agricultural fields etc. • NEA may compost biodegradable kitchen scraps on site if of small volume in enclosed composting facilities (enclosed to avoid attraction of vermin etc.) located ideally 500m but at least 100m from water sources (surface water and groundwater wells, springs, water spouts etc.). • Incineration may be permitted on-site if enclosed, small volume solid waste incinerator with stack and pollution control that is designed for residence time and temperatures that minimize incomplete combustion for waste disposal at substation is available. • Document all wastes removed off site using transfer notes, to be taken by licensed waste contractors who should reuse/recycle or dispose of the waste to suitably licensed and engineered waste management facilities according to type – for solid waste disposal this will need to be to Kathmandu, and for hazardous waste this will need to be to a neighboring country since no such facilities currently exist in Nepal. • Collect solid waste and dispose of it along with municipal waste to suitably engineered and licensed sanitary waste facilities– in Kathmandu as no such facilities are existing in rural municipalities. • Ensure any hazardous waste such as oily rags or old drums disposed of in suitably licensed hazardous waste facilities– out of country since no such facilities in Nepal. • Label all containers with its content and potential risk signs (e.g. flammable, corrosive, toxic, etc.) Display material data sheets for fuels, oil, or chemicals. If chemicals are handled on site, provide an emergency eye wash or shower. • Store end-of-life or unused equipment in designated areas on site, ensure these are not left lying around. • Store equipment in the dedicated, covered, labelled storage area (tools, machinery, material, equipment, and spare parts)	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA as determined through regular site checks, etc. Monitoring confirms ambient noise within national standards or no worsening of the baseline situation if already exceeded. No outstanding O&M-related grievances from local communities			n/a	

APPENDIX XI: EMP REQUIREMENT TO BE COMPLIED BY THE CONTRACTOR DURING IMPLEMENTATION (PART OF SUPPLEMENTARY DOCUMENT IN VOLUME II)

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)			Budget/source	
						Contractor / Subcontractor		
		• Ensure liquids (fuel, oil, and chemicals, empty drums, old transformers, etc.) are stored in area with impermeable floor with spill containment bund of 110% capacity. • Ensure liquids storage areas are locked at all times. • Keep track of any maintenance activities carried out with regards to transformers (in particular each time transformer oil is changed) on a maintenance logbook kept on the premises. • Ensure transformers have a label indicating it contains PCB (polychlorinated biphenyl) or is PCB free. Obtain and keep evidence to confirm transformers are PCB free, for future reference. • Perform visual checks of any evidence of oil leaking or having previously leaked from transformers, and if identified, address immediately - maintenance of and handling of transformer oil is to be carried out only by trained workers using appropriate PPE. • Keep spill prevention equipment available on site at all times.						
Socio-economic environment								
Presence of electrical infrastructure and need for maintenance	Occupational safety risks (project maintenance workers) and community safety risks	• Ensure adequate sag and tension always maintained. • Maintain warning / advisory signs in good and visible condition on all dangerous equipment. • Maintain the good condition of non-climb features on transmission towers. • Maintain the good condition of boundary fences, regularly check the security fence for any gaps and repair. Keep boundary gates locked at all times (except when workers are in-coming or exiting) but at times when the gate is unlocked, ensure one staff is always present to control any unauthorized entry. • Consider employing security personnel to guard the premises where the risk of entry for theft might be high. • Carry out periodic safety related awareness raising in neighboring communities regarding living in proximity to power lines and substations, including but not limited to, electrocution risks and effects of EMF; include information to the community regarding potential corona noise heard during operation. • NEA to ensure all substation staff and maintenance workers have received appropriate OHS trainings for their role **<u>EMF:</u>** • Monitor electromagnetic field strength workers are exposed to and ensure occupational exposures are within the limits of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) reference level. If EMF limits are often reached, provide workers with personal radiation monitors that shall set off an alarm when exposure limits are reached. • Monitor electromagnetic field strength where regularly occupied properties are in the ROW and ensure public exposures are within the reference levels of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines. **<u>Housekeeping:</u>** • Keep the substation neat and tidy at all times.	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA as determined through regular site checks, photographic record etc. No outstanding H&S related grievances All fatalities reported to government			n/a		

APPENDIX XI: EMP REQUIREMENT TO BE COMPLIED BY THE CONTRACTOR DURING IMPLEMENTATION (PART OF SUPPLEMENTARY DOCUMENT IN VOLUME II)

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)		Contractor / Subcontractor		Budget/source
		• Remove any trip hazards on the ground, e.g. open channels, materials, equipment, trash laying around. • Carry out regular pest control where pests are a risk; favor natural pest control measures when possible. • Display clear emergency exits signs (in working order, if light signs, ensure works) and keep exits clear of any blockage. • Visually inspect for any standing water on site, and when identified, remove or provide appropriate drainage to remove in timely manner; ensure drainage system is not blocked and fully operational. • Maintain all lights in working order. • Ensure all vents are free of blockages and regularly maintained. **<u>Emergency situations:</u>** • Ensure a recent, full, first aid kit and adequate firefighting equipment is available on site at all times, stored in clearly labelled and easily accessible area. • Replace the first aid equipment timely as required to keep all equipment within its expiry date. • Service the firefighting equipment timely as required to keep all equipment in date • Provide first aid and firefighting training to select, volunteer staff; at least one staff having recently carried out first aid and firefighting training must be present on site at all times. Refreshers are to be provided once a year. • Hang posters showing first aid procedures especially for electrocution, and fire procedures, as well as listing all emergency contacts. Display the emergency phone number and location of doctor and hospital in a clear and easily accessible location. • Keep an accident log and make accident logbook available on site upon request. • Monitor closely in case of extreme weather events and be ready to act immediately. • Ensure any buildings on site are structurally sound if any earthquake occurs, check building soundness prior to allowing workers back on site.	within 24h and to ADB within 48h. No project-related accident reported.				
Site-specific EMP								

APPENDIX XI: EMP REQUIREMENT TO BE COMPLIED BY THE CONTRACTOR DURING IMPLEMENTATION (PART OF SUPPLEMENTARY DOCUMENT IN VOLUME II)

Project component or activity	Impact or risk to be mitigated	Mitigation measure(s)	Performance indicators	responsibilities (including implementation, supervision, and monitoring)			Budget/source
						Contractor / Subcontractor	
Mulpani SS	Vibration, Noise and damage to neighboring structures	• Information on construction will be shared with neighboring household regarding prior to commencement of works. • Ensuring safe distance to the neighboring houses are kept from the drilling locations within the Substation premises. • Any structural damage to the neighboring houses caused by the construction works will be compensated. • Ground works will ensure coordinate with the neighboring households on disruption of any utility such as power, water supply etc.	Compliance with national laws and regulations. Mitigation measures successfully implemented by NEA and Contractor as determined through regular site checks, photographic record etc. No outstanding site specific-related grievances from local communities.			Contractor to comply with requirements throughout detailed design, preconstruction, construction.	Part of contract cost, include costs of implementing EMP as BOQ line

CHAPTER 2- GENERAL TECHNICAL REQUIREMENT

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1.0 FOREWORD

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

2.0 GENERAL REQUIREMENT

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

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

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

3.0 STANDARDS

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

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

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

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

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

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

individual chapters for various equipments shall be subject to Purchaser's approval.

4.0 SERVICES TO BE PERFORMED BY THE EQUIPMENT BEING FURNISHED

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

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

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

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

4.5 The equipment shall also comply to the following:

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

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

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

4.6.1 System Parameter

220kV System

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

SL No	Description of parameters	220 kV System
ii.	Phase to earth	2100 mm
iii)	Sectional clearances	5000 mm
10.	Rated short circuit current for 1 sec. duration	40kA
11.	System neutral earthing	Effectively earthed

132kV & 11kVSystem

SL No	Description of parameters	132 kV System	66 kV System	11 kV System
1.	System operating voltage	132kV	66kV	11kV
2.	Maximum operating voltage of the system(rms	145kV	72kV	12kV
3.	Rated frequency	50Hz	50Hz	50Hz
4.	No. of phase	3	3	3
5.	Rated Insulation levels			
i)	Full wave impulse withstand voltage (1.2/50 microsec.)	650 kVp	325 kVp	75 kVp
ii)	One minute power frequency dry and wet withstand voltage (rms)	275kV	140kV	28kV
6.	Corona extinction voltage	105kV	-	-
7.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 92KV rms for 132KV system	500 micro-volt	-	-
8.	Minimum creepage distance (25mm/kV)	3625 mm	1800 mm	300 mm
9.	Min. Clearances			
i.	Phase to phase	1300 mm	1300 mm	280 mm
ii.	Phase to earth	1300 mm	13000 mm	140 mm
iii)	Sectional clearances	4000 mm	3500 mm	3000 mm
10.	Rated short circuit current	31.5 kA for 1 Sec	31.5 kA for 1 Sec	25 kA for 3 Sec
11.	System neutral earthing	Effectively earthed	Effectively earthed	Effectively earthed

Note :

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

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

220kV System

S.N.	Parameters	**220 kV**
(a)	Max. System voltage Um(kV)	245
(b)	Impulse withstand voltage (dry & wet) (kVp)	± 1050
(c)	Power frequency withstand voltage (dry and wet) (kV rms)	460
(d)	Total creepage distance (min) (mm)	6125

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

132kV, 22kV & 11kV System

S.N.	Parameters	**132 kV**	**66kV**	**11kV**
(a)	Max. System voltage Um(kV)	145	72	12
(b)	Impulse withstand voltage (dry & wet) (kVp)	± 650	± 325	± 74
(c)	Power frequency withstand voltage (dry and wet) (kV rms)	275	140	28
(d)	Total creepage distance (min) (mm)	3625	1800	300

4.6.3 Major Technical Parameters

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

4.6.3.1

(A) For 245 kV & 145 kV Equipments

Rated voltage kV (rms)	245	145
Rated frequency (Hz)	50	50
No. of Poles	3	3
Design ambient temperature (°C)	50	50

Rated insulation levels :

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

-	between line terminals and ground	± 1050 kVp	±650 kVp
-	between terminals with circuit breaker open	± 1050 kVp	±650 kVp
-	between terminals with isolator open	± 1200 kVp	±750 kVp

2)	One minute power frequency dry and wet withstand voltage		
-	between line terminals and ground	460 kV (rms)	275 kV (rms)
-	between terminals with circuit breaker open	460 kV (rms)	275 kV (rms)
-	between terminals with Isolator open	530 kV (rms)	315kV (rms)
Max. radio interference voltage (microvolts) for frequency between 0.5 MHz and 2 MHz in all positions of the equipments.		1000 (at 156 kV rms)	500 (at 92 kV rms)
Minimum creepage distance :-			
Phase to ground (mm)		6125	3625
Between CB Terminals (mm)		6125	3625
System neutral earthing		Effectively earthed	Effectively earthed
Seismic acceleration		- 0.5g horizontal -	
Rating of Auxiliary Contacts		10 A at 220/110 V DC (as applicable)	
Breaking capacity of Auxiliary Contacts		2 A DC with circuit time constant of not less than 20ms.	
Phase to phase spacing (mm)		4500 or 4000	3000 or 2700

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

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

Rated voltage kV (rms)		245	145
Rated frequency (Hz)		50	50
No. of poles		1	1
Design ambient temperature (°C)		50	50
Rated insulation levels :			
1)	Full wave impulse withstand voltage (1.2/50 micro sec.)		
-	between line terminals and ground for CT and CVT	± 1050 kVp	±650 kVp
-	for arrester housing	± 1050 kV peak	±650 kVp
2)	One minute power frequency dry and wet withstand voltage		
-	between line terminals and ground for CT and CVT	460 kV rms	275 kV rms
-	for arrester housing	460 kV rms	275kV rms
Max. radio interference voltage (microvolts) for		1000 for CT/CVT 500 for SA	500

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

(C) **For 33 kV, 22kV & 11kV Vacuum Circuit Breaker and Isolator**:

Rated voltage kV (rms)		36	25
Rated frequency (Hz)		50	50
No. of Poles		3	3
Design ambient temperature (°C)		50	50
Rated insulation levels :			
1)	Full wave impulse withstand voltage (1.2/50 micro sec.)		
- between line terminals and ground	±170 kVp	±150 kVp	±75 kVp
- between terminals with circuit breaker open	±170 kVp	±150 kVp	±75 kVp
- between terminals with isolator open	±170 kVp	±150 kVp	±75 kVp
2)	One minute power frequency dry and wet withstand voltage		
- between line terminals and ground	70kV(rms)	50kV(rms)	28kV(rms)
- between terminals with circuit breaker open	70kV(rms)	50kV(rms)	28kV(rms)
- between terminals with Isolator open	70kV(rms)	50kV(rms)	28kV(rms)
Minimum creepage distance:			
Phase to ground (mm)	900	625	300
Between CB Terminals (mm)	900	625	300
System neutral earthing		Effectively earthed	
Seismic acceleration		0.5 g	0.5 g
Rating of Auxiliary Contacts		10 A at 250 V DC	
Breaking capacity of Auxiliary Contacts		2 A DC with circuit time constant of not less than 20ms	

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

(D) FOR 33kV, 22kV & 11kV CT/VT/SA

Rated voltage kV (rms)	36	25	12
Rated frequency (Hz)	50	50	11
No. of poles	1	1	1
Design ambient temperature (°C)	50	50	50
Rated insulation levels :			
1) Full wave impulse withstand voltage (1.2/50 micro sec.)			
- between line terminals and ground	±170 kVp	±150 kVp	±75 kVp
- for arrester housing	±170 kVp	±150 kVp	±75 kVp
2) One minute power frequency dry and wet withstand voltage			
- between line terminals and ground	70kV rms	50kV rms	28kV rms
- for arrester housing	70kV rms	50kV rms	28kV rms
Minimum creepage distance :			
Phase to ground (mm)	900	625	300
Between Terminals (mm)	900	625	300
System neutral earthing	- Effectively earthed -		
Seismic acceleration	0.5 g	0.5 g	
Cantilever strength of bushing	350 kg (minimum)		

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

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

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

5.0 ENGINEERING DATA AND DRAWINGS

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

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

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

5.3 Drawings

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

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

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

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

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

5.7 Approval Procedure

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

i)	Approval/comments/ by Purchaser on initial submission	As per agreed schedule
ii)	Resubmission (whenever required)	Within 3 (three) weeks from date of comments
iii)	Approval or comments	Within 3 (three) weeks of

		receipt of resubmission.
iv)	Furnishing of distribution copies (5 hard copies per substation and one scanned copy (pdf format) for Corporate Centre)	2 weeks from the date of approval
v)	Furnishing of distribution copies of test reports	
	(a) Type test reports (one scanned softcopy in pdf format per substation plus one for corporate centre & one hardcopy per substation)	2 weeks from the date of final approval
	(b) Routine Test Reports (one copy for each substation)	-do-
vi)	Furnishing of instruction/ operation manuals (2 copies per substation and one softcopy (pdf format) for corporate centre & per substation)	As per agreed schedule
(vii)	As built drawings (two sets of hardcopy per substation & one softcopy (pdf format) for corporate centre& per substation)	On completion of entire works

NOTE :

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

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

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

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

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

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

6.0 MATERIAL/ WORKMANSHIP

6.1 General Requirement

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

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

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

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

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

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

6.2 Provisions for Exposure to Hot and Humid climate

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

6.2.1 Space Heaters

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

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

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

6.2.2 FUNGI STATIC VARNISH

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

6.2.3 Ventilation opening

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

6.2.4 Degree of Protection

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

a) Installed out door: IP- 55

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

c) Installed in covered area: IP-52

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

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

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

6.3 RATING PLATES, NAME PLATES AND LABELS

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

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

6.4 FIRST FILL OF CONSUMABLES, OIL AND LUBRICANTS

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

7.0 DESIGN IMPROVEMENTS / COORDINATION

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

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

7.3 The Contractor shall be responsible for the selection and design of appropriate equipments to provide the best co-ordinated performance of the entire system. The basic design requirements are detailed out in this Specification. The design of

various components, sub-assemblies and assemblies shall be so done that it facilitates easy field assembly and maintenance.

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

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

8.0 QUALITY ASSURANCE PROGRAMME

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

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

(b) Documentation control system;

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

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

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

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

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

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

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

(j) System for quality audits;

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

(l) System for maintenance of records;

(m) System for handling storage and delivery; and

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

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

8.2 Quality Assurance Documents

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

9.0 TYPE TESTING, INSPECTION, TESTING & INSPECTION CERTIFICATE

9.1 All equipment being supplied shall conform to type tests as per technical specification and shall be subject to routine tests in accordance with requirements stipulated under respective chapters.

9.2 The reports for all type tests as per technical specification shall be furnished by the Contractor alongwith equipment / material drawings. The type tests conducted earlier should have either been conducted in accredited laboratory (accredited based on IEC Guide 25 / 17025 or EN 45001 by the national accreditation body of the country where laboratory is located) or witnessed by Utility or representative of accredited test lab or reputed consultant.

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

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

i) Lightning Impulse Test

ii) Switching Impulse Test

iii) Multiple Chopped Impulse Test (For CT)

iv) Chopped Impulse Test (For CVT)

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

Further, in the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design/manufacturing changes (including substitution of components) or due to non-compliance with the requirement stipulated in the Technical Specification or any/all type tests not carried out, same shall be carried out without any additional cost implication to the Purchaser.

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

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

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

9.4 The Contractor shall give the Purchaser /Inspector fifteen (15) days written notice for on-shore and six (6) weeks notice for off-shore material being ready for joint testing including contractor and Purchaser. Such tests shall be to the Contractor's account except for the expenses of the Inspector. The Purchaser /inspector, unless witnessing of the tests is virtually waived, will attend such tests within

fifteen (15) days of the date of which the equipment is notified as being ready for test/inspection, failing which the Contractor may proceed alone with the test which shall be deemed to have been made in the Inspector's presence and he shall forthwith forward to the Inspector duly certified copies of tests in triplicate.

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

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

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

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

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

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

10.0 TESTS

10.1 Pre-commissioning Tests

On completion of erection of the equipment and before charging, each item of the equipment shall be thoroughly cleaned and then inspected jointly by the Purchaser and the Contractor for correctness and completeness of installation and acceptability for charging, leading to initial pre-commissioning tests at Site. The list

of pre-commissioning tests to be performed are given in respective chapters and shall be included in the Contractor's quality assurance programme.

10.2 Commissioning Tests

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

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

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

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

11.0 PACKAGING & PROTECTION

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

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

12.0 FINISHING OF METAL SURFACES

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

12.2 HOT DIP GALVANISING

12.2.1 The minimum weight of the zinc coating shall be 610 gm/sq.m and minimum average thickness of coating shall be 86 microns for all items having thickness 6mm and above. For items lower than 6mm thickness requirement of coating thickness shall be as per relevant ASTM. For surface which shall be embedded in concrete, the zinc coating shall be 610 gm/sq. m minimum.

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

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

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

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

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

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

12.3 PAINTING

12.3.1 All sheet steel work shall be degreased, pickled, phosphated in accordance with the IS-6005/Equivalent International standard “Code of practice for phosphating iron and sheet”. All surfaces, which will not be easily accessible after shop assembly, shall beforehand be treated and protected for the life of the equipment. The surfaces, which are to be finished painted after installation or require corrosion protection until installation, shall be shop painted with at least two coats of primer. Oil, grease, dirt and swaf shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

12.3.2 After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying. The phosphate coating shall be sealed with application of two coats of ready mixed, stoving type zinc chromate primer. The first coat may be “flash dried” while the second coat shall be stoved.

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

12.3.4 The exterior and interior colour of the paint in case of new substations shall preferably be RAL 7032 for all equipment, marshalling boxes, junction boxes, control cabinets, panels etc. unless specifically mentioned under respective chapters of the equipments. Glossy white colour inside the equipments /boards /panels/junction boxes is also acceptable. The exterior colour for panels shall be matching with the existing panels in case of extension of a substation. Each coat

of primer and finishing paint shall be of slightly different shade to enable inspection of the painting. A small quantity of finishing paint shall be supplied for minor touching up required at site after installation of the equipments.

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

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

S.No.	PIPE LINE	Base colour	Band colour
Fire Protection System			
1	Hydrant and Emulsifier system pipeline	FIRE RED	-
2	Emulsifier system detection line – water	FIRE RED	Sea Green
3	Emulsifier system detection line – Air	FIRE RED	Sky Blue
4	Pylon support pipes	FIRE RED	
Air Conditioning System			
5	Refrigerant gas pipeline – at compressor suction	Canary Yellow	-
6	Refrigerant gas pipeline – at compressor discharge	Canary Yellow	Red
7	Refrigerant liquid pipeline	Dark Admiralty Green	-
8	Chilled water pipeline	Sea Green	-
9	Condenser water pipeline	Sea Green	Dark Blue

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

Base Colour Direction of flow Band Colour

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

13.0 HANDLING, STORING AND INSTALLATION

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

13.2 Contractor may engage manufacturer's Engineers to supervise the unloading, transportation to site, storing, testing and commissioning of the various equipment being procured by them separately. Contractor shall unload, transport, store,

erect, test and commission the equipment as per instructions of the manufacturer's supervisory Engineer(s) and shall extend full cooperation to them.

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

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

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

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

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

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

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

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

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

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

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

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

13.13 Equipment Bases

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

14.0 TOOLS AND TACKLES

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

15.0 AUXILIARY SUPPLY

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

Normal Voltage	Variation in Voltage	Frequency in HZ	Phase/Wire	Neutral connection
400V	± 10	50 ± 2.5%	3/4 Wire	Solidly Earthed.
230V	± 10	50 ± 2.5%	1/2 Wire	Solidly Earthed.
220V	190V to 240V	DC	-	Isolated 2 wire System
110V	95V to 120V	DC	-	Isolated 2 wire System
48V	_	DC	_	2 wire system (+) earthed

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

16.0 SUPPORT STRUCTURE

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

16.2 Support structure shall meet the following mandatory requirements:

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

17.0 CLAMPS AND CONNECTORS INCLUDING TERMINAL CONNECTORS

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

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

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

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

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

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

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

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

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

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

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

17.11 Tests

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

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

ii) Short time current test

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

iv) Resistance test and tensile test

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

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

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

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

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

18.5 All doors, removable covers and plates shall be gasketed all around with suitably profiled EPDM/Neoprene gaskets. The gasket shall be tested in accordance with approved quality plan, BS:4255 / Equivalent International Standard . Ventilating

Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh made of brass.

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

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

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

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

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

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

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

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

i) Check for wiring

ii) Visual and dimension check

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

20.0 TERMINAL BLOCKS AND WIRING

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

20.2 Terminal blocks shall be 650V grade and have continuous rating to carry the maximum expected current on the terminals and non breakable type. These shall be of moulded piece, complete with insulated barriers, stud type terminals,

washers, nuts and lock nuts. Screw clamp, overall insulated, insertion type, rail mounted terminals can be used in place of stud type terminals. But preferably the terminal blocks shall be non-disconnecting stud type of Elmex or Phoenix or Wago or equivalent make.

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

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

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

20.6 The terminal blocks shall be of extensible design.

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

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

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

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

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

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

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

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

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

21.0 LAMPS & SOCKETS

21.1 Sockets

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

21.2 Hand Lamp:

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

21.3 Switches and Fuses:

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

21.3.2 All fuses shall be of HRC cartridge type conforming to IS:9228/ Equivalent International Standard mounted on plug-in type fuse bases. Miniature circuit breakers with thermal protection and alarm contacts will also be accepted. All accessible live connection to fuse bases shall be adequately shrouded. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage.

22.0 Bushings, Hollow Column Insulators, Support Insulators:

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

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

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

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

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

22.5 When operating at normal rated voltage there shall be no electric discharge between the conductors and bushing which would cause corrosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action. No radio interference shall be caused by the insulators/bushings when operating at the normal rated voltage.

22.6 Bushing porcelain shall be robust and capable of withstanding the internal pressures likely to occur in service. The design and location of clamps and the

shape and the strength of the porcelain flange securing the bushing to the tank shall be such that there is no risk of fracture. All portions of the assembled porcelain enclosures and supports other than gaskets, which may in any way be exposed to the atmosphere shall be composed of completely non hygroscopic material such as metal or glazed porcelain.

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

22.8 Tests

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

23.0 MOTORS

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

23.1 Enclosures

a) Motors to be installed outdoor without enclosure shall have hose proof enclosure equivalent to IP-55 as per IEC 60529/ Equivalent International Standard . For motors to be installed indoor i.e. inside a box, the motor enclosure, shall be dust proof equivalent to IP-44 as per IS: 4691/ Equivalent International Standard .

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

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

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

23.2 Operational Features

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

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

23.3 Starting Requirements:

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

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

c) The locked rotor current shall not exceed six (6) times the rated full load current for all motors, subject to tolerance as given in IS:325/ Equivalent International Standard .

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

e) The locked rotor withstand time under hot condition at 110% of rated voltage shall be more than starting time with the driven equipment of minimum permissible voltage by at least two seconds or 15% of the accelerating time whichever is greater. In case it is not possible to meet the above requirement, the Bidder shall offer centrifugal type speed switch mounted on the motor shaft which shall remain closed for speed lower than 20% and open for speeds above 20% of the rated speed. The speed switch shall be capable of withstanding 120% of the rated speed in either direction of rotation.

23.4 Running Requirements:

a) The maximum permissible temperature rise over the ambient temperature of 50 degree C shall be within the limits specified in IS:325/ Equivalent International Standard (for 3 - phase induction motors) after adjustment due to increased ambient temperature specified.

b) The double amplitude of motor vibration shall be within the limits specified in IS: 4729/ Equivalent International Standard. Vibration shall also be within the limits specified by the relevant standard for the driven equipment when measured at the motor bearings.

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

23.5 TESTING AND COMMISSIONING

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

(a) Insulation resistance.

(b) Phase sequence and proper direction of rotation.

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

24.0 TECHNICAL REQUIREMENT OF EQUIPMENTS

24.1 1.1 KV Grade Power & Control Cables

24.1.1 Applicable for PVC Control Cable

The manufacturers, whose PVC control cables are offered, should have designed, manufactured, tested and supplied in a single contract at least 100 Kms of 1.1 KV grade PVC insulated control cables as on the date of bid opening. Further the

manufacturer should also have designed, manufactured, tested and supplied at least 1 km of 27C x 2.5 Sq.mm or higher size as on the originally Scheduled date of bid opening.

24.1.2 Applicable for PVC Power Cable

The manufacturer, whose PVC Power Cables are offered, should have designed, manufactured, tested and supplied in a single contract atleast 100 Kms of 1.1 KV or higher grade PVC insulated power cables as on the date of bid opening. Further the manufacturer should also have designed, manufactured, tested and supplied at least 1 km of 1C x 150 Sq. mm or higher size as on the originally Scheduled date of bid opening.

24.1.3 Applicable for XLPE Power Cables

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

24.2 LT Switchgear

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

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

ANNEXURE - A

LIST OF SPECIFICATIONS

GENERAL STANDARDS AND CODES

IEC-60060 (Part 1 to P4)	-	High Voltage Test Techniques
IEC 60068	-	Environmental Test
IEC-60117	-	Graphical Symbols
IEC-60156,	-	Method for the Determination of the Electrical Strength of Insulation Oils.
IEC-60270,	-	Partial Discharge Measurements.
IEC-60376	-	Specification and Acceptance of New Sulphur Hexafloride
IEC-60437	-	Radio Interference Test on High Voltage Insulators.
IEC-60507	-	Artificial Pollution Tests on High Voltage Insulators to be used on AC Systems.
IEC-62271-1	-	Common Specification for High Voltage Switchgear & Controlgear Standards.
IEC-60815	-	Guide for the Selection of Insulators in respect of Polluted Conditions.
IEC-60865 (P1 & P2)	-	Short Circuit Current - Calculation of effects.
ANSI-C.1/NFPA.70	-	National Electrical Code
ANSI-C37.90A	-	Guide for Surge Withstand Capability (SWC) Tests
ANSI-C63.21,	-	Specification for Electromagnetic Noise and
C63.3	-	Field Strength Instrumentation 10 KHz to 1 GHZ
C36.4ANSI-C68.1	-	Techniquest for Dielectric Tests
ANSI-C76.1/EEE21	-	Standard General Requirements and Test Procedure for Outdoor Apparatus Bushings.
ANSI-SI-4	-	Specification for Sound Level Metres
ANSI-Y32-2/C337.2	-	Drawing Symbols
ANSI-Z55.11	-	Gray Finishes for Industrial Apparatus and Equipment No. 61 Light Gray
NEMA-107T	-	Methods of Measurements of RIV of High Voltage Apparatus
NEMA-ICS-II	-	General Standards for Industrial Control and Systems Part ICSI-109
CISPR-1	-	Specification for CISPR Radio Interference Measuring Apparatus for the frequency range 0.15 MHz to 30 MHz
CSA-Z299.1-1978h	-	Quality Assurance Program Requirements
CSA-Z299.2-1979h	-	Quality Control Program Requirements
CSA-Z299.3-1979h	-	Quality Verification Program Requirements
CSA-Z299.4-1979h	-	Inspection Program Requirements

TRANSFORMERS AND REACTORS

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

CIRCUIT BREAKERS

IEC-62271-100	-	High-voltage switchgear and controlgear - Part 100: Alternating current circuit-breakers
IEC-62271-101	-	High-voltage switchgear and controlgear - Part 101: Synthetic testing
IEC-62155	-	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V
IEC-62271-110	-	High-voltage switchgear and controlgear - Part 110: Inductive load switching
IEC-62271-109	-	High-voltage switchgear and controlgear - Part 110: Inductive load switching

CURRENT TRANSFORMERS, VOLTAGE TRANSFORMERS AND COUPLING CAPACITOR VOLTAGE TRANSFORMERS

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

ANSI-C5713	-	Requirements for Instrument transformers
ANSIC92.2	-	Power Line Coupling voltage Transformers
ANSI-C93.1	-	Requirements for Power Line Carrier Coupling Capacitors
BUSHING		
IEC-60137	-	Insulated Bushings for Alternating Voltages above 1000V
SURGE ARRESTERS		
IEC-60099-4	-	Metal oxide surge arrestors without gaps
IEC-60099-5	-	Selection and application recommendation
ANSI-C62.1	-	IEE Standards for S A for AC Power Circuits
NEMA-LA 1	-	Surge Arresters
CUBICLES AND PANELS & OTHER RELATED EQUIPMENTS		
IEC-60068.2.2	-	Basic environmental testing procedures Part 2: Test B: Dry heat
IEC-60529	-	Degree of Protection provided by enclosures.
IEC-60947-4-1	-	Low voltage switchgear and control gear.
IEC-61095	-	Electromechanical Contactors for household and similar purposes.
IEC-60439 (P1 & 2)	-	Low Voltage Switchgear and control gear assemblies
ANSI-C37.20	-	Switchgear Assemblies, including metal enclosed bus.
ANSI-C37.50	-	Test Procedures for Low Voltage Alternating Current Power Circuit Breakers
ANSI-C39	-	Electric Measuring instrument
ANSI-C83	-	Components for Electric Equipment
NEMA-AB	-	Moulded Case Circuit and Systems
NEMA-CS	-	Industrial Controls and Systems
NEMA-PB-1	-	Panel Boards
NEMA-SG-5	-	Low voltage Power Circuit breakers
NEMA-SG-3	-	Power Switchgear Assemblies
NEMA-SG-6	-	Power switching Equipment
NEMA-5E-3	-	Motor Control Centers
1248 (P1 to P9)	-	Direct acting indicating analogue electrical measuring instruments & their accessories.
Disconnecting switches		
IEC-62271-102	-	High-voltage switchgear and controlgear - Part 102: Alternating current disconnectors and earthing switches
IEC-60265 (Part 1 & 2)	-	High Voltage switches

ANSI-C37.32	-	Schedule of preferred Ratings, Manufacturing Specifications and Application Guide for high voltage Air Switches, Bus supports and switch accessories
ANSI-C37.34	-	Test Code for high voltage air switches
NEMA-SG6	-	Power switching equipment
PLCC and line traps		
IEC-60353	-	Line traps for A.C. power systems.
IEC-60481	-	Coupling Devices for power line carrier systems.
IEC-60495	-	Single sideboard power line carrier terminals
IEC-60683	-	Planning of (single Side-Band) power line carrier systems.
CIGRE	-	Teleprotection report by Committee 34 & 35.
CIGRE	-	Guide on power line carrier 1979.
CCIR	-	International Radio Consultative Committee
CCITT	-	International Telegraph & Telephone Consultative Committee
EIA	-	Electric Industries Association
Protection and control equipment		
IEC-60051: (P1 to P9)	-	Recommendations for Direct Acting indicating analogue electrical measuring instruments and their accessories.
IEC-60255 (Part 1 to 23)	-	Electrical relays.
IEC-60297		
(P1 to P4)	-	Dimensions of mechanical structures of the 482.6mm (19 inches) series.
IEC-60359	-	Expression of the performance of electrical & electronic measuring equipment.
IEC-60387	-	Symbols for Alternating-Current Electricity meters.
IEC-60447	-	Man machine interface (MMI) - Actuating principles.
IEC-60521	-	Class 0.5, 1 and 2 alternating current watt hour metres
IEC-60547	-	Modular plug-in Unit and standard 19-inch rack mounting unit based on NIM Standard (for electronic nuclear instruments)
ANSI-81	-	Screw threads
ANSI-B18	-	Bolts and Nuts
ANSI-C37.1	-	Relays, Station Controls etc.
ANSI-C37.2	-	Manual and automatic station control, supervisory and associated telemetering equipment
ANSI-C37.2	-	Relays and relay systems associated with electric power apparatus
ANSI-C39.1	-	Requirements for electrical analog indicating instruments

MOTORS

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

Electronic equipment and components

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

Clamps & connectors

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

Bus hardware and insulators

IEC-60120	-	Dimensions of Ball and Socket Couplings of string insulator units.
IEC-60137	-	Insulated bushings for alternating voltages above 1000 V.
IEC-60168	-	Tests on indoor and outdoor post insulators of ceramic material or glass for Systems with Nominal Voltages Greater than 1000 V.
IEC-62155	-	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V
IEC-60273	-	Characteristices of indoor and outdoor post insulators for systems with nominal voltages greater than 1000V.
IEC-61462	-	Pressurized and un-pressurized insulator for use in electrical equipment with rated voltage greater than 1000V – Definitions, Test methods, acceptance criteria and design recommendations
IEC-60305	-	Insulators for overhead lines with nominal voltage above 1000V-ceramic or glass insulator units for a.c. systems Characteristics of String Insulator Units of the cap and pintype.
IEC-60372 (1984)	-	Locking devices for ball and socket couplings of string insulator units : dimensions and tests.
IEC-60383 (P1 and P2)	-	Insulators for overhead lines with a nominal voltage above 1000 V.
IEC-60433	-	Characteristics of string insulator units of the long rod type.
IEC-60471	-	Dimensions of Clevis and tongue couplings of string insulator units.

ANSI-C29	-	Wet process proelain insulators
ANSI-C29.1	-	Test methods for electrical power insulators
ANSI-C92.2	-	For insulators, wet-process porcelain and toughened glass suspension type
ANSI-C29.8	-	For wet-process porcelain insulators apparatus, post-type
ANSI-G.8	-	Iron and steel hardware
CISPR-7B	-	Recommendations of the CISPR, tolerances of form and of Position, Part 1
ASTM A-153	-	Zinc Coating (Hot-Dip) on iron and steel hardware
Strain and rigid bus-conductor		
ASTM-B 230-82	-	Aluminum 1350 H19 Wire for electrical purposes
ASTM-B 231-81	-	Concentric - lay - stranded, aluminum 1350 conductors
ASTM-B 221	-	Aluminum - Alloy extruded bar, road, wire, shape
ASTM-B 236-83	-	Aluminum bars for electrical purpose (Bus-bars)
ASTM-B 317-83	-	Aluminum-Alloy extruded bar, rod, pipe and structural shapes for electrical purposes (Bus Conductors)
Batteries and batteries charger		
Battery		
IEC:60896-21&22	-	Lead Acid Batteries Valve Regulated types – Methods of Tests & Requirements
IEC: 60623	-	Vented type nickel Cadmium Batteries
IEC:60622	-	Secondary Cells & Batteries – Sealed Ni-Cd rechargeable single cell
IEC:60623	-	Secondary Cells & Batteries – Vented Ni-Cd rechargeable single cell
IEC:60896-11	-	Stationary Lead Acid Batteries – Vented Type – General requirements & method of tests
IEEE-485	-	Recommended practices for sizing of Lead Acid Batteries
IEEE-1115	-	Sizing of Ni-Cd Batteries
IEEE-1187	-	Recommended practices for design & installation of VRLA Batteries
IEEE-1188	-	Recommended practices for design & installation of VRLA Batteries
IEEE-1189	-	Guide for selection of VRLA Batteries
Battery Charger		
IEEE-484	-	Recommended Design for installation design and installation of large lead storage batteries for generating stations and substations.
IEEE-485	-	Sizing large lead storage batteries for generating stations and substations

Wires and cables

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

Painting

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

HORIZONTAL CENTRIFUGAL PUMPS

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

DIESEL ENGINES

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

PIPING VALVES & SPECIALITIES

BS:5150	-	Specification for cast iron gate valves

PG Test Procedures

NFPA-13	-	Standard for the installation of sprinkler system
NFPA-15	-	Standard for water spray fixed system for the fire protection
NFPA-12A	-	Standard for Halong 1301 Fire Extinguishing System

NFPA-72E	-	Standard on Antomatic Fire Detectors
NFPA-12	-	Standard on Carbon dioxide extinguisher systems
Electrical generating and distributing stations code of practice		
Steel structures		
ANSI-B18.2.1	-	Inch series square and Hexagonal bolts and screws
ANSI-B18.2.2	-	Square and hexagonal nuts
ANSI-G8.14	-	Round head bolts
ASTM-A6	-	Specification for General Requirements for rolled steel plates, shapes, sheet piling and bars of structural use
ASTM-A36	-	Specifications of structural steel
ASTM-A47	-	Specification for malleable iron castings
ASTM-A143	-	Practice for safeguarding against embilement of Hot Galvanized structural steel products and procedure for detaching embrilement
ASTM-A242	-	Specification for high strength low alloy structural steel
ASTM-A283	-	Specification for low and intermediate tensile strength carbon steel plates of structural quality
ASTM-A394	-	Specification for Galvanized steel transmission tower bolts and nuts
ASTM-441	-	Specification for High strength low alloy structural manganese vanadium steel.
ASTM-A572	-	Specification for High strength low alloy colombium-Vanadium steel of structural quality
AWS D1-0	-	Code for welding in building construction welding inspection
AWS D1-1	-	Structural welding code
AISC	-	American institute of steel construction
NEMA-CG1	-	Manufactured graphite electrodes
Piping and pressure vessels		
ASME	-	Boiler and pressure vessel code
ASTM-A120	-	Specification for pipe steel, black and hot dipped, zinc-coated (Galvanized) welded and seamless steel pipe for ordinary use
ASTM-A53	-	Specification for pipe, steel, black, and hot-dipped, zinc coated welded and seamless
ASTM-A106	-	Seamless carbon steel pipe for high temperature service
ASTM-A284	-	Low and intermediate tensile strength carbon-silicon steel plates for machine parts and general construction.
ASTM-A234	-	Pipe fittings of wrought carbon steel and alloy steel for moderate and elevated temperatures

ASTM-S181	-	Specification for forgings, carbon steel for general purpose piping
ASTM-A105	-	Forgings, carbon steel for piping components
ASTM-A307	-	Carbon steel externally threated standard fasteners
ASTM-A193	-	Alloy steel and stainless steel bolting materials for high temperature service
ASTM-A345	-	Flat rolled electrical steel for magnetic applications
ASTM-A197	-	Cupola malleable iron
ANSI-B2.1	-	Pipe threads (Except dry seal)
ANSI-B16.1	-	Cast iron pipe flangesand glanged fitting. Class 25, 125, 250 and 800
ANSI-B16.1	-	Malleable iron threaded fittings, class 150 and 300
ANSI-B16.5	-	Pipe flanges and flanged fittings, steel nickel alloy and other special alloys
ANSI-B16.9	-	Factory-made wrought steel butt welding fittings
ANSI-B16.11	-	Forged steel fittings, socket-welding and threaded
ANSI-B16.14	-	Ferrous pipe plug, bushings and locknuts with piplethreads
ANSI-B16.25	-	Butt welding ends
ANSI-B18.1.1	-	Fire hose couplings screw thread.
ANSI-B18.2.1	-	Inch series square and hexagonal bolts and screws
ANSI-B18.2.2	-	Square and hexagonal nuts
NSI-B18.21.1	-	Lock washers
ANSI-B18.21.2	-	Plain washers
ANSI-B31.1	-	Power piping
ANSI-B36.10	-	Welded and seamless wrought steel pipe
ANSI-B36.9	-	Stainless steel pipe

ACSR MOOSE CONDUCTOR

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

GALVANISED STEEL EARTHWIRE

P5:1992)	overhead transmission purposes.

ANNEXURE - B

Sl No.	LIST OF DRAWINGS/DOCUMENTS
1	Single Line Diagram
2	Electrical Layout – Plan and Sections
3	Tower, Equipment & cable trench layout drawing
4	Earthing system design calculation & layout drawing
5	Lighting protection system design & drawings
6	Structure Layout (Plan & Section) drawing
7	Cantilever Strength calculations (if applicable)
8	Design calculation for Sag – Tension stringing chart
9	GTP and drawings for Bus-Post Insulator
10	Tension/suspension string insulator and Hardware Assembly GTP and drawing
11	Soil Investigation Report (if applicable)
12	**Circuit Breakers (220kV,132kV, 33 kV- As applicable)** - GA drawing, GTP, Type test Reports
13	**CTs & CVTs (220kV,132 kV, 33kV- As applicable)** - GA drawing, GTP, Type test Reports
14	**Surge Arrestors (216kV,120kV, 30kV- As applicable)** - GA drawing, GTP, Type test Reports
15	**Isolators (220kV,132kV, 33 kV- As applicable)** - GA drawing, GTP, Type test Reports
16	**Control, Relay Panels and Substation Automation system** - GTP, technical literature, type test reports
17	**PLCC, LINE TRAP & Digital Protection Coupler** - GTP and technical literature
18	**Civil Works (as applicable)** **a)** Control Room Building Structure Design, Foundation Design & Drg., Plinth Beam Design & Drg. and column Design & Drg. upto G.F. Level **b)** Auto transformer foundation design/drawings **c)** Reactor foundation design/drawings **d)** 220/132/11kV Tower, structure & foundation design/drawings. **e)** 220/132/11kV Equipment support structure & foundation design/drawing

NOTE:

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

CHAPTER 3.3: SWITCHGEAR
INSTRUMENT TRANSFORMERS
CONTENTS

CHAPTER 3 - SWITCHGEAR

INSTRUMENT TRANSFORMERS

1.0 GENERAL:

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

Current Transformers IEC: 60044-1

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

Inductive Voltage Transformers IEC:60044-2

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

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

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

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

2.0 CONSTRUCTION FEATURES:

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

2.1 a) Instrument transformers shall be of 245/145 kV class, oil filled/ SF6 gas filled, suitable for outdoor service and upright mounting on steel structures. 245/145 kV Instrument transformers shall be with shedded porcelain/ polymer bushings/Insulators

b) Bushings/Insulators shall conform to requirements stipulated in Section-GTR. The bushing/insulator for CT shall be one piece without any metallic flange joint.

c) Oil filling and drain plugs, oil sight glass shall be provided for CT and for electromagnetic unit of CVT etc. The Instrument transformer shall have cantilever strength of not less than 350 kg and 350 kg **respectively for** 245kV and 145 kV Instrument transformers. For CVT with polymer housing, the cantilever strength shall not be less than 150kg. Oil filling and drain plugs are not required with SF6 gas filled CT.

d) Instruments transformers shall be hermetically sealed units. Bidder/ Manufacturer shall furnish details of the arrangements made for the sealing of instrument transformers *during detailed engineering*.

Bidder/Manufacturer shall also furnish the details of site tests to check the effectiveness of hermetic sealing for approval.

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

f) In case of SF_6 filled CTs/Inductive VTs, it shall be provided with a suitable SF_6 gas density monitoring device, with NO/NC contacts to facilitate the remote annunciation and tripping in case of SF_6 leakage. Provisions shall be made for online gas filling. Suitable rupture disc shall be provided to prevent explosion.

2.2 **Terminal box/Marshalling Box:**

Terminal box shall conform to the requirements of Chapter 2-GTR.

2.3 **Insulating Oil:**

a) Insulating oil to be used for instrument transformers shall be of EHV grade and shall conform to IEC - 60296 (required for first filling). Non–PCB based synthetic insulating oil conforming to IEC 60867 can also be used in the capacitor units of CVT with specific approval from the owner, the proposal for which shall be submitted during detailed engineering stage.

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

2.4 **Name Plate:**

Name plate shall conform to the requirements of IEC incorporating the year of manufacture. The rated current, extended current rating in case of current transformers and rated voltage, voltage factor in case of voltage transformers shall be clearly indicated on the name plate. The rated thermal current in case of CT shall also be marked on the name plate.

The intermediate voltage in case of capacitor voltage transformer shall be indicated on the name plate.

3.0 CURRENT TRANSFORMERS:

a) Current transformers shall have single primary either ring type, or hair pin type and suitably designed for bringing out the secondary terminals in a weather proof (IP 55) terminal box at the bottom. PF Terminal for measurement of tan delta and capacitance of the unit shall be provided. These secondary terminals shall be terminated to stud type non disconnecting terminal blocks inside the terminal box. In case "Bar primary" inverted type current transformers are offered the manufacturer will meet following additional requirements:

(i) The secondaries shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution.

(ii) The lowest part of the insulation assembly shall be properly secured to avoid any risk of damage due to transportation stresses.

(iii) The upper part of insulation assembly resting on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly & top dome.

(iv) Nitrogen if used for hermetic sealing (in case of live tank design) should not come in direct contact with oil.

(v) Bidder/Manufacturer shall recommend whether any special storage facility is required for spare CT.

b) Different ratios specified shall be achieved by secondary taps only and primary reconnection shall not be accepted.

c) Core lamination shall be of cold rolled grain oriented silicon steel or other equivalent alloys. The cores used for protection shall produce undistorted secondary current under transient conditions at all ratios with specified CT parameters.

d) The expansion chamber at the top of the porcelain insulators should be suitable for expansion of oil.

e) Facilities shall be provided at terminal blocks in the marshalling box for star delta formation, short circuiting and grounding of CT secondary terminals.

f) Current transformer's guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

g) For 245/145 kV class CTs, the rated extended primary current shall be 120% (or 150% if applicable) on all cores of the CTs as specified in the Chapter 1 – GTS.

h) For 245/145 kV current transformer, characteristics shall be such as to provide satisfactory performance of burdens ranging from 25% to 100% of rated burden over a range of 5% to 120%(or specified rated extended current whichever is higher) of rated current in case of metering CTs and up to the accuracy limit factor/knee point voltage in case of relaying CTs.

i) The current transformer shall be suitable for horizontal transportation. It shall be ensured that the CT is able to withstand all the stresses imposed on it while transporting and there shall be no damage in transit. The Contractor shall submit the details of packing design to the Purchaser for review.

j) For 245/145 kV CTs the instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be inbuilt construction of the CTs. In case these are to be mounted separately these shall be mounted in the central marshalling box suitably wired upto the terminal blocks.

k) The wiring diagram plate for the interconnections of the three single phase CTs shall be provided inside the marshalling box. A typical wiring diagram No. 0000-000-T-E-L-028 (Sh. 1 & 2) is enclosed herewith to be followed by the Bidder/Manufacturer

l) The current transformers should be suitable for mounting on lattice support structure or pipe structure to be provided by the Contractor in accordance with stipulations of Chapter 2-GTR.

m) The CT shall be so designed as to achieve the minimum risks of explosion in service. Bidder/Manufacturer shall bring out in his offer, the measures taken to achieve this.

n) 245/145 kV current transformers shall be suitable for high speed auto reclosing.

4.0 VOLTAGE TRANSFORMERS:

a) 245/145 kV Voltage transformers shall be capacitor voltage divider type with electromagnetic units and shall be suitable for carrier coupling..

b) Voltage transformers secondaries shall be protected by HRC cartridge type fuses or MCBs for all the windings. In addition fuses/MCBs shall be provided for the protection and metering windings for fuse monitoring scheme. The secondary terminals of the VTs shall be terminated to the stud type non - disconnecting terminal blocks in the individual phase secondary boxes via the fuse/MCB.

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

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

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

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

g) 245/145 kV CVTs shall be suitable for mounting on tubular GI pipe in accordance with stipulations of Chapter 2-GTR.

h) It should be ensured that access to secondary terminals is without any danger of access to high voltage circuit.

i) A protective surge arrester shall be provided *if required,* to prevent breakdown of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor/primary winding, tuning reactor/RF choke etc. due to short circuit

in transformer secondaries. In case of an alternate arrangement, bidder shall bring out the details in the bid.

j) The wiring diagram for the interconnection of the three single phase CVTs shall be provided inside the marshalling box in such a manner that it does not deteriorate with time. *A typical wiring diagram no. : 0000-000-T-E-L-029 is enclosed herewith to be followed by the Bidder/Manufacturer.*

5.0 TERMINAL CONNECTORS:

The terminal connectors shall meet the requirements as given in Chapter 2-GTR.

6.0 TESTS:

6.1 In accordance with the requirements in Section-GTR, Current and Voltage Transformers should have been type tested and shall be subjected to routine tests in accordance with IEC:60044-1 and IEC: 60044-5/60044-2 respectively.

6.2 The test reports of the type tests and the following additional type tests (additional type tests are required for Instrument Transformers, rated above 72.5 kV only) shall also be submitted for the Purchaser's review.

a) **Current Transformers:**

i) Radio interference voltage test as per IEC 60044-1.

ii) Seismic withstand test.

iii) Thermal stability test, i.e. application of rated voltage and rated extended thermal current simultaneously by synthetic test circuit. (not applicable for SF6 filled CT)

iv) Thermal co-efficient test i.e. measurement of tan delta as a function of temperature (at ambient and between 80^{O}C & 90^{O}C) and voltage (at 0.3, 0.7, 1.0 and 1.1 Um/□3) (not applicable for SF6 filled CT)

v) The current transformer shall be subjected to Multiple chopped impulse test (not applicable for SF6 filled CT) by any one of the following two methods given below to assess the CT performance in service to withstand the high frequency over voltage generated due to closing & opening operation of isolators. Alternatively, method as per IEC:60044-1 may be followed:

Method I*: 600 negative polarity lightning impulses chopped on crest will be applied to current transformer. The opposite polarity amplitude must be limited to 50% of crest value when the wave is chopped. One impulse per minute shall be applied and every 50 impulse high frequency currents form the windings and total current to earth will be recorded and be compared with reference currents recorded applying one or more (max 20) reduced chopped impulses of 50% of test value.*

Oil samples will be taken before and 3 days after the test. Gas analysis must not show appreciable rate of increase in various gases related with the results of the analysis performed before test.

Total sum of crest values of current through secondaries must not exceed 5% of the crest value of total current to earth.

CT must withstand dielectric tests after this test to pass the test.

***Method II**: 100 negative polarity impulses with a rise and fall time of less than 0.25 microsecond corrected to atmospheric condition shall be applied at one minute interval and total current through insulation of earth will be recorded. The amplitude of first opposite polarity should be limited to 50% of the chopped impulse crest value. Voltage and total current wave shapes shall be recorded after every 10 impulses, and will be compared with reference wave shapes recorded before test at 50% of test values.*

Oil sample shall be taken before and 3 days after the test and CT shall be deemed to have passed the test if the increase in gas content before and after test is not appreciable.

b) **Voltage transformers:**

i) High frequency capacitance and equivalent series resistance measurement (as per IEC-60358) for CVT.

ii) Seismic withstand test.

iii) Stray capacitance and stray conductance measurement of the low voltage terminal (as per IEC-60358) for CVT.

iv) Determination of temperature coefficient test (as per IEC-60358).

v) Radio interference voltage test as per IEC-60044-5/IEC-60044-2. However the RIV level shall be as specified in clause Major Technical Parameters in Section-GTR.

vi) Apart from the above, report of all special tests mentioned in IEC-60044-5 for Capacitive voltage transformer shall also be submitted for approval.

6.3 The current and voltage transformer shall be subjected to the following routine tests in addition to routine tests as per IEC.

a) **CURRENT TRANSFORMERS:**

ROUTINE TESTS:

for Oil filled CTs

i) Measurement of Capacitance.

ii) Oil leakage test.

iii) Measurement of tan delta at 0.3, 0.7, 1.0 and 1.1 Um/□3.

for SF6 filled CTs

i) Dew point measurement

ii) SF6 alarm/ lockout check.

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

b) **VOLTAGE TRANSFORMERS:**

Routine tests on Capacitive voltage transformer shall be done in line with IEC-60044-5.

7.0 SPARE PARTS AND MAINTENANCE EQUIPMENT:

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

8.0 TECHNICAL PARAMETERS:

A. 245 kV CURRENT TRANSFORMERS:

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

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

B. 145 kV CURRENT TRANSFORMERS:

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

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

D. 245 KV VOLTAGE TRANSFORMERS:

D8.1	System fault level (for 1 second)	40 kA kA (as applicable)
D8.2	Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement
D8.3	High frequency capacitance frequency capacitance **(for CVT only)** range	Within 80% to 150% of ratedfor entire carrier
D8.4	Equivalent series resistance over the entire carrier frequency range	Less than 40 ohms **(for CVT only)**
D8.5	Stray capacitance and stray conductance of the LV terminal over entire carrier frequency range	As per IEC:358 **(for CVT only)**

D8.6 One minute power frequency withstand voltage:

	i) Between LV (HF) terminal and earth terminal	10 kV (rms) for exposed terminals and 4 KV (rms) for terminals enclosed in a weather proof box
	ii) For secondary winding	3 kV (rms)
D8.7	Maximum temperature rise over design ambient temperature	As per IEC:60044-2 or 60044-5
D8.8	Number of terminals in control cabinet (interpole cabling is to be supplied by Purchaser)	All terminals are wired upto marshaling box plus 12 terminals exclusively for Purchaser's use.
D8.9	Rated Total Thermal burden (VA)	300 (100VA/winding)

Voltage Transformers shall also comply with the requirements of Table-IA of this Section.

E. 145 KV VOLTAGE TRANSFORMERS:

E8.1	System fault level	31.5 kA for 1 second
E8.2	Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement
E8.3	High frequency capacitance for entire carrier frequency range	Within 80% to 150% of rated capacitance **(for CVT only)**
E8.4	Equivalent series resistance over the entire carrier frequency range	Less than 40 ohms **(for CVT only)**
E8.5	Stray capacitance and stray conductance of the LV terminal over entire carrier frequency range	As per IEC:358 **(for CVT only)**
E8.6	One minute power frequency withstand voltage:	
	i) Between LV (HF) terminal and earth terminal For secondary winding	10 kV (rms) for exposed terminals and 4 KV (rms) for terminals enclosed in a weather proof box ii) 3 kV (rms)
E8.7	Maximum temperature rise over design ambient temperature	As per IEC:60044-2 or 60044-5

E8.8	Number of terminals in control cabinet (interpole pole cabling is to be supplied by Purchaser)	All terminals are wired upto marshaling box plus 12 terminals exclusively for Purchaser's use.
E8.9	Rated Total Thermal burden (VA)	300 (100VA/winding)

Voltage Transformers shall also comply with the requirements of Table-IB of this Section.

9.0 PRE-COMMISSIONING TESTS

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

9.2 **Current Transformers**

(a) Insulation Resistance Test for primary and secondary.

(b) Polarity test

(c) Ratio identification test - checking of all ratios on all cores by primary injection of current.

(d) Dielectric test of oil (wherever applicable).

(e) Magnetizing characteristics test.

(f) Tan delta and capacitance measurement

(g) Secondary winding resistance measurement

(h) Contact resistance measurement (wherever possible/accessible).

(i) Test for SF6 (for SF6 filled CTs) – Dew point measurement, SF6 alarm/ lockout check.

(j) DGA test of oil.

Dissolved gas analysis to be carried out at the time of commissioning. CTs must have adequate provision for taking oil samples from the bottom of the CT without exposure to atmosphere. Bidder/Manufacturer shall recommend the frequency at which oil samples should be taken and norms for various gases in oil after being in operation for different durations. Bidder/Manufacturer should also indicate the total quantity of oil which can be withdrawn from CT for gas analysis before refilling or further treatment of CT becomes necessary.

9.3 Voltage Transformers/Capacitive Voltage Transformers

(a) Insulation Resistance test for primary (if applicable) and secondary winding.

(b) Polarity test

(c) Ratio test

(d) Dielectric test of oil (wherever applicable).

(e) Tan delta and capacitance measurement of individual capacitor stacks.

(f) Secondary winding resistance measurement.

TABLE - IA

REQUIREMENTS OF 245 KV CAPACITIVE VOLTAGE TRANSFORMERS

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	245		
2.	Type	Single phase capacitor VT		
3.	No. of secondaries	3		
4.	Rated voltage factor	1.2 continuous		
		1.5 - 30 seconds		
5.	Phase angle error	± 10 minutes (For metering core)		
6.	Capacitance (pf)	4400/8800 (As applicable)	+ 10% - 5%	
		Secondary I	Secondary II	Secondary III
7.	Voltage Ratio	220/0.11	220/0.11	220/0.11
8.	Application	Protection	Protection	Metering
9.	Accuracy	3 P	3 P	0.2
10.	Output burden (VA) (minimum)	50	50	50

TABLE - IB

REQUIREMENTS OF 145 KV CAPACITIVE VOLTAGE TRANSFORMERS

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	145		
2.	Type	Single phase capacitor VT		
3.	No. of secondaries	3		
4.	Rated voltage factor	1.2 continuous		
		1.5 - 30 seconds		
5.	Phase angle error	± 10 minutes (For metering core)		
6.	Capacitance (pf)	8800	+ 10%/-5%	
		Secon-dary I	Secon-dary II	Secon-dary III
7.	Voltage Ratio	132/0.11	132/0.11	132/0.11
8.	Application	Protec-tion	Protec-tion	Meter-ing
9.	Accuracy	3 P	3 P	0.2
10.	Output burden (VA) (minimum)	50	50	50

TABLE - IIA
REQUIREMENTS FOR 245 KV CURRENT TRANSFORMERS

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accuracy class as per IEC: 44-1	Min. knee pt.volt-age (Vk)	Max. CT sec.wdg. resist-ance(ohms)	Max. Excit-ation cur-rent at Vk (in mA)
5 CHECK	1	BUS DIFF 800/1	1600-800/1 Tap	-	- 800 Tap; 50 on 800/1 Tap	1600/	8/4 1600/1	25 on 1600/1 Tap; 50 on 800/1 Tap
MAIN	2	BUS DIFF 800/1	1600-800/1	-	- 800 50 on 800/1	1600/	8/4 Tap;	25 on 1600/1 Tap
	3	METERING	1600-800/1	20	**0.2S**	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	1600-800/1	-	-	1600/ 800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	5	TRANS. DIFF/LINE PROTN	1600-800/1	-	-	1600/ 800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap

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

TABLE - IIB

REQUIREMENTS FOR 145 KV CURRENT TRANSFORMERS

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accuracy class as per IEC: 44-1	Min. knee pt.volt-age Vk	Max. CT sec.wdg. resist-ance(ohms)	Max. Excit-ation cur-rent at Vk (in mA)
5	1	BUS DIFF CHECK	1200-800/1	-	-	1200/800	12/8	25 on 1200/1 Tap; 50 on 600/1 Tap
	2	BUS DIFF MAIN	1200-800/1	-	-	1200/800	12/8	25 on 1200/1 Tap; 50 on 600/1 Tap
	3	METERING	1200-800/1	20	**0.2S**	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	1200-800/1	-	-	1200/800	12/8	25 on 1200/1 Tap; 50 on 600/1 Tap
	5	TRANS. DIFF/LINE PROTN	1200-800/1	-	-	1200/800	12/8	25 on 1200/1 Tap; 50 on 600/1 Tap

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

TABLE – II C

REQUIREMENTS FOR 145 kV CURRENT TRANSFORMERS

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accuracy class as per IEC: 44-1	Min. knee pt.volt-age Vk	Max. CT sec.wdg. resist-ance(ohms)	Max. Excit-ation cur-rent at Vk (in mA)
5	1	BUS DIFF CHECK	1200-800/1	-	-	1200/800	12/8	25 on 1200/1 Tap; … on 800/1 Tap
	2	BUS DIFF MAIN	1200-800/1	-	-	1200/800	12/8	25 on 1200/1 Tap; .. on 800/1 Tap
	3	METERING	200-400/1	20	**0.2S**	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	200-400/1	-	-	200/400		Tap; .. on Tap
	5	TRANS. DIFF/LINE PROTN	200-400/1	-	-	200/400		n Tap; .. on Tap

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

NOTE: The ratio and ratings of the instrument transformer will be finalized during Detail Engineering.

CHAPTER 3.4 - SWITCHGEAR

SURGE ARRESTERS

CONTENTS

CHAPTER 3 - SWITCHGEAR

SURGE ARRESTERS

1.0 GENERAL:

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

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

1.3 The Surge Arrestors shall be designed for use in the geographic and meteorological conditions as given in the Chapter 2 -GTR.

2.0 DUTY REQUIREMENTS:

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

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

c. 245/145 kV class arrester shall be capable for discharging energy equivalent to class 3 of IEC for 245/145/12 kV system on two successive operations.

d. The surge arresters shall be suitable for withstanding forces as defined in Chapter 2-GTR.

e. The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

f. The surge arresters are being provided to protect the following equipment whose insulation levels are indicated in the table given below:-

Equipment to be protected	Lightning impulse(kVp) for 245 kV system	Lightning Surge for 145 kV system
Power transformer	± 950	± 550
Instrument Transformer	± 1050	± 650
Reactor	--	--

CB/Isolator Phase to ground	± 1050	± 650
CB/Isolator Across open contacts	± 1050(for CB) ± 1200(for Isolator	± 750

g. The duty cycle of CB installed in 245/145 kV System of the Purchaser shall be O-0.3 sec-CO-3 min-CO. The Surge Arrester shall be suitable for such circuit breaker duties in the system.

3.0 CONSTRUCTIONAL FEATURES:

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

a) The non-linear blocks shall be of sintered metal oxide material. These shall be provided in such a way as to obtain robust construction, with excellent mechanical and electrical properties even after repeated operations.

b) The surge arresters shall be fitted with pressure relief devices suitable for preventing shattering of porcelain housing and providing path for flow of rated fault currents in the event of arrester failure. Details shall be furnished in the bids alongwith quality checks.

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

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

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

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

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

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

h) The heat treatment cycle details alongwith necessary quality checks used for individual blocks alongwith insulation layer formed across

each block are to be furnished. Metalizing coating thickness for reduced resistance between adjacent discs is to be furnished with additional information schedule of bid proposal sheets alongwith procedure for checking the same. Details of thermal stability test for uniform distribution of current on individual disc is to be furnished.

i) The manufacturer will submit Data for rejection rate of ZnO blocks during manufacturing/operation for the past three years.

j) The sealing arrangement of the Surge Arrester stacks shall be done incorporating grooved flanges with the O-rings/elliptical cross-section gaskets of Neoprene or Butyl rubber.

k) The Surge arrester with porcelain housing shall have a cantilever strength of not less than 350 kg for 216/120kV surge arresters respectively or as per the value obtained vide Chapter 2-GTR, whichever is higher. For Surge arrester with polymer housing, the cantilever strength shall not be less than 150kg.

4.0 FITTINGS AND ACCESSORIES:

a) 216/120 kV Arresters shall be complete with insulating base and Surge monitor having provision for bolting to flat surface of structure.

b) Self contained discharge counters, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole unit alongwith necessary connection. Suitable leakage current meters should also be provided. The reading of milliammeter and counters shall be visible through an inspection glass panel. The terminals shall be robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends. The surge counter shall be provided with a potential free contact rated for 220 V (DC) which shall close whenever a surge is recorded by the surge monitor. Necessary arrangement shall be provided for extending the contact information to substation automation system.

c) Surge monitor consisting of discharge counters and milliammeters should be suitable to be mounted on support structure of the arrester and should be tested for IP66 degree of protection. The standard supporting structure for surge arrester should be provided with a mounting pad, for fixing the surge monitor. The surge monitor should be suitable for mounting on this standard mounting pad. Also all nuts, bolts, washers etc. required for fixing the surge monitor shall have to be supplied by the Contractor.

The arrangement for Surge Monitor enclosure fixing to the structure shall be at its rear/bottom. Connection between the Surge Arrester base and Surge Monitor shall be through a 2.0 m(minimum) long insulated copper rod/strip of at least 75 sq.mm cross sectional area. The cable shall be terminated at rear/bottom side of the Surge Monitor. The gaskets of the surge monitors shall be of Neoprene, Butyl or equivalent material.

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

5.0 TESTS:

5.1 **In accordance with the requirements stipulated under Chapter 2-GTR, the surge arresters should have been type tested as per IEC and shall be subjected to routine and acceptance tests in accordance with IEC document For contamination test, procedures outlined in 60099-3 shall be followed.**

The test reports of the type tests and the following additional type tests(additional type tests are required for Surge Arresters above 72.5 kV class only) shall also be submitted for the Purchaser's review.

i) Radio interference voltage test as per IEC 60099-4.

ii) Seismic withstand test.

iii) Accelerated ageing test.

iv) Test to verify the Power frequency versus time characteristics. Temporary over voltage profile for arresters are to be mutually agreed.

Each metal oxide block of surge arresters shall be tested for the guaranteed specific energy capability in addition to the routine/acceptance test as per IEC: 60099-4.

5.2 (a) **Acceptance Tests:**

1. Measurement of power frequency reference voltage of the arrester units.

2. Lightning Impulse Residual voltage on arrester units. (IEC clause 6.3.2).

3. Internal Ionisation or partial Discharge test.

(b) **Special Acceptance Test:**

1. Thermal stability test on three sections. (IEC Clause 7.2.2).

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

3. Wattloss test.

(c) **Routine Tests:**

1. Sealing test: Water dip test at 1.5m depth from top of Surge Arrestor for 30 minutes shall be performed during assembly of Surge Arrester stacks (followed by other routine tests, i.e. P.D. Measurement, Reference Voltage, Residual Voltage & IR measurement).

2. Measurement of reference voltage.

3. Residual voltage test of arrester unit.

4. Internal Ionisation test or partial discharge test.

5. Verticality check on completely assembled Surge arresters as a sample test on each lot.

(d) **Test on Surge Monitors:**

The Surge monitors shall also be connected in series with the test specimens during residual voltage and current impulse withstand tests to verify efficacy of the same. Additional routine/ functional tests with one 100A and 10kA current impulse (8/20 micro sec.) shall also be performed on the Surge monitor.

Surge monitors shall be routinely tested for water dip test at 1.5m for 30 minutes. No water vapors shall be visible on the monitor glass.

(e) **Test on insulators**

All routine tests shall be conducted on the hollow column insulators as per IEC 62155. Polymer housing shall be tested in accordance to IEC-61462.

6.0 SPARE PARTS AND MAINTENANCE EQUIPMENT:

Bidder shall include in his proposal spare parts and maintenance equipment, as mentioned in Chapter 1-PSR.

7.0 TECHNICAL PARAMETERS:

A. 245 kV CLASS SURGE ARRESTER

A7.0(a)	Rated arrester voltage	216 kV
A7.0(b)	Nominal discharge current	10 kA of 8/20 microsecond wave
A7.0(c)	Minimum discharge capability	5kJ/kV (referred to rated arrester voltage corresponding to minimum discharge characteristics.
A7.0(d)	Continuous operating voltage at 50 deg.C	168 kV rms
A7.0(e)	Max. switching surge residual voltage (1kA)	500 kVp
A7.0(f)	Max. residual voltage at	
	i) 5 kA	560 kVp
	ii) 10 kA nominal discharge current	600 kVp
A7.0(g)	Max. steep current impulse residual voltage at 10 kA.	650 kVp
A7.0(h)	Long duration discharge class	3
A7.0(i)	High current short duration test value (4/10 micro second wave)	100 kAp
A7.0(j)	Current for pressure relief test	40 kA rms / 50 kA rms (as applicable)
A7.0(k)	Low current long duration test value (2400 micro sec)	As per IEC.
A7.0(l)	Pressure relief class	40 kA / 50 kA (as applicable)

B. 145 kV CLASS SURGE ARRESTER

B7.0(a)	Rated arrester voltage	120 kV
B7.0(b)	Nominal discharge current	10 kA of 8/20 microsecond wave
B7.0(c)	Minimum discharge capability	5kJ/kV (referred to rated arrester voltage corresponding to minimum discharge characteristics.
B7.0(d)	Continuous operating voltage at 50 deg.C	102 kV rms
B7.0(e)	Max. switching surge residual voltage (1kA)	280 kVp
B7.0(f)	Max. residual voltage at	
	i) 5 kA	310 kVp
	ii) 10 kA nominal discharge current	330 kVp
B7.0(g)	Long duration discharge class	3
B7.0(h)	High current short duration test value (4/10 micro second wave)	100 kAp
B7.0(i)	Current for pressure relief test	40 kA rms
B7.0(j)	Low current long duration test value (2400 micro sec)	As per IEC.
B7.0(k)	Pressure relief class	31.5 kA

C 11kV Surge Arresters

C7.0(a)	Rated arrester voltage	9 kV
C7.0(b)	Nominal discharge capability	10 kA of 8/20 microsecond wave
C7.0(c)	Minimum discharge	4kJ/kV (referred to rated

	capability	arrester voltage corresponding to minimum discharge characteristics).
C7.0(d)	Continuous operating voltage at 50 deg.C	7.2 kV rms
c7.0(e)	Max. switching surge residual voltage (0.5kA)	22.4 kVp
C7.0(f)	Max. residual voltage	
	(i) 5 kA	26 kVp
	(ii) 10 kA nominal discharge current	28 kVp
C7.0(g)	Long duration discharge class	2
C7.0(k)	Pressure relief class	25k A

8.0 PRE-COMMISSIONING TESTS

8.1 An indicative list of tests is given below.

(a) operation check of LA counter.

(b) Insulation resistance measurement

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

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

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

CHAPTER - 4
A.C. and DC DISTRIBUTION BOARD

1.0 SCOPE

1.0.1 These specifications are intended to cover the design, engineering, manufacturing, inspection and testing at manufacturer's works, packing, supply & delivery, Testing & commissioning of 400 volts, 3 phase, 4 wire, AC distribution switch boards cubical in-door type complete with all materials, accessories and fittings, erection & maintenance tools & tackles, mandatory spares as detailed in this specification.

1.0.2 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life.

1.0.3 Any material and equipment not specifically stated in this specification but which are necessary for satisfactory operation of the equipment shall be deemed to be included unless specifically excluded and shall be supplied without any extra cost.

1.1 STANDARDS

1.1.1 The equipment covered by this specification shall confirm to the provisions of the following IEC/International standards as amended up to date except where specified otherwise in this specification.

The Equipment and material meeting the requirement of any other Indian standards or internationally recognized standards which ensure a quality equal or better than the standard mentioned above shall also be acceptable. Where the equipment confirms to any other standards then salient points of difference between the standards adopted and those prescribed in these specifications shall be clearly brought out in the bid and a copy of the applicable standards shall also be enclosed by the bidder with the bid.

1.2 DESCRIPTION

1.2.1 The LT AC Distribution Board shall be fed from 630 KVA, 11kV/400 V distribution transformer.

1.2.2 Tentatively the following minimum feeders shall be required from the AC Distribution Board, and each shall be suitably rated as per requirement.

a. Incoming from the Station Transformers i.e. 4 wire, 3 phase supply.
b. 3 phase, 4 wires supply for oil filtration set.
c. Single phase supply to various 132 kV Circuit Breakers (separate feeders to each).
d. 3 phase, 4 wires supply for indoor lighting.
e. 3 phase, 4 wires supply for outdoor lighting.
f. 3 phase, 4 wires for transformer Marshalling boxes.

g. 1 phase supply to 33 kV switchgear panel board.

h. 1 phase supply to 132 kV C&R Panels.

i. 1 phase supply to Substation Automation System, HMI, printers etc.

j. 1 phase supply to 132 kV isolator boxes for motor operation.

k. 3 phase, 4 wires feeders for Battery chargers.

l. Supply for OPGW Communication Panel.

m. At least 20% (minimum 1) of each rating as spares.

n. Three phase/single phase supply as per requirement with individual MCCB/MCB's to Air conditioning system, Fire detection, alarm and control system, etc.

1.2.3 Incoming from transformer shall be provided with the following:

a. Suitable MCCBs (with adjustable setting) with O/L & S/C releases

b. One No. 100 mm dia. flush mounted Ammeter with range 0-600 amp with phase selector switch.

c. One No. 100 mm dia. flush mounting voltmeter scale range 0-500 V with fuse and selector switch, along with LED type, indicating lamps before the selector switch.

d. Suitable CTS having burden 25 VA and accuracy class – I

e. One No. 3 phase, 4 wires unbalanced load integrating watt – load meter operable on CT. Each circuit as indicated above shall have switch rating and labeling as mentioned against each and shall include bus-bar connections, terminals cable glands and legs etc.

f. Bus bar shall be of Aluminum and designed for 630 Amps for phases and 400A for neutral.

1.2.4 400VAC switch board cubical type shall consist of feeders as above and shallhave MCBof rating and labeling as per system requirement. It shall include bus-bar connections terminals, Cable glands and lugs. The aluminum bus- bar shall be designed for 630 Amps for phases and 400 Amp for neutral based current density of 85 Amp per sq. cm. The bidder shall design the ratings of MCB/MCCBs' which shall be approved by purchaser. The above detail of outgoing feeders is provisional and is subject to change during detailed engineering.

1.2.5 The A.C. Board shall be fitted with the following accessories:

1. 230 V, AC space heater with MCB and thermostat.
2. Only MCB/MCCBs' as appropriate shall be provided. No fuses are allowed.
3. All the feeders shall be provided with single phase ammeters. For three phase supplies an ammeter with selector switch (or in yellow phase only) shall be provided. Typical ammeter size shall be 70 mm x 70 mm. These details shall be finalized during detailed engineering.

4. Necessary CTs wherever required for current measurement shall be provided. The secondary rating of each shall be 1A.
5. Indicating lamps shall be of low wattage typically 2.6 W or less.
6. All the terminals for external cabling shall be suitably rated as per the size of the external cables.
7. All the indicating instruments, lamps, handles, MCCBs', MCB's shall be flush mounted.
8. Panel shall be indoor, single front, fixed type.
9. Base frame shall be of ISMC-100.
10. Phase clearances shall be as per IS/IEC.
11. Panel Paint: will be decided during detailed engineering
12. Interior & mounting plate: Glossy white
13. Bus bars to be colour coded and also the circuits taken from it.
14. Earth bus of 50 x 6mm copper strip shall project out of the panel at both ends and shall have two holes for earth connections.
15. Control Wiring: 1.5 mm^2 copper (48 strands), 2.5 mm^2 copper for CTs (48 strands)
16. Power Switch & MCCB shall be door interlocked and shall have pad locking
17. Caution Name Plates for live terminals shall be provided.

DC DISTRIBUTION BOARD

1.3.1 The DC Distribution Board for both 220V and 48V system shall be fed from respective Battery Charger.

1.3.2 Tentatively the following minimum feeders shall be required from the DC Distribution Board, and each shall be suitably rated as per requirement.

a. Incoming 2 Nos with change-over facility from the battery chargers i.e. 4 wire, 3 phase supply.
b. Supply to various 132 kV Circuit Breakers, Disconnectors etc (separate feeders to each).
c. supply to 11 kV switchgear panel board.
d. supply to 132 kV C&R Panels.
e. supply to Substation Automation System, HMI, printers etc.
f. Supply for Communication Panel.
g. Emergency lighting
h. Others required services
i. At least 20% (minimum 1) of each rating as spares.

1.2.6 The switch board cubical type shall consist of feeders as above and shall have MCB of rating and labeling as per system requirement. It shall include bus-bar connections terminals,

Cable glands and lugs. The aluminum bus- bar shall be designed to cater the current as required by the capacity of the battery charger and loads. The bidder shall design the ratings of MCB/MCCBs' which shall be approved by purchaser. The above detail of outgoing feeders is provisional and is subject to change during detailed engineering.

1.2.7 The A.C. Board shall be fitted with the following accessories:

18. 230 V, AC space heater with MCB and thermostat.
19. Only MCB/MCCBs' as appropriate shall be provided. No fuses are allowed.
20. All the feeders shall be provided with ammeters.
21. Indicating lamps shall be of low wattage typically 2.6 W or less.
22. All the terminals for external cabling shall be suitably rated as per the size of the external cables.
23. All the indicating instruments, lamps, handles, MCCBs', MCB's shall be flush mounted.
24. Panel shall be indoor, single front, fixed type.
25. Base frame shall be of ISMC-100.
26. Phase clearances shall be as per IS/IEC.
27. Panel Paint: will be decided during detailed engineering
28. Interior & mounting plate: Glossy white
29. Bus bars to be colour coded and also the circuits taken from it.
30. Earth bus of 50 x 6mm copper strip shall project out of the panel at both ends and shall have two holes for earth connections.
31. Control Wiring: 1.5 mm^2 copper (48 strands), 2.5 mm^2 copper for CTs (48 strands)
32. Power Switch & MCCB shall be door interlocked and shall have pad locking
33. Caution Name Plates for live terminals shall be provided.

1.3 CONSTRUCTIONAL FEATURES

1.3.1 Station Supply LT Board

The supply board shall comprise of:

a. Metal enclosed, indoor /outdoor mounted, dust and vermin proof and self-supporting cubicle type made –up of mild steel sections and cold rolled sheet steel of 2 mm thickness for enclosure and all load bearing members, doors & fitting plate. The Gland Plate shall be 3 mm thick, sheet steel, with double compressions, chromium plated brass glands.

b. The board shall be stiffened properly to be free from vibration, twist and bends. The degree of protection of enclosure to be not less than IP-54 for all indoor type panels

and IP-55 for all outdoor mounted panel or boards respectively as stipulated by relevant IEC.

c. Requisite number of sheet steel enclosure for mounting circuit breakers, relays, switches, CTs and other components. Light structural members shall be jointed preferably by bolting.

d. Separate cable / bus- bar chambers duly partitioned, removable covers and metals still frames of single front double access type having feeders located in the front and vertical bus bars and cable chamber located in the rear.

e. Detachable or hinged type door with handle and locking arrangements and easy access for inspection and maintenance works.

f. Bottom frame suitable for erection on flush concrete floor by means of evenly spaced grouting bolts projecting through the base channel members.

g. Necessary facilities for entry of cable from the bottom. No access to any live part inside the panel to avoid accident. Separate cable support to avoid load on the thimble of cable as well as on the links.

h. Synthetic rubber Gaskets all-round the perimeter of cover, gland plates, removable covers and doors shall be provided.

i. Eye bolts at the top to facilitate lifting and anti-vibration pads between base frame and panel to prevent vibration.

j. Adequate strength to withstanding all stresses imposed during handling, transportation, installation and operation without distortion or damage. The panels shall be assembled to the extent possible within transporting and handling limitations duly wired up and ready for installation in accordance with this specification.

k. Each MCB to have separate bus –link wired up to terminal block so that by removal of link, the outgoing feeder is isolated without removing cable from the terminals.

l. The minimum component height will be 250 mm form the ground level for case of maintenance.

m. It must be ensured while designing the switch boards that adequate electrical clearance as required under the rules shall be provided for the various components inside the cubical.

1.3.2 Distribution Board

a. The boards shall be fabricated out of best quality cold rolled sheet steel of 2 mm including for doors & sides and shall be fully dust and vermin proof affording a degree of protection of IP – 54 for indoor DBs and IP 55 for outdoor DBs as per IS – 2174.

b. Distribution boards shall be provided both hinged door with handle and looking facility for switch on inter lock facility for switch on interlock of doors. Doors shall be gasketted all round with neoprene gaskets.

c. All accessible live connections / parts shall be shrouded and it shall possible to change /replace individual MCB /Fuse units from the front of the board without danger & coming in to contact with live parts.

d. Adequate interior cabling space and suitable removable type cable entry plates shall be provided for top/ bottom entry of cable gland plate shall be supplied undrilled. Necessary number of glands to suit the specified cable shall be provided. Cable glands shall be screwed on type and made of chromium plated brass.

e. The DB shall have two earthing terminals for connecting to the stations earthing.

f. The AC and DC DBs shall be either floor mounted type. Suitable foundations channels with necessary bolts and nuts shall be provided.

g. The danger board shall be fixed on the front of the door of DBs as per standards.

h. Wiring inside the panel shall be carried out with 1100 V grade PVC insulated stranded copper conductors of adequate size on both ends of each wire engraved identification ferrules shall be provided.

i. Bus bar shall be of copper adequately sized for the specified continuous current rating such that the maximum temperature of the busbar and links does not exceed 75^0 C.

j. All MCBs /Isolators /switches etc. shall be flush mounted with hinged door provided with locking arrangement and an inner Bakelite sheet /fibre glass sheet shall be provided inside such accidental contact.

k. Equipment mounted inside the panel shall be provided with individual labels with equipment designation /rating. Front of the panel shall be provided with label engraved with designation of the panel as furnished by the purchaser. Label shall be made of 3 ply lamicold /engraved PVC having white letters on black ground. Letter size shall be 4 mm minimum.

l. Terminal blocks shall be 1100 V grade clip on type, molded in melamine suitable for terminating incoming cable of suitable size of stranded copper conductor and outgoing circuits of approved sizes. All the terminals shall be shrouded, numbered and provided with identification strip for the feeders.

m. MCB's shall be current limiting type magnetic and thermal release suitable for manual closing and automatic tripping under fault condition single pole MCB's shall have interrupting capacity not less than 10 kA. MCB knob shall be marked with ON/OFF indication. A trip free release shall be provided to ensure tripping on

fault even if the knob is held in on position to avoid accidental contact. MCCB shall have adjustable setting, O/L & S.C. releases.

n. Fuses if required shall be HRC cartridge type complete with fuses fittings. Fuses fittings shall incorporate fully insulated shrouded contacts. Visible indication of operation of fuses shall be provided. However, purchaser would not prefer to have fuses instead MCB's should be provided.

o. The indoor panel shall be finalized during detailed engineering. The inside of the panel shall be glossy white.

1.4 PAINTING

a. All sheet work shall be phosphate in accordance with following procedure and in accordance with IS/IEC, code of practice for phosphating iron and steel, with seven tank process.

b. Oil, grease and dirt shall be thoroughly removed by emulsion cleaning.

c. Rust and scale shall be thoroughly removed by emulsion cleaning.

d. Rust and scale shall be removed by pickling with dilute acid followed by washing and running water rinsing with slightly alkaline hot water and drying.

e. After phosphating, through rinsing shall be carried out by clean water followed by final rinsing with dilute solution and oven drying.

f. The phosphate coating shall be sealed by the application of two coats of red mixed stoving type Zinc chromate primer. The coat may be 'flash dried' while the second coat shall be stove dried.

g. After the application of the primer, two coats of finishing synthetic enamel shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests. The color of the finishing paint on the exterior should be got approved form the purchasers before painting. All the panels and DBs shall be painted white in the interior.

h. Each coat of primer and furnishing paint shall be of a slightly different shade to enable inspection of painting.

i. The final finished film thickness of paint on sheet steel shall not be less than 100 microns and shall not be more than 150 microns.

j. Finished painted appearance shall present an aesthetically pleasing appearance free from dents and uneven surface.

k. Adequacy quantity of finishing paint shall be supplied for minor touchup required at site after the installation of the L.T., AC station board and distribution boards.

1.5 BUS – BAR, SWITCHING DEVICES & CONNECTIONS

1.5.1 LT Station Supply Board

Bus bar system for LT station supply board shall be assembled and fully tested and certified in accordance with relevant standards i.e. IS :375 or BS : 5486 & IEC 439

The busbars of LT station supply boards shall be of high conductivity aluminum and of uniform rectangular cross section. The size of bus bar shall be got approved from the purchaser before the procurement /fabrication. The bus bars and supporting arrangements shall be designed to withstand thermal and magnetic stresses corresponding to 10 kA fault level. All bus bars and metallic bus supports shall be insulated by heat shrunk PVC sleeves with exceptional dielectric properties to provide additional protection against accidental contact and to prevent failure in the event of accidental presence of external agents. Bus bars supports shall be arc resistant flame retardant, porcelain type or sheet moulding compound having high insulation resistance and de-moulding compound having high insulation resistance and dielectric strength to avoid ground faults of bus due to dust collection. At the bus- bar joints and tap-off points, removable shrouds (sleeves) shall be provided. Temperature rise shall not exceed the maximum allowable temperature for the equipment as specified in relevant IS/IEC specification even under over load conditions and shall be of sufficient size to limit the temperature rise not to exceed the specified value in the applicable standard inside the enclosure. Ground bus shall be provided at the bottom of each station supply board throughout the entire length of the board. This bus shall be earthed solidly by connecting to the main earthling system of the sub- station. There should be provision for earthing at both ends of the switchboard Lugs, bolts, nuts and spring washers shall be provided for earth connection.

1.5.2 Distribution Board

These shall be provided whenever required to further distribute the three phase supply taken from the ACDB. The bus bars of distribution boards shall be of electrolytic copper having 99.9 % purity as per IS-440 unless otherwise specified. The size of the Bus bars be got approved form the purchaser during detailed engineering.

a) All bus bars, MCBs, Switch fuse units, fuses and connection shall be of sufficient size to limit the temperature not to exceed the specified value in the relevant standard inside the enclosure while carrying full load current. All main busbars connections and bus bar outgoing taps be tin plated and tightly clamped with through bolts to ensure maximum conductivity. All bus bars shall be rigid type. All bus bars connections shall be accessible for inspection and maintenance purpose.

b) Bus bars supports shall be made of suitable insulating material such as sheet moulding compound, glass reinforced moulded plastic material, or cast resin etc., of

thickness not less than 6 mm. Separate supports shall be provided for all three phases, anti – tracking barriers shall be incorporated.

c) The bus bars shall be protected from Accidental contact by using highly not less than 6 mm thick.

d) The size of neutral bus of the wall mounted type 3 phase 4 wire distribution board shall be rated as the phase bus-bars. The neutral bus should have sufficient terminals and detachable links for all the single phase outgoing and supports shall have sufficient strength to with stand thermal and electromechanical stresses for a short circuit level of 10 kA of the system.

1.6 MOULDED CASE CIRCUIT BREAKERS (MCCB)

The MCBs shall be of reputed make having proven performance record with minimum rupturing capacity of 10 kA. The MCCBs shall be quick make quick break, independent manual type trip free mechanism. Position of knob shall be provided to test trip the MCCBs mechanically. Overload and short circuit protection for all circuits shall be provided for MCCBs. The MCCBS shall be covered with the insulating case and covers made of high strength, high resistant and flame retardant thermosetting insulating material.

1.7 MINIATURE CIRCUIT BREAKERS (MCB)

The MCBs shall be of reputed make and the characteristics of MCB shall be suitable for control & protection circuit equipment's, high pressure mercury vapour / sodium vapor lamps / fluorescent tubes & power points etc. MCB shall be hand operated, air break, quick make, quick break confirming to applicable standards mentioned. The out-going MCBs shall be provided with overload / short circuit device for protection under overload and short circuit conditions. The MCB shall have a minimum interrupting rating of 10 kA. MCB shall be flush mounted and fitted on Zinc chromium M.S channel provided in DB construction. Single pole MCBs shall be provided for all outgoing A.C feeders.

1.8 RESIDUAL CURRENT – OPERATED CIRCUIT BREAKERS (RCCB) / EARTH LEAKAGE CIRCUIT BREAKERS (ELCB)

1.8.1 The RCCB/ELCB offered shall be suitable for particular application in conjunction with MCB and arranged for manual closing and opening and automatic tripping on earth fault condition. In case of multi-pole circuit breakers, the indication shall represent the position of all the poles. The metallic portions of the mechanism shall be either inherently resistant to or treated so as to make them resistant to atmospheric corrosion. The operating mechanism shall be trip free. The operation mechanism case shall be effectively sealed by the manufacturer to prevent access to the mechanism. The case shall be of insulating material.

1.8.2 The RCCB shall be provided with test device for testing automatic opening of the circuit breaker by an integral test device. The test device shall be arranged for external operation in such a way that the protection afforded by the cover or enclosure is not impaired.

1.8.3 The product of rated residual current (rated tripping current) in amperes and the earth loop impedance in ohm should not exceed the value 50. The RCCB shall be so chosen that the same has lowest suitable tripping current.

1.9 FUSE HOLDER /BASE

Fuse holder be suitable for HRC fuse links of required rating. They shall be made up of superior grade phenolic moulding compound with non – inflammable property. Fuses holder shall be supplied with necessary cable holding screws and terminal lug fasteners and conducting portion copper carrier with extruded brass base support. Further conducting part shall be silver plated to provide long lasting shall be complete with pressure clip so formed to provide durable firm grip of male and female parts. Fuse holder shall be fully shrouded to ensure personnel safety.

1.10 FUSES

Generally fuses shall not be used anywhere. However if approved by purchaser due to specific situation the fuses shall be of reputed make and shall be HRC Cartridge type with minimum rupturing capacity of 10 kA. The fusing factor shall be greater than 1.5 and shall be provided with visible indicator for having operated. Fuses shall be dimensionally interchangeable with any other compatible make and shall be so designed to ensure non-deteriorating time current characteristics.

1.11 INTERNAL WIRING

The LT AC and DC station supply board and the distribution boards shall be supplied with complete internal wiring. The wiring shall be carried out the 1100 V grade, PVC insulated. Stranded supper conductor cables of adequate size shall be used to suit the rated circuit current. Engraved identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends of each wire. All wiring shall be terminated on terminal blocks. Terminal blocks shall be one piece moulded and suitable for 500 V. Stud type terminal blocks shall be used for higher current rating. Terminals shall be adequately rated for the short circuit current. Typically terminals of ‘Phoenix Contact’ make shall be provided which shall be approved by purchaser during detailed engineering.

1.12 NAME PLATE

Name plate shall be made of non-rusting metal or engraved on PVC shall be of size 50 mm x 20 mm indicating the feeder details and shall be provided for all feeders for easy identification DB No. etc. shall be provided.

1.13 DRAWINGS & LITERATURE

After receipts of the order, the contractor shall be required to furnish 10 prints of the following drawings for approval:-

a) General arrangements drawing of AC distribution board.

b) Typical schematic diagram of AC distribution board.

c) Complete assembly drawing of AC distribution boards showing plan, elevation. sectional views and location of terminal blocks cable entry details

d) Control and wiring diagram for each module of AC distribution board including spare terminals and inter modular and inter panel wiring.

e) Foundation plan showing location, channels, foundation bolts etc.

f) Schematic control diagram for control interlocks, relays, instruments and space heaters.

g) Protective relay characteristics of each type of relay

h) Fuse characteristics curve for each type of rating

i) Technical and descriptive literature giving details of the equipment offered.

1.14 TESTING & INSPECTION

1.14.1 All tests and inspection shall be made at the manufacturer's works unless otherwise specifically agreed upon by the manufacturer and purchaser at the time of placement of purchase order. The manufacturer shall afford to the inspector representing the purchaser, all reasonable facilities, without charge to satisfy him that the material being furnished is in accordance with these specifications. The purchaser reserves the right to get any component/material being used by the manufacturer of the L.T. board tested from any recognized test house. No material shall be dispatched without prior approval of the all the test reports and certificates by the purchaser.

1.14.2 The inspection by the purchaser or his authorized representative shall not relieve the bidder of his obligation of furnishing equipment in accordance with the specification.

TABLE-1.14.2.1

TECHNICAL PARTICULARS

1.	**AC SYSTEM**	3 phase, 4 wire, solidly earthed

	a. Voltage	400 volts- 15 % to +10 %
	b. Frequency	50 Hz ± 3 %
	c. Combined variation in voltage & frequency	- 10 % to + 10 % Absolute sum
	d. Fault level	10 kA (rms)
2.	**BUS BAR**	
	a. Continuous	630 A Aluminum
	b. Short time (1 Sec)	10 kA rms
3.	**ONE MINUTE POWER FREQUENCY WITHSTAND VOLTAGE**	
	a. Power circuits	2.5 kV (rms)
	b. Control circuits	2.5 kV (rms)
4.	**MOULDED CASE CIRCUIT BREAKER**	
	a. Voltage	AC 3- phases –415 V (-15 to + 10 %)
	b. Frequency	50 Hz
	c. Short circuit Performance	10 kA (rms)
	d. Making capacity	2.5 times breaking capacity
	e. Operating Mechanism	Manual , trip free
	f. Temperature rise	As per IEC
	g. Mechanical rise	As per IEC
	h. Auxiliary contacts	4 No., 4 NC
5.	**METERS**	
	a. Accuracy class	1.0 or better
	b. one minute power frequency withstand voltage	2 .5 kV (rms)
6.	**CURRENT TRANSFORMERS**	
	a. Type	Cast resin, Bar primary
	b. Secondary circuit	1 Amp.
	c. Voltage class and Frequency	1100 V, 50 Hz
	d. Class of insulation	E or better
	e. Accuracy	
	I. Accuracy class metering CT	Class 1, 10 VA

	II. Accuracy class protection CT	5p 10 , 15 VA
	f. Short time current rating	10 kA (rms) for 1 sec.
	g. one minute power frequency withstand voltage	2.5 kV (rms)
7.	**VOLTAGE TRANSFORMERS**	
	I. Type	Cast resin
	II. Rated voltage	415 V±10%
	a. Primary	415 V /√3
	b. Secondary	110V/√3
	III. Accuracy class and VA burden	
	a. Metering	1.0, 10 VA
	b. Protection	3 p, 50 VA
	IV. Method of connection	
	a. Primary	Star
	b. Secondary	Star
	V. Rated voltage factor	1.1 continuous , 1.5 for 3 sec.
	VI. Class of insulation	E or better
	VII. One minute power frequency withstand voltage	2.5 kV (rms)
8.	**RELAY**	
	a. One minute power frequency withstand voltage	2.0 kV (rms)
9.	**CUBICLE COLOUR FINISH**	
	a. Interior	Glossy white
	b. Exterior	Decided during detailed engineering
10.	**ACCESSORIES**	
	a. Plug point with switch fuse.	
	b. Space heater with thermostat	
	c. Name plate on front of rear	
	d. Danger plate	

TECHNICAL PARTICULARS

1.	**DC SYSTEM**	3 phase, 4 wire, solidly earthed
	a. Voltage	400 volts- 15 % to +10 %
	b. Frequency	50 Hz ± 3 %
	c. Combined variation in voltage & frequency	- 10 % to + 10 % Absolute sum
	d. Fault level	10 kA (rms)
2.	**BUS BAR**	
	a. Continuous	250 A Aluminum
	b. Short time (1 Sec)	10 kA rms
3.	**MOULDED CASE CIRCUIT BREAKER**	
	a. Voltage	DC 220 V (-15 to + 10 %)
	b. Short circuit Performance	10 kA (rms)
	c. Making capacity	2.5 times breaking capacity
	d. Operating Mechanism	Manual , trip free
	e. Temperature rise	As per IEC
	f. Mechanical rise	As per IEC
	g. Auxiliary contacts	4 No., 4 NC
4.	**METERS**	
	a. Accuracy class	1.0 or better
	b. one minute power frequency withstand voltage	2 .5 kV (rms)
5.	**RELAY**	
	a. One minute power frequency withstand voltage	2.0 kV (rms)
6.	**CUBICLE COLOUR FINISH**	
	a. Interior	Glossy white
	b. Exterior	Decided during detailed engineering
7.	**ACCESSORIES**	
	a. Plug point with switch fuse.	
	b. Space heater with thermostat	
	c. Name plate on front of rear	
	d. Danger plate	

CHAPTER 5: BATTERY AND BATTERY CHARGER

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CHAPTER: BATTERY & BATTERY CHARGER

1.1. GENERAL TECHNICAL REQUIREMENTS

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

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

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

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

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

	Load	**Duration**	**Type Of Loads**
220V DC System	Continuous Load	3 hours	Relays, IEDs, Station HMIs, spring charging, Isolator interlocking load, Miscellaneous permanently connected loads etc.
	Emergency Load	1 hour	Substation emergency lighting loads.
	Momentary Load	1 minute	Breaker closing, Tripping loads (taking simultaneous occurrence as per system)
	Load	**Duration**	**Type Of Loads**
110V DC System	Continuous Load	3 hours	Relays, IEDs, Station HMIs, spring charging, Isolator interlocking load, Miscellaneous permanently connected loads etc.
	Emergency Load	1 hour	Substation emergency lighting loads.
	Momentary Load	1 minute	Breaker closing, Tripping loads (taking simultaneous occurrence as per system)
48V DC System	Continuous Load	3 hours	Continuous load associated with PLCs.(when speech is not working)
	Momentary Load	15 minute	Loads associated with PLCs (when speech is working)

1.2. Battery

1.2.1. **Type**
The DC Batteries shall be VRLA (Valve Regulated Lead-Acid) type and shall be Normal Discharge type. These shall be suitable for a long life under

continuous float operations and occasional discharges. Air-conditioning shall be provided in Battery room the requirement of which has been specified elsewhere in the Technical Specification. The 220 V / 110V DC system is unearth and 48 V DC system is + ve earth system.

1.2.2. Constructional Requirements

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

1.2.3. Containers

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

1.2.4. Cell Covers

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

1.2.5. Separators

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

1.2.6. Pressure Regulation Valve

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

1.2.7. Terminal Posts

Both the +ve and –ve terminals of the cells shall be capable of proper termination and shall ensure its consistency with the life of the battery. The surface of the terminal post extending above the cell cover including bolt hole

shall be coated with an acid resistant and corrosion retarding material. Terminal posts or any other metal part which is in contact with the electrolyte shall be made of the same alloy as that of the plates or of a proven material that does not have any harmful effect on cell performance. Both +ve and –ve posts shall be clearly and unambiguously identifiable.

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

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

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

1.2.9. **Flame Arrestors**

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

1.2.10. **Battery Bank Stand**

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

1.2.11. **Capacity Requirements**

When the battery is discharged at 10 hour rate, it shall deliver 80% of C (rated capacity, corrected at 27º Celsius) before any of the cells in the battery bank reaches 1.85V/cell.

The battery shall be capable of being recharged from the fully exhausted condition (1.75V/cell) within 10 hrs up to 90% state of charge. All the cells in a battery shall be designed for continuous float operation at the specified float voltage throughout the life.

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

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

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

1.2.12. **Expected Battery Life**

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

1.2.13. **Routine Maintenance of Battery system**

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

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

1.2.14. **Type Test of Battery**

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

S.No.	Description of test
1.	Gas emission
2.	High current tolerance
3.	Short circuit current and d.c. internal resistance
4.	Protection against internal ignition from external spark sources
5.	Protection against ground short propensity
6.	Content & durability of required markings
7.	Material identification
8.	Valve operation
9.	Flammability rating of materials
10.	Intercell connector performance
11.	Discharge Capacity
12.	Charge retention during storage
13.	Float service with daily discharges for reliable mains power
14.	Recharge behaviour
15.	Service life at an operating temperature of 40^0 C for brief duration exposure time.
16.	Impact of a stress temperature of 60^0 C for brief duration exposure time

	with 3 h rate discharge test.
17.	Abusive over-discharge
18.	Thermal runaway sensitivity
19.	Low temperature sensitivity
20.	Dimensional sensitivity at elevated internal pressure and temperature
21.	Stability against mechanical abuse of units during installation

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

1.2.14.2. **List of Factory & Site Tests for Battery**

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

1.2.15. **Installation and commissioning**

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

1.2.16. Contractor shall be submitted following documents for approval:

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

1.3. Battery Charger

The DC system for 220 V & 110V DC is unearthed and for 48 V DC is +ve earthed. The Battery Chargers as well as their automatic regulators shall be of static type and shall be compatible with offered VRLA batteries. All battery chargers shall be capable of continuous operation at the respective rated load in float charging mode, i.e. Float charging the associated Lead-Acid Batteries at 2.13 to 2.27 Volts per cell while supplying the DC load. The chargers shall also be capable of Boost charging the associated DC Battery at 2.28 to 2.32 volts per cell at the desired rate.
Charger shall regulate the float/boost voltage in case of prescribed temperature rise of battery as per manufacturer's recommendation to avoid thermal runaway. Necessary temperature sensors shall be provided in mid location of battery banks and shall be wired up to the respective charger for feedback

control. The manufacturer shall demonstrate this feature during testing of each charger.

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

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

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

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

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

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

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

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

1.3.9. **MCCB**

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

1.3.10. **Rectifier Transformer**

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

1.3.11. **Rectifier Assembly**

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

1.3.12. **Instruments**

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

1.3.13. **Air Break Switches**

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

1.3.14. **Fuses**

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

1.3.15. **Blocking Diode**

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

1.3.16. **Annunciation System**

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

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

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

1.3.17. **Name Plates and Marking**

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

1.3.18. **Charger Construction**

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

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

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

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

1.3.19. **Painting**

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

1.3.20. **TESTS**

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

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

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

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

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

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

(i) Switches.
(ii) Relays/ MCCBs
(iii) Instruments.
(iv) DC fuses.
(v) SCR.

(vi) Diodes.
(vii) Condensers.
(viii) Potentiometers.
(ix) Semiconductor
(x) Annunciator.
(xi) Control wiring
(xii) Push buttons and contactors.

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

Annexure-I

BATTERY SYSTEM DATA SHEETS

S.No.	Description of Data	Unit	220 V/ 110 V	48 V
1	General Data			
a)	Battery Type:			
	Grid alloy: Pure lead(Pb), lead calcium (Pb-Ca),lead antimony (Pb-Sb), or lead selenium (Pb-Se) or other pl. specify			
	Cell type: Absorbed glass mat or gel cell or other please specify			
	Seller's type number			
	Number of positive plates per cell			
b)	Does each battery and battery [rack]/ [cabinet] meet the seismic requirements	[Yes] [No]		
c)	Manufacturer's Designed Life of Battery	Yrs		
d)	Recommended Battery Charger Data:			
	Floating voltage range	V		
	Boost charge	V		
	Current rating	Amps.		
	Recharge time	hr		
e)	Heat Released During:			
	Discharge duty cycle	Watt		
	Float charge	Watt		
	Boost Charge	Watt		
f)	Maximum Amount of Hydrogen Gas Evolved			
	During Battery-Boost Charge (2.33 V per cell) at Maximum Battery Temperature	(Litre /h)		

	Hydrogen Gas Evolution at Float	(Litre /h)		
g)	Time Battery may be Stored Without a Freshening Charge	months		
h)	Temperature Compensation Provided and its Details			

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

	Inter-[Tier] [Step]:					

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

CHAPTER 6: LIGHTING SYSTEM

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1.0 LIGHTING SYSTEM

1.1 *LIGHTING SYSTEM FOR SUBSTATION*

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

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

1.1.1 SYSTEM DESCRIPTION

The lighting system shall comprise of the following:

1.1.2 AC Normal Lighting

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

1.1.3 AC Emergency Lighting

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

1.1.4 D.C. Emergency lighting

A few DC emergency lighting fixtures operated on the DC system will be provided in the strategic locations including staircase, corridors, electrical rooms, Battery charger room, LT switchgear room in control room building, and Fire fighting pump house so that the operating personnel can safely find their way

even during emergency of a total AC failure. These lights will be normally 'OFF' and will be switched 'ON' automatically when under voltage occurs in the AC main lighting distribution board. GLS lamp down lighters in false ceiling area and Bulkhead fixtures in non false ceiling area to be used.

1.1.5 **Exit Lightings**

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

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

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

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

For achieving the specified lux levels in the switchyard, the contractor can provide luminaries of 1x400 W/1x250 W and 2x400 W/ 2x250 W flood light as per requirement.

The contractor shall submit detailed calculation for reaching the above Lux level. Contractor shall conform the Lux levels at different locations of the switch yard and street lighting by measurement.

In addition to the normal lighting provided in the switchyard area to maintain the desired lux levels, high beam fixtures(Type SF4- 8 nos) on swivel support shall be provided in strategic locations near equipments for new substations which shall be kept normally OFF and these shall be switched ON in case of maintenance work.

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

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

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

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

1.1.10 **For Outdoor Illumination**

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

1.1.11 **For Indoor Illumination**

The conduit layout drawing for substation buildings, Electrical distribution diagram for substation buildings, & for substation yard etc. shall be prepared by the Contractor. All wiring including telephone wiring (tinned two pair copper) shall be in concealed conduit. Concealed MS junction boxes for sockets and light points shall be provided in all the rooms of Control Room cum

Administrative Office Building and Fire Fighting pump house. In case where false ceiling surface conducting is permissible, all down run conduits will be concealed in wall below the false ceiling.

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

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

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

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

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

1.2 LIGHTING SYSTEM FOR TOWNSHIP

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

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

1.2.2 SYSTEM DESCRIPTION

The township lighting system shall comprise of the following:

1.2.3 EXTERNAL ELECTRIFICATION WORKS

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

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

1.2.4 INTERNAL ELECTRIFICATION WORKS

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

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

2.0 DESCRIPTION OF ITEMS

2.1 *DESCRIPTION OF ITEMS FOR SUBSTATION LIGHTING*

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

2.1.1 LIGHTING PANELS

2.1.1.1 OUTDOOR

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

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

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

2.1.1.2 INDOOR

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

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

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

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

2.1.1.3 Sub-Lighting Panels

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

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

2.1.2 **Lighting Fixtures**

Please Refer Annexure-1

2.1.3 **RECEPTACLES**

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

2.1.4 (a) **SWITCH BOARDS**

Modular type switches, 5/15 Amp. Receptacles.

2.1.4 (b) **CONDUITS AND ACCESSORIES**

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

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

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

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

2.1.8 **MAINTENANCE EQUIPMENT**

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

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

2.1.9. RECEPTACLES

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

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

i) **Type RO**-15A, 230V, 2 pole, 3 pin type with third pin grounded, metal clad with gasket having cable gland entry suitable for 2Cx6 sq.mm. PVC/aluminum armoured cable and a metallic cover tied to it with a metallic chain and suitable for installation in moist location and or outdoor. The switch shall be of rotary type. Receptacles shall be housed in an enclosure made out of 2 mm thick Gl sheet with hinged doors with padlocking arrangements. Door shall be lined with good quality gasketing. This shall conform to IP-55.

ii) **Type RI-**The 5/15 amp 6 pin receptacles with switches will be of Modular type with flush type switches and electroplated metal enclosures of approved make

iii) **Type RP** - 63A, 400V, 3 phase, 4 pin interlocked plug and switch with earthing contacts. Other requirements shall be same as type RO. The receptacle shall be suitable for 3.5C x 35/3.5Cx70 sq.mm. aluminium conductor cable entry and shall also be suitable for loop-in and loop out connection of cables of identical size. Receptacle shall be suitable for outdoor application. Receptacles shall be housed in a box made out of 2mm thick G.I. sheet, with hinged door with padlocking arrangement. Door shall be lined with good quality gasketing. This shall conform to IP-55.

2.1.10. LIGHTING PANELS (L.P.)

2.1.10.1 Each panel shall be provided with one incoming triple pole MCB with neutral link and outgoing miniature circuit breakers as per clause 2.0. The panels shall conform to IEC: 60439.

2.1.10.2 Constructional Features

a) Panels shall be sheet steel enclosed and shall be dust, weather and vermin proof. Sheet steel used shall be of thickness not less than 2.00 mm (cold rolled) smoothly finished, levelled and free from flaws. Stiffners shall be provided wherever necessary. The indoor lighting panels will be ready made DB of minimum 1.6 mm sheet thickness.

b) The panels shall be of single front construction, front hinged and front connected,

suitable for either floor mounting on channels, sills or on walls/columns by suitable M.S. brackets. Indoor panels in control room shall be flush mounted.

c) Panels shall have a dead front assembly provided with hinged door(s) and out door panels will be with padlocking arrangement with single key supplied in duplicate.

d) All out door panels, removable covers, doors and plates shall be gasket all around with neoprene gaskets.

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

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

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

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

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

j) **Main Bus Bars**

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

2.1.10.3 **JUNCTION BOXES**

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

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

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

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

e) The junction boxes shall have the following indelible markings

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

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

2.1.10.4 **Occupancy Sensors:**

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

2.2 DESCRIPTION OF FCOMMON ITEMS FOR LIGHTING

2.2.1 LIGHTING FIXTURES AND ACCESSORIES

2.2.1.1 General

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

2.2.1.2 Temperature Rise

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

2.2.1.3 Supply Voltage

Lighting fixtures and accessories meant for 230V A.C. operation shall be suitable for operation on 230V A.C. 50Hz, supply voltage variation of ± 10%, frequency variation of ± 2.5% and combined voltage and frequency variation of ± 10%.

Lighting fixture and accessories meant for 220V DC operation shall be suitable for operation on 220V DC with variation between 190 to 230 Volts.

2.2.1.4 **Lighting Fixtures**

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

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

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

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

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

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

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

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

2.2.1.5 **ACCESSORIES**

2.2.1.5.1 **Lamp holders and Starter Holders**

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

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

2.2.1.5.2 **Ballasts**

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

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

c) The wire-wound ballasts shall be of the inductive, heavy duty type, filled with thermosetting insulating moisture repellent polyester compound filled under pressure or vacuum. The ballast wiring shall be of copper wire. They shall be free from hum. Ballasts which produce humming sound shall be replaced free of cost by the Contractor. Ballasts for high pressure mercury vapour/ HPSV lamps shall be provided with suitable tappings to set the voltage within the range specified. End connections and taps shall be brought out in a suitable terminal block, rigidly fixed to the ballast enclosure.

d) Separate ballast for each lamp shall be provided in case of multi-lamp fixtures.

e) High frequency electronic ballasts shall be capable of satisfactory performance in adverse environment like that of EHV substation. Ballasts shall consist of AC/DC converter, high frequency power oscillator and low pass filter. The ballasts shall be suitable for use of nominal voltage of 230V +/- 10%, 50 Hz supply. The filter circuit shall suppress the feedback of high frequency signals to the mains. The ballast shall be rated for 36/40W fluorescent fixtures. The ballasts shall confirm to IEC 68-2-6FC, IEC 60929 for performance, IEC 60928 for safety and EN 55015, EN 55022A for RFI and EN 61003.

2.2.1.5.3 **Capacitors**

a) The capacitors shall have a constant value of capacitance and shall be connected across the supply of individual lamp circuits.

b) Power factor of fluorescent lamp fixtures with HF electronic ballast shall

not be less than 0.90 and that of High pressure Sodium Vapour, Mercury Vapour and Metal Halide lamp fixtures shall not be less than 0.85. The capacitors shall be suitable for operation at supply voltage as specified and shall have a value of capacitance so as to correct the power factors of its corresponding lamp circuit to the extent of 0.98 lag.

c) The capacitors shall be hermetically sealed in a metal enclosure.

2.2.1.5.4 **Lamps**

a) General Lighting Services (GLS) lamps shall be provided with screwed caps and shall be of 'clear' type unless otherwise specified.

b) The Bidder shall furnish typical wiring diagram for Fluorescent, HPMV & HPSV fitting including all accessories. The diagram shall include technical details of accessories i.e. starters, chokes, capacitors etc.

c) Flexible conduits if required, for any fixture shall be deemed to be included in Contractor's scope.

2.2.1.5.5 **SWITCH AND SWITCHBOARD**

(a) All Switch board/boxes, 5/15 Amp Receptacles and electronic fan regulators located in office/building areas shall be modular flush mounted type or brick wall with only the switch knob projecting outside.

(b) Switch boards/boxes shall have conduit knock outs on all the sides.

(c) The exact number of switches including regulator for fans and layout of the same in the switchboard shall be to suit the requirement during installation.

(d) The maximum number of luminaires, controlled by one no 6 amp switch would 4 nos. For DC fixtures there will be no switch and the same shall be directly controlled from DC LP

(e) The luminaires shall be wired in such a fashion that luminaires on each phase are evenly distributed all over the room.

2.2.1.5.6. **CONDUITS & CONDUIT ACCESSORIES**

a) The conduits shall conform to IEC: 61386 or IEC: 61035 or IEC: 60614 as applicable. All steel conduits shall be seemed by welding, shall be of heavy gauge and shall be hot dip galvanised.

b) Flexible conduits wherever required shall be made with bright, cold rolled annealed and electro-galvanised mild steel strips or PVC/Plastic.

c) All conduits accessories shall conform to relevant IEC and shall be hot dip galvanized or High quality virgin PVC.

2.2.1.5.7 **TERMINAL BLOCKS**

Each terminal shall be suitable for terminating upto 2 Nos. 10 sq.mm. stranded Aluminium Conductors without any damage to the conductors or any looseness of connections. Terminal strips provided in street - lighting poles shall be suitable for terminating upto 2 nos. 4C x 16 sq. mm aluminium cables.

2.2.1.5.8 **PULL OUT BOXES**

a) The pull out boxes shall be concealed type for indoor lighting and suitable for mounting on column, structures etc., for outdoor lighting. The supply of bolts, nuts and screws required for the erection shall be included in the installation rates.

b) The pull out boxes shall be circular of cast iron or 16 SWG sheet steel and shall have cover with good quality gasket lining.

c) The pull out boxes and cover shall be hot dip galvanised.

d) The pull out boxes shall be completed with conduit knock outs/threaded hubs and provided at approximately 3 meters intervals in a conduit run.

2.2.1.5.9 **Residual Current Circuit Breakers (RCCB)**

For indoor panels 63A 4pole 300 ma RCCB conforming IEC 13947 will be provided along with incomer.

2.2.1.5.10 **Miniature Circuit Breaker (MCB)**

a) The miniature circuit breakers shall be suitable for manual closing, opening, automatic tripping under overload and short circuit. The MCBs shall also be trip free. MCB of Type C tripping characteristics as per IEC: 60898 will be used for Switchyard lighting.

b) Single pole as well as three pole versions shall be furnished as required in the Schedule of Lighting Panels.

c) The MCBs and panel MCCB together shall be rated for full fault level. In case the MCB rating is less than the specified fault level the bidder shall co-ordinate these breaker characteristics with the back up MCCB in such a way that if fault current is higher than breaker rating, the MCCB should blow earlier than the breaker. If the fault current is less than MCB breaking capacity, MCB shall operate first and not the incomer MCCB.

d) The MCBs shall be suitable for housing in the lighting panels and shall be suitable for connection with stranded copper wire connection at both the incoming and outgoing side by copper lugs or for bus bar connection on the incoming side.

e) The terminals of the MCBs and the 'open' 'close' and 'trip' conditions shall be clearly and indelibly marked.

f) The tenderer shall check and co-ordinate the ratings of MCBs with respect to starting characteristics of discharge lamps. The vendor has to furnish overload and short circuit curve of MCB as well as starting characteristics curves of lamps for Employer's approval.

g) The MCB shall generally conform to IEC: 60898.

2.2.1.5.11 **Contactors**

Contactors shall be of the full voltage, direct-on line air break, single throw, electro-magnetic type. They shall be provided with atleast 2-'NC' and 2'NO' auxiliary contacts. Contactor shall be provided with the three element, positive acting, ambient temperature compensated time lagged, hand reset type thermal overload relay with adjustable settings to suit the rated current. Hand reset button shall be flush with the front of the cabinet and suitable for resetting with starter compartment door closed. The Contactor shall be suitable for switching on Tungsten filament lamp also. The bidder shall check the adequacy of the Contactors rating wire with respect to lighting load.

2.2.1.5.12 **Push Buttons**

All push buttons shall be of push to actuate type having 2 'NO' and 2 'NC' self reset contacts. They shall be provided with integral escutcheon plates engraved with their functions. Push buttons shall be of reputed make.

2.2.1.5.13 **Labels**

a) The lighting panels shall be provided on the front with panel designation labels on a 3 mm thick plastic plate of approved type. The letter shall be black engraved on white back ground.

b) All incoming and outgoing circuits shall be provided with labels. Labels shall be made of non-rusting metal or 3 ply lamicold. Labels shall have white letters on black or dark blue background.

2.2.1.5.14 **Earthing Terminals**

Panels shall be provided with two separate and distinct earthing terminals suitable to receive the earthing conductors of size 50x6 G.S. Flat.

2.2.1.5.15 Type test reports for following tests on all lighting panels shall be submitted for approval as per clause 9.2 of Chapter 2: GTR.

(i) Wiring continuity test
(ii) High voltage (2.5 KV for 1 minute) and insulation test
(iii) Operational test
(iv) Degree of protection (not less than IP-55 test on outdoor Lighting Panels and IP-52 test on indoor Lighting Panels as per IEC: 60947 (part 1)
(v) Heat run test

2.2.1.5.16. **LIGHTING POLES**

a) The Contractor shall supply, store and install the following types of steel tubular lighting poles required for street lighting.

i) Type A1 Street Lighting Pole - for one fixture
ii) Type E1 Post top lantern pole - for one fixture

b) Street/flood light poles shall conform to the enclosed drawings. In front of control room building, and Fire Fighting Buildings, decorative post top lantern (Type E1) poles and Bollards shall be installed.

c) Lighting poles shall be complete with fixing brackets and junction boxes. Junction boxes should be mounted one meter above ground level.

d) The lighting poles shall be coated with bituminous preservating paint on the inside as well as on the embedded outside surface. Exposed outside surface shall be coated with two coats of metal primer (comprising of red oxide and zinc chromate in a synthetic medium).

e) The galvanised sheet steel junction box for the street lighting poles shall be completely weather proof conforming to IP-55 and provided with a lockable door and HRC fuse mounted on a fuse carrier and fuse base assembly. The fuses & junction box shall be as specified in the specification. However, terminals shall be stud type and suitable for 2 nos. 16 sq.mm. cable.

f) Wiring from junction box at the bottom of the pole to the fixture at the top of the pole shall be done through 2.5 sq. mm wire.

g) Distance of centre of pole from street edge should be approximately 1000 to 1200 mm.

h) Earthing of the poles should be connected to the switchyard main earth mat wherever it is available and the same should be earthed through 3M long, 20 mm dia, earth electrode.

2.2.1.5.17 CEILING & WALL MOUNTED FANS AND REGULATORS

a) The contractor shall supply and install 1400 mm sweep ceiling fans complete with electronic regulator and switch, suspension rod, canopy and accessories. The wall mounted fans shall be of 400 mm sweep

b) The contractor shall supply and install the switch, electronic regulator and board for mounting switch and electronic regulator for celling fans. The regulator will be housed in common switchboard for lighting and shall be of similar make and model as that of modular switches.

c) Winding of the fans and regulators shall be insulated with Class-E insulating material. Winding shall be of copper wire.

d) Electronic regulator with stepped control shall be provided.

2.2.1.5.18 LIGHTING WIRES

a) The wiring used for lighting shall be standard products of reputed manufacturers.

b) The wires shall be of 1100 V grade, PVC insulated product of reputed manufacturers.

c) The conductor sizes for wires used for point wiring beyond lighting panels shall be 2.5 sq.mm, 4 sq.mm, 6 sq.mm and 1.5 sq.mm stranded copper wire.

d) The wires used for connection of a lighting fixture from a nearest junction box or for loop-in loop-out connection between two fluorescent fixtures shall be single core copper stranded conductor, 1100V grade flexible PVC insulated cords, unsheathed, conforming to IEC:60502 with nominal conductor cross sectional areas of 2.5 sq. mm.

e) The wires shall be colour coded as follows:

Red for R - Phase
Yellow for Y - Phase
Blue for B - Phase
Black for Neutral
White for DC (Positive)
Grey for DC (Negative)

2.2.1.5.19 LIGHTING SYSTEM INSTALLATION WORKS

2.2.1.5.19.1 General

In accordance with the specified installation instructions as shown on manufacturer's drawings or as directed by Employer, Contractor shall unload, erect, install, test and put into commercial use all the electrical equipment included in the contract. Equipment shall be installed in a neat, workmanship manner so that it is level, plumb square and properly aligned and oriented. Tolerances shall be as established in manufacturers drawing or as stipulated by Purchaser.

All apparatus, connections and cabling shall be designed so as to minimize risk of fire or any damage which will be caused in the event of fire.

2.3.1.5.19.2 Conduit System

a) Contractor shall supply, store and install conduits required for the lighting installation as specified. All accessories/fittings required for making the installation complete, including but not limited to pull out boxes (as specified in specification ordinary and inspection tees and elbow, checknuts, male and female bushings (brass or galvanised steel), caps, square headed make plugs, nipples, gland sealing fittings, pull boxes, conduits terminal boxes, glands, gaskets and box covers, saddle terminal boxes, and all steel supporting work shall be supplied by the Contractor. The conduit fittings shall be of the same material as conduits. The contractor shall also supply 20 mm PVC conduit and accessories for telephone wiring.

b) All unarmoured cables/wires shall run within the conduits from lighting panels to lighting fixtures, receptacles. etc.

c) Size of conduit shall be suitably selected by the Contractor.

d) Conduit support shall be provided at an interval of 750 mm for horizontal runs and 1000 mm for vertical runs.

e) Conduit supports shall be clamped on the approved type spacer plates or brackets by saddles or U-bolts. The spacer plates or brackets in turn, shall be securely fixed to the building steel by welding and to concrete or brick work by grouting or by nylon rawl plugs. Wooden plug inserted in the masonary or concrete for conduit support is not acceptable.

f) Where conduits are along with cable trays they shall be clamped to supporting steel at an interval of 600 mm.

g) For directly embedding in soil, the conduits shall be coated with an asphalt-base

compound. Concrete pier or anchor shall be provided wherever necessary to support the conduit rigidly and to hold it in place.

h) For long conduit run, pull boxes shall be provided at suitable intervals to facilitate wiring.

i) Conduit shall be securely fastened to junction boxes or cabinets, each with a lock nut inside and outside the box.

j) Conduits joints and connections shall be made through water-tight and rust proof by application of a thread compound which insulates the joints. White lead is suitable for application on embedded conduit and red lead for exposed conduit.

k) The entire metallic/PVC conduit system, shall be embedded, electrically continuous and thoroughly grounded. Where slip joints are used, suitable bounding shall be provided around the joint to ensure a continuous ground circuit.

l) Conduits and fittings shall be properly protected during construction period against mechanical injury. Conduit ends shall be plugged or capped to prevent entry of foreign material.

2.2.1.5.19.3 **Wiring**

a) Wiring shall be generally carried out by PVC insulated wires in conduits. All wires in a conduit shall be drawn simultaneously. No subsequent drawings of wires is permissible.

b) Wires shall not be pulled through more than two equivalent 90 deg. bends in a single conduit run. Where required, suitable junction boxes shall be used.

c) Wiring shall be spliced only at junction boxes with approved type terminal strip.

d) For lighting fixtures, connection shall be teed off through suitable round conduit or junction box, so that the connection can be attended without taking down the fixture.

e) For vertical run of wires in conduit, wires shall be suitably supported by means of wooden/hard rubber plugs at each pull/junction box.

f) Maximum two wires can be terminated to each way of terminal connections.

g) Separate neutral wires are to be provided for each circuit.

h) AC and DC wiring should not run through the same conduit.

2.2.1.5.19.4 Lighting Panels

a) The lighting panels shall be erected at the locations to be finalised during detailed engineering.

b) Suitable foundations/supporting structures for all outdoor type lighting panels shall be provided by the Contractor.

2.2.1.5.19.5 Foundation & civil works

a) Foundation for street lighting poles, panel foundation and transformer foundation shall be done by the Contractor. The payment towards execution, PCC & RCC shall be made under relevant items of civil work mentioned in Bid Price schedule.

b) All final adjustment of foundation levels, chipping and dressing of foundation surfaces, setting and grouting of anchor bolts, sills, inserts and flastening devices shall be carried out by the Contractor including minor modification of civil works as may be required for erection.

c) Any cutting of masonary / concrete work, which is necessary shall be done by the Contractor at his own cost and shall be made good to match the original work.

ANNEXURE-1

SI. No.	Type of Lighting Fixture	Description	Philips Catalogue No
1	F1	2x28W T5 type fluorescent lamps in industrial reflector type fixture, complete with accessories and suitable for pendent /surface mounting.	TMS 122/228 HF
2	FF	2x28 T5 energy efficient fluorescent lamps with low glare, mirror optics suitable for recess mounting type lighting fixture.	TBS 088/228 C5 HF
3	FL	2x28W T5 energy efficient fluorescent lamps with low glare mirror optics suitable for pendent/surface mounting with all accessories	TCS 398/228 D6 HF
4	TL	Sleek and Functional electronic decobatten suitable for use with 1x'TLD'36W fluorescent lamp with dual tone end caps. Pre-phosphated & powder coated CRCA steel channel complete with all electrical accessories like electronic ballast, lamp holders all prewired up to a terminal block	TMS500/136 HF
5	IB	60/100w GLS lamp in Bulkhead fixtures with Cast Aluminium alloy body, suitable for column, wall,and ceiling mounting finished stove enameled silver grey outside	NXC101
6	BL	Aesthetic wall/ceiling mounted luminaire suitable for 1x PL-C 13W OR 11W CFL. Low loss O.C. Copper ballast.Built in high gloss anodized reflector. Twin finish UV stabilised SAN diffuser for protection & elimination of lamp glare.	FMC21/113
7	SL	Aesthetic ceiling mounted luminaire for Ecotone crystal/Décor CFL of 2x9W or 1x18W. ABS housing pre-wired with porcelain lampholder. Pre-phospated plated CRCA gear tray.	FL343/118
8	BH	Bulkhead luminaire suitable for use with PL-S 9W CFL. Single piece pressure die-cast aluminium & cover retaining Frame. Opal acrylic cover along with a gasket made of E.P.R..	FXC 101/109
9	BLD	2X9 Or 1x18 watt CFL bollard light for landscape lighting having FRP/LLDPE housing	FGC202 /118
10	DLR	2x18 watt CFL Downlighter with HF ballast suitable for recess mounting	FBH145/218L HF
11	DSM	1X13 WATT surface mounted CFL	FCS100/113
12	IF	Incandescent GLS lamp down light	DN622

13	SF1	1 X 400W HPSV lamps in high flood lighting fixture with integral control gear	SWF 330/1X400
14	SF2	2 X 400W HP sodium Vapour lamps in high flood lighting, non-integral control gear:	RVP302/2x400W
15	SF3	1 X 250W HPSV lamps in high flood lighting fixture with integral control gear:	SWF 330/1X250
16	SF4	150W HP Metal halide MHN-TD lamp in flood lighting fixture with integral control gear.	SWF230/150 MHN-TD
17	SF5	125 HP MV Lamp in weather proof post top lantern for mounting on pole top	HPC-101/125 HPF
18	SC	150W SON-T Tubular Sodium Vapour lamp in street lighting	SRX-51/150

CHAPTER-7: LT TRANSFORMER

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CHAPTER 7: LT TRANSFORMER

1.0 INTENT

This specification is intended to cover outdoor type oil filled 630 kVA, 11/0.400kV, transformers **.**

2.0 SCOPE OF WORK

2.1 Scope of Supply

- Transformers as listed above, with insulating oil, all materials and accessories, and complete in all respects.
- Gland plates, power cable, lugs, anchor bolts and hardwares.
- Mandatory & optional spares and special maintenance equipments if any.

2.2 Scope of Service

The scope includes but is not limited to the following items of work to be performed for all equipment and materials furnished under this chapter:

a) Design, manufacturing, shop testing, packing & despatch

b) Transportation inclusive of insurance and delivery, FOR site basis

c) Unloading, handling, storing, transportation at site up to foundations, oil filling and treatment, erection, testing and commissioning

d) Civil Works

e) Supply of external cables and termination as required.

f) Fire protection system.

3.0 General Information

3.1 All temperature indicators, Buchholz relays and other auxiliary devices shall be suitable for 220 V DC Control supply. All alarm and trip Contacts shall also be suitable for connection in 220V DC Circuits.

3.2 Bidders may specifically note that transformers offered shall conform to dynamic short circuit test and dielectric test as per IEC: 60076. Test report for the same shall be submitted during detail engineering for approval.

4.0 TECHNICAL REQUIREMENTS

4.1 Core

The core shall be constructed from high grade, non-aging, cold rolled grain-oriented silicon steel laminations. The maximum flux density in any part of the cores and yoke at normal voltage and frequency shall be such that the flux density at any tap position with 10% voltage variation from the voltage corresponding to the tap shall not exceed 1.9 Wb/sq-m.

4.2 Windings

The conductor shall be of electrolytic copper, free from scales and burrs.

4.3 Insulating Oil

The oil supplied with transformer shall be unused and have the parameters for unused new oil conforming to IEC: 60296 while tested at oil Contractor's premises, No inhibitors shall be used in oil. Ten percent extra oil shall be supplied for topping up after commissioning in nonreturnable containers suitable for outdoor storage.

4.4 Terminal Arrangement

a) Bushing terminals shall be provided with suitable terminal connectors of approved type and size for cable/overhead conductors' termination of HV side and cable termination on LV side.

b) The neutral terminals of 400V winding shall be brought out on a bushing along with the 433 volt phase terminals to form a 4 wire system for the 400 volt. Additional neutral bushing shall also be provided for earthing.

4.5 Off Circuit Tap Changing Equipment

The tap change switch shall be three phase, hand operated for simultaneous switching of similar taps on the three phases by operating an external hand wheel.

4.6 Marshalling Box

A metal enclosed, weather, vermin & dust proof marshalling box shall be provided with each transformer to accommodate temperature indicators, terminal blocks etc. It shall have a degree of protection of IP 55 as per IEC: 60947 Part-1.

4.7 Cable boxes

Whenever cable connections are required, suitable cable boxes shall be provided and shall be air insulated. They shall be of sufficient size to accommodate Purchaser's cables and shall have suitable removable side/top cover to facilitate cable termination and inspection. Cable boxes shall be dust & vermin proof.

5.0 Inspection and Testing

a) The Contractor shall draw up and carry out a comprehensive inspection and testing program during manufacture and commissioning of the transformer. The programme shall be duly approved by the Purchaser.

b) The Contractor shall carryout all routine tests on all the transformers as per relevant standards. Type test report shall be submitted for approval during detail engineering.

6.0 Inspection

6.1 Tank and Accessories

a) Physical and dimensional check of transformer tank and accessories.

b) Crack detection of major strength weld seams by dye penetration test.

6.2 Core

a) Physical inspection and check of quality of varnish, if used.

b) Sample testing of core material for checking specific loss, bend properties, magnestisation, characteristics and thickness.

c) Check on completed core for measurement of iron loss and check for any hot spot by exciting the core so as to induce the designed value of flux density in the core.

d) HV Test

6.3 Insulating Material

a) Sample checks for physical properties of the material

b) Check for dielectric strength

c) Check for the reaction of hot oil on insulating material

6.4 Winding

a) Sample check on winding conductor for mechanical properties and electrical conductivity and on installation covering.

b) Sample check on insulation paper for pH value, Bursting strength, Electric strength.

6.5 Assembled Transformer

a) Check complete transformer against approved outline drawing provision for all fittings, finish etc.

b) Jacking test on all the assembled transformers.

6.6 Oil

All Standard tests in accordance with relevant Standards shall be carried out on oil samples taken from the transformer before and after testing of the transformer.

The contractor shall also prepare a comprehensive inspection and testing programme for all bought out sub-contracted items and shall submit the same to the Purchaser for approval. Such programme shall include the following components:

a) Buchholz Relay
b) Winding temperature Indicator
c) Bushings
d) Marshaling Box
e) Tap changer switch
f) Oil temperature indicator

7.0 Factory Test

7.1 All standard routine tests in accordance with latest issue of IEC: 60076 shall be carried out on each transformer.

7.2 The transformer shall conform to all the type tests in accordance with latest issues of IEC: 60076. The manufacturer shall submit type tests & additional test reports as listed above as already carried out on transformers of identical design for owner's acceptance. In such a case validity of type test reports shall be in line with clause 9.2 of Chapter 2-GTR of technical specifications. Following parameters in general shall be ensured for establishment of identical design as per IEC 60076, Part-V.

a) Same Voltage ratio, KVA rating, vector group & impedance.
b) Same conceptual design of core and winding.
c) Same arrangement and geometrical sequence of the main windings.
d) Same type of winding conductors.
e) Same type of main windings.
f) Absorbed power at short circuit (ie rated power/per unit short circuit impedance) between 30% and 130% of that relating to the reference transformer.
g) Axial forces and winding stresses occurring at short circuit not exceeding 120% of those relating to the reference transformer.
h) Same manufacturing process.
i) Same Clamping and winding support arrangement..

7.3 In addition to all type and routine tests, transformer shall also conform to following additional type tests as per IEC: 60076.

a) Measurement of zero sequence impedance

b) Short circuit test

c) Measurement of acoustic noise level. This shall conform to NEMA standard publication TR-1.

d) Measurement of capacitance and tan delta of transformer winding.

e) Test on oil samples as per IS 60296

7.4 All auxiliary equipment shall be tested as per the relevant IS Test Certificates shall be submitted for bought out items.

7.5 High voltage withstand test shall be performed on auxiliary equipment and wiring after complete assembly.

7.6 Tank Tests:

i) Routine Tests: As per IEC: 60076 Part-1 including
ii) Vacuum Tests: As per IEC: 60076 Part-1
iii) Pressure Test: As per IEC: 60076 Part-1

7.7 In addition to the above, the following checks should be carried out at manufacturer's works before despatch for all transformers:

a) Check for interchangeability of components of similar transformers and for mounting dimensions.

b) Check for proper packing and preservation of accessories like radiators, bushings explosion vent, dehydrating breather, Buchholz relay, conservator etc.

c) Check for proper provision of bracings to arrest the movements of core and winding assembly inside the tank.

d) Test for gas tightness and derivation of leakage rate. To ensure adequate reserve gas capacity during transit and storage.

7.8 The Contractor shall submit a detailed inspection and testing programme for field activities, covering areas right from the receipt of material stage upto commissioning stage as per IS : 1886 - Code of practice for installation and maintenance of transformers. The indicative checks and tests are given below.

a) Physical checks on each transformer on receipt at site for any damage or short supply.
b) Tests on oil samples
c) Oil leakage test
d) Physical checks for colour of silica in breather
e) Check for oil level in breather housing, conservator tank, etc.
f) Check for correct operation of all protections and alarms.
g) Insulation Resistance Measurement for Main Winding, control wiring etc.
h) Continuously observe the transformer operation at no load for 24 hours.

8.0 **Fittings**

The following fittings shall be provided with each transformer covered under this specification.

i) Conservator with drain plug and oil filling hole with blanking plate
ii) Plain oil Gauge
iii) Silica gel Breather
iv) Pressure Relief vent

v) Pocket on tank cover for Thermometer
vi) Valves
vii) Earthing Terminals
viii) Rating & Terminal Marking Plates
ix) Lifting Lugs
x) Rollers
xi) Air Release Plug

The fittings listed above are only indicative and any other fittings which generally are required for satisfactory operation of transformer are deemed to be included.

9.0 Spare Parts

9.1 The list of spares for outdoor type transformers covered under this chapter shall be as specified in Chapter 1- PSR

9.2 In addition, the Bidder shall also recommend optional spare parts and maintenance equipment necessary for three (3) years of successful operation of the equipment. The prices of these shall be indicated in respective schedules and these shall not be considered for the purpose of evaluation.

10.0 Technical Specification

S No	Description	Unit	Parameters
1	Rated Capacity	kVA	630 KVA
2	Rated Voltage		
a)	HV	kV	11
b)	LV	kV	0.400
3	Type of Winding		Two Winding
4	Service		Outdoor
5	No of Phases	No.	Three
6	Frequency	Hz	50
7	Type of Cooling		ONAN
8	Impedance at 75 Deg C	%	0.05
9	Tolerance on Impedance	%	±10

S No	Description	Unit	Parameters
10	Duty		Continuous
11	Overload		IEC:60076-7
12	Max. Temp. Rise over an ambient of 50 Deg C		
a)	Oil (Temperature rise measurement by thermometer)	^{O}C	50
b)	Winding Temperature rise measurement by resistance method)	^{O}C	55
13	Windings		
a)	System Apparent Short circuit level (kA)		As per IEC: 60076-Part 1
b)	Winding Connection		
(i)	HV		Delta
(ii)	LV		Star
14	Vector Group		Dyn11
15	Insulation		Uniform
16	Insulation Level	kVrms	
a)	Power Frequency Test Level		
(i)	HV	kVrms	28
(ii)	LV	kVrms	2
17	Basic Impulse Level		
(i)	HV	kVp	75
(ii)	LV	kVp	-
18	Highest voltage (kV) for each winding	kV	12
19	Method of earthing		Solidly earthed
20	Tap changer		
a)	(i) Tap Change		+5% to -10% in step of 2.5% on HV side
b)	(ii) Tap control		Off Circuit Tap Change Switch
21	HV Bushing		
a)	Rated Voltage	kV	12
b)	Rated current	A	100
c)	Basic Impulse Level (kVp)	kVp	75
d)	Wet & Dry Power frequency Withstand	kVrms	28

S No	Description	Unit	Parameters
	Voltage		
e)	Min. Total Creepage Distance	mm	300
f)	Mounting		Tank / Transformer Body
22	LV & Neutral Bushing		
a)	Rated Voltage	kV	1.1
b)	Rated current	A	1000
c)	Basic Impulse Level (kVp)	kVp	- -
d)	Wet & Dry Power frequency Withstand Voltage	kVrms	2
e)	Mounting		Tank / Transformer Body
23	Terminal Details		
a)	HV		Suitable for 11kV Cable or Over Head Conductor
b)	LV & Neutral		Cable Box
24	Min. Clearance in Air	mm	
a)	Ph-Ph (HV/LV)	mm	280/25
b)	Ph-Earth (HV/LV)	mm	140/25

CHAPTER 8: FIRE PROTECTION

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TECHNICAL SPECIFICATION FOR

FIRE PROTECTION SYSTEM

1.00.00 **INTENT OF SPECIFICATION**

This section covers the design and performance requirements of the following types of fire protection systems consisting of; (as required)

a. Hydrant System

b. High Velocity Water (H.V.W) Spray System

c. Fire Detection and alarm System

d. Portable Fire Extinguishers

e. Wheel/ Trolley mounted Fire Extinguishers

1.00.01 It is not the intent to completely specify all details of design and construction. Nevertheless, the system design and equipment shall conform in all respects to high standard of engineering, design and workmanship and shall be capable of performing in continuous commercial operation in a manner acceptable to the Owner. The system design shall also conform to NFPA norms.

1.00.02 The scope of work include complete earthwork (i.e. excavation, backfilling etc.) for the entire buried piping for the system, valve pits and pipe supports for buried, entrenched and overground piping.

1.00.03 The equipment offered shall comply with the relevant latest International Standards **unless specified otherwise**. The Deluge valves, HVW spray nozzles & quartzoid bulb detectors shall have the approval of any of the following agencies;

a. UL of USA.
b. F M of USA
c. LPCB of UK or
d. VDS of Germany,

1.00.04 Ambient temperature for design of all equipment shall be considered as 50°C.

1.00.05 The piping and instruments diagram for Hydrant and HVW spray system for 400kV switchyard is enclosed at Appendix-I. respectively. The successful bidder shall prepare detailed layout and piping drawing based on this drawing and other drawings such as road, drainage, cable trench, switch yard layout, etc. as furnished by the Employer during detailed engineering.

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2.00.00 DESIGN AND CONSTRUCTION

2.01.00 Hydrant System

Hydrant system of fire protection essentially consists of a large network of pipe, both under ground and over ground which feeds pressurised water to a number of hydrant valves, indoor (if applicable) as well as outdoor. These hydrant valves are located at strategic locations near buildings, Transformers and Reactors. Hose pipes of suitable length and fitted with standard accessories like branch pipes, nozzles etc., are kept in Hose boxes. In case of emergency, these hoses are coupled to the respective hydrant valves through instantaneous couplings and jet of water is directed on the equipment on fire. Hydrant protection shall be provided for the following in all substations of voltage levels 132kV and above (This is not applicable for extension of existing 220kV and 132kV substations where Hydrant system is not available). At least one hydrant post shall be provided for every 60m of external wall measurement of buildings.

a) Control room building

b) L.T. Transformer area.

c) Fire Fighting pump House.

d) Stores

e) Transformers

f) GIS Building.

g) Auxiliary Building for Indoor Switchyard

2.01.01 A warning plate shall be placed near the hydrant points for the transformers and reactors substations to clearly indicate that water shall be sprayed only after ensuring that the power to the transformer/ reactor which is on fire is switched off and there are no live parts within 20metres of distance from the personnel using the hydrant.

2.02.00. HIGH VELOCITY WATER (H.V.W) SPRAY SYSTEM

H.V.W. spray type fire protection essentially consists of a network of projectors and an array of heat detectors around the Transformer/Reactor to be protected. On operation of one or more of heat detectors, Water under pressure is directed to the projector

network through a Deluge valve from the pipe network laid for this system. This shall be provided for transformers and reactors in all 132kV & above substations (This is not applicable for extension of existing 220kV and 132kV substations where HVWS system is not available). Wet detection initiation system shall be employed for automatic operation.

The system shall be designed in such a way that the same can be extended to protect additional Transformer/ Reactor to be installed in future. However, for the purpose of design it shall be assumed that only one Transformer/ Reactor will be on fire. The main header pipe size in the yard shall be 250mmNB (for 400kV switchyard) and 200mmNB(for 220kV & 132kV switchyard). Branch to the equipment (shall not be more than 20metres length) shall be of the same size as of deluge valve.

2.02.01 The Electrical clearance between the Emulsifier system pipe work and live parts of the protected equipment shall not be less than the values given below :

1.	245 kV bushing	2150 mm
2.	145 kV bushing	1300 mm
3.	52 kV bushing	630 mm
4.	36/11 kV bushing	320 mm

2.02.02 System shall be designed in such a way that the Water pressure available at any spray nozzle shall be between 3.5bar and 5.0bar and shall be demonstrated through hydraulic calculations. Water shall be applied at a minimum rate of 10.2 LPM/M^2 of the surface area of the transformer / Reactor including radiator, conservator, oil pipes, bushing turrets, etc. (including bottom surface for transformer). The nozzle arrangement shall ensure direct impingement of water on all exterior surfaces of transformer tank, bushing turrets, conservator and oil pipes, except underneath the transformer, where horizontal spray may be provided.

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2.02.03 **Deluge Valve**

Deluge Valve shall be water pressure operated manual reset type. The Deluge valve shall be closed water tight when water pressure in the heat detector pipe work is healthy and the entire pipe work shall be charged with water under pressure upto the inlet of the Deluge valve. On fall of water pressure due to opening of one or more heat detectors, the valve shall open and water shall rush to the spray

water network through the open Deluge valve. The valves shall be manually reset to initial position after completion of operation. Each Deluge Valve shall be provided with a water motor gong which shall sound an alarm when water after passing through the Deluge valve, is tapped through the water motor.

Each Deluge valve shall be provided with a local panel with provision of opening of Deluge valve from local and remote from control room/ remote centre. In addition to this, each valve shall be provided with local operation latch.

Deluge valves of 100mmNB size shall be used if the flow requirement is ≤ 200m^3/hr and 150mmNB size shall be used for flow requirement >200m^3/hr.

Test valves shall simulate the operation of Deluge valves and shall be of quick opening type. The general construction shall conform to requirements under clause no.7.00.00 for piping, valves and specialities.

2.02.04 **High Velocity Spray Nozzles (Projectors)**

High velocity spray system shall be designed and installed to discharge water in the form of a conical spray consisting of droplets of water travelling at high velocity, which shall strike the burning surface with sufficient impact to ensure the formation of an emulsion. At the same time the spray shall efficiently cut off oxygen supply and provide sufficient cooling.

2.02.05 Minimum set point of the heat detectors used in the HVW spray system shall be 79^oC. The optimum rating shall, however, be selected by the Bidder, keeping in mind the maximum and minimum temperature attained at site.

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2.03.00 **Fire Detection and alarm System**

This system shall be provided for control room building ,GIS Building,Indoor Switchgear Building and Switchyard panel rooms of substations**.**

2.03.01 Suitable fire detection system using smoke detectors and/or heat detectors shall be provided for the entire building, including corridor and toilets. Fire detectors shall be located at strategic locations in various rooms of the building. Each Switchyard panel room shall be considered a separate zone. Adequate number of extra zones shall be provided for Switchyard panel rooms for future bays identified in Single line diagram of the substation. The operation of any of the fire detectors/ manual call point should result in the following;

1. A visual signal exhibited in the annunciation panels indicating the area where the fire is detected.
2. An audible alarm sounded in the panel, and
3. An external audible alarm sounded in the building, location of which shall be decided during detailed engineering.
4. If the zone comprises of more than one room, a visual signal shall be exhibited on the outer wall of each room.

2.03.02 Each zone shall be provided with two zone cards in the panel so that system will remain healthy even if one of the cards becomes defective.

2.03.03 Coverage area of each smoke detector shall not be more than 80 m^2 and that of heat detectors shall not be more than 40 m^2. Ionisation type smoke detectors shall be provided in all areas except pantry room where heat detectors shall be provided. If a detector is concealed, a remote visual indication of its operation shall be provided. Manual call points (Break glass Alarm Stations) shall be provided at strategic locations in the control room building. All cabling shall be done through concealed conduits.

2.03.04 Cables used should be exclusively for fire detection and alarm system and shall be 2Cx1.5sq.mm Cu. cables. Un-armoured PVC insulated FR cables conforming to latest IEC / International standards shall be used.

2.04.00 Portable and Wheel/ Trolley mounted Fire Extinguishers

2.04.01 Portable Fire Extinguishers

Adequate number of portable fire extinguishers of pressurised water, dry chemical powder, and Carbon dioxide type shall be provided in suitable locations in control room building and FFPH building as indicated in the drawing. In addition to this one (1) CO2 type fire extinguisher of 4.5kg capacity shall be provided for each Switchyard panel room. These extinguishers will be used during the early phases of fire to prevent its spread and costly damage.

The design, construction & testing of portable fire extinguishers shall meet the requirements as per clause 10.00.00.

2.04.02 Wheel/ Trolley mounted Fire Extinguishers

Wheel/Trolley mounted Mechanical foam type fire extinguishers of 50litre capacity, conforming to latest international standards, shall be provided for the protection of the following:

1. Transformers and reactors in 220kV and 132 kV substations

where Hydrant/HVWS system is not available. Two (2) nos. for each 220kV or 132kV transformer and reactor.

2. LT transformers in all substations. One (1) no. for each LT transformer.

The design, construction & testing of Mechanical foam type 50 litre capacity shall meet the requirements of relevant International Codes and clause 10.00.00 of this specification.

2.05.00 Water Supply System

For 400kV and above level substations water for hydrant & HVW system shall be supplied by one electrical motor driven pump of rated capacity 410m3/hr. at 70MWC head, with another pump of same capacity , driven by diesel engine, shall be used as standby. Water storage tank with two compartments of adequate capacity shall be provided. Pumps shall work under positive suction head. Annunciations of the hydrant & HVW spray systems shall be provided in fire water pump house and repeated in control room. Provision for sending data to remote control centre shall also be available.

The outdoor piping for the system in general shall be laid above ground on concrete pedestals with proper supporting arrangement. However, at road/rail crossings, in front/access of buildings, places where movement of cranes/vehicles is expected and at any other place where above ground piping is not advisable, the pipes shall be laid underground. Such locations shall be finalised during detailed engineering.

The whole system will be kept pressurised by providing combination of air vessel and jockey pump of $10.8M^3$/hr. capacity at 80MWC. The capacity of air vessel shall not be less than $3m^3$. Minor leakage will be met by Jockey pump. One additional jockey pump shall be provided as standby. All pumps shall be of horizontal centrifugal type. Pumps and air vessel with all auxiliary equipment will be located in firewater pump house. A pressure relief valve of suitable rating shall be provided in water header to release excess pressure due to atmospheric temperature variations.

Operation of all the pumps shall be automatic and pumps shall be brought into operation at preset pressure. Fire pumps shall only be stopped manually. Manual start/stop provision shall be provided in local control panel.

2.05.01 The general design of the fire fighting pump sets shall meet the requirements under clauses no.5.00.00 for Horizontal centrifugal pumps, no.6.00.00 for Diesel engines and no.12.00.00 for Electrical motors.

2.05.02 Each pump shall be provided with a nameplate indicating suction lift/delivery head, capacity and number of revolutions per minute.

2.05.03 Design, construction, erection, testing and trial operation of piping, valves, strainers, hydrant valves, hoses, nozzles, branch pipes, hose boxes, expansion joints etc. shall conform to the requirements of clause no. 7.00.00.

2.06.00 **Instrumentation and Control System**

2.06.01 All instruments like pressure indicators, differential pressure indicators, pressure switches, level indicators, level switches, temperature indicators, alarms and all other instruments and panels as indicated in the specification and drawings and those needed for safe and efficient operation of the whole system shall be furnished according to the requirements of clause 11.00.00. Pump running/ fails to start signal shall be taken from the pressure switch immediately after the discharge of the pump.

2.06.02 **Control Panel**

Power feeder for motors will be from switchgear board located in control building but control supply for all local control panels, annunciation panels, battery charger units, space heaters etc. shall be fed from the AC and DC distribution boards located in pump house. These AC & DC distribution boards will be fed from the switchgears and DCDBs located in control building.

a) Panel for motor driven fire water pump

The panel shall be provided with the following:

1.	TPN switch	1 No.
2.	Auto/manual selection facility	
3.	Start/Stop facility with indication lamp	1 Set
4.	DOL starter with thermal O/L relay	1 Set
5.	Indicating lamp showing power ON	1 Set
6.	Indication lamp with drive ON/OF	1 Set
7.	Indication lamp showing	1 No.

Motor Trip

Additional provisions shall be made for controlling the following from the remote control centre:

1. Auto/manual selection facility

2. Start/Stop facility

Main power cable from breaker feeder of main switchboard shall be terminated in this panel and another cable shall emanate from this panel which shall be terminated at motor terminals.

b) Panel for Two nos. Jockey Pump 1No.

The panel shall be provided with the following :

1.	Fuse-switch unit for Jockey pumps	1 Set for each pump
2.	Auto/manual selection facility for eachpump	
3.	Selector switch for selecting either jockey pump	1 No.
4.	D.O.L. starter with overload relay self-resetting type, for all the drives.	1 No. each
5.	Start/stop push button for Jockey Pump with indication lamp with pad-locking arrangements in stop position	1 Set for each pump
6.	Indication lamp for trip indication	1 No. each for pump

Additional provisions shall be made for controlling the following from the remote control centre:

1. Auto/manual selection facility for each pump**.**

a) Panel for 2 Nos. battery charger & Diesel Engine driven fire water pump 1 No.

The panel shall be provided with the following :

1. Auto/Manual selection facility for 1 No.

Diesel Engine driven pump

2.	Start/Stop facility with indication lamp	1 Set
3.	Indicating lamp showing drive ON/OFF	1 Set
4.	D.C. Voltmeter/Ammeter in the battery charger circuit	1 No. each
5.	Battery charger will be as per specification described	1 Set
6.	Selector switch for selecting either of battery chargers for the battery sets.	1 No.
7.	Selector switch for selecting either set of batteries for Diesel engine starting.	1No.
8.	Selector switch for boost charging/Trickle charging of battery set.	1 Set

Additional provisions shall be made for controlling the following from the remote control centre:

1. Manual Start/Stop of Diesel Engine

d) Individual local control panel is to be considered for each transformer/ Reactor deluge system wherever these equipment are envisaged. This panel shall contain push buttons with indicating lamps for spray ON/OFF operation in the valve operation circuit. Push buttons shall be concealed behind glass covers, which shall be broken to operate the buttons. Provision shall be made in the panel for the field signal for the annunciations such as spray ON and fire in the Transformer/Reactor. A signal for spray ON shall also be provided in the control room fire alarm panel for employer's event logger. Remote operation facility to open the Deluge valve from control room/ remote centre shall also be provided.

2.06.03 **Annunciation Panels**

a) Location: Fire Water Pump House

i) Indicating lamps showing power supply "ON".

ii) Annunciation windows complete with buttons. Details are as follows:

Sl.No.	Description	Number
1.	Electric motor driven fire water pump running	1
2.	Electric motor driven fire water pump fails to start	1
3.	Diesel engine driven fire water pump running.	1
4.	Diesel engine driven water pump fails to start	1
5.	Jockey pump-1 running	1
6.	Jockey pump-1 fails to start	1
7.	Jockey pump-2 running	1
8.	Jockey pump-2 fails to start	1
9.	Fire in Transformer/ Reactor	1 for each equipment
10.	Deluge system operating for Transformer/Reactor	1 for each equipment
11.	Header pressure low	1
12.	Fire in smoke detection system zone (Common Fire Signal)	1
13.	Water storage tank water level low	2
14.	High speed diesel tank level low	1
15.	Spare	10

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b) **Location: Substation Control Room**

i) Indication lamp showing power supply 'ON'

ii) Provision shall be made in the panel for a signal for spray ON for each Transformer/Reactor for owner's use for event logger.

iii) Each Switchyard panel room shall be considered as separate zone for fire

detection and alarm system.

iv) Following annunciations shall be provided.

Sl.No.	Description	Number
1.	Fire in Transformer/ Reactor	1 for each equipment
2.	Diesel engine driven fire water pump in operation	1
3.	Motor driven fire water pump in operation	1
4.	Jockey pump in operation	1
5.	Fire fighting Water storage tank level Low	2
6.	Fire/Fault (zone alarm module)	1+1(duplicate) For each zone as applicable
7.	Spare windows complete in all respect, with relays	10
8.	Spare zone alarm modules	Number of future A/c Kiosks required for the bays identified

c) Each annunciation panel shall be provided with a hooter**.** A hooter in parallel to the hooter in fire panel shall be provided in the security room of substation for alert in case of fire.

d) Indication for fault in respective areas shall also be provided. Each zone alarm module shall exhibit 'FIRE' and 'FAULT' conditions separately.

e) **Provision for sending data to Remote Control Unit for the following**

(i) Fire in Switchyard Panel Room (Switchyard Panel room shall be considered as separate zone for fire detection and alarm system).

(ii) Fire in Transformer/Reactor (1 for each equipment)

(iii) Diesel engine driven fire water pump in operation.

(iv) Motor driven fire water pump in operation

(v) Fire/Fault in Control Room.

(vi) Water Storage tank level (low and very low for each storage tank).

(vii) High Speed Diesel tank level (low & very low)

(viii) AC Mains Supply Healthy/Fail for Main Pump & Jockey Pump

(ix) DC Control Supply Healthy/Fail for Main Pump & Jockey Pump

(x) DC Control Supply Healthy/Fail for Diesel Engine driven pump.

2.06.04 The control and interlock system for the fire protection system shall meet the following requirements:

1. **Electric Motor Driven Fire water Pump**

Pump should start automatically when the System header pressure is low.

Pump should be stopped manually only. Pump should also be started manually if required from local control panel.

2. **Diesel Engine Driven Standby Pump**

The pump should automatically start under any of the following conditions:

a) System Header pressure low.

b) Electric motor operated fire water pump fails to start.

Pump should be stopped manually only. Pump should also be started manually if required from the local control panel. The battery set which is connected for starting of Diesel engine shall not be subjected to boost charge.

3. **Jockey Pump**

It shall be possible to select any one of the Jockey pumps as main and the other as standby. Main Jockey pump shall start automatically when water pressure in header falls below the set value. If the main jockey pump fails to start then the standby should start. Jockey pump shall stop automatically when the pressure is restored to its normal value.

Manual starting/stopping shall be possible from the local control

panel.

3.00.00 **TESTS**

3.01.00 **Shop Tests**

3.01.01 Shop tests of all major equipment centrifugal pumps, diesel engines, electrical drive motors, piping, valves and specialties, pressure and storage vessels, MCC, electrical panels, controls, instrumentation etc. shall be conducted as specified in various clauses and as per applicable standards/codes.

3.01.02 Shop tests shall include all tests to be carried out at Contractor's works, works of his sub-contractor and at works where raw materials supplied for manufacture of equipment are fabricated. The tests to be carried out shall include but not be limited to the tests described as follows :

a) Materials analysis and testing.

b) Hydrostatic pressure test of all pressure parts, piping, etc.

c) Dimensional and visual check.

d) Balancing test of rotating components.

e) Response of heat/smoke detectors.

f) Performance characteristics of HVW spray nozzles (projectors).

g) Flow rate and operational test on Flow control valves.

h) Operational test of alarm valve (water-motor gang).

i) Calibration tests on instruments and tests on control panel.

j) Destruction/burst tests on 2% or minimum one (1) no. of hoses and portable type fire extinguishers for each type as applicable. Any fraction number shall be counted as next higher integer.

k) Performance test on fire extinguishers as required in the code.

3.01.03 In the absence of any Code/Standard, equipment shall be tested as per mutually agreed procedure between the supplier and the Employer.

3.01.04 A comprehensive visual and functional check for panels would be conducted and will include a thorough check up of panel dimensions,

material of construction, panel finish, compliance with tubing and wiring specifications, quality of workmanship, proper tagging & locations of instruments/accessories. The wiring check shall be complete point to point ring out and check for agreement with installation drawings and equipment vendor prints of the complete system and an inspection of all field connection terminals and levelling.

3.01.05 All test certificates and reports shall be submitted to the Employer for approval.

3.01.06 The Employer's representative shall be given full access to all tests. The manufacturer shall inform the Employer allowing adequate time so that, if the Employer so desires, his representatives can witness the test.

3.02.00 **Pre-commissioning Tests**

3.02.01 **General**

a) All piping and valves, after installation will be tested hydraulically at a pressure of 16kg/cm^2 for a period of 30 minutes to check against leak tightness.

b) All manually operated valves/gates shall be operated throughout 100% of the travel and these should function without any trouble whatsoever, to the satisfaction of the Employer.

c) All pumps shall be run with the specified fluid from shut off condition to valve wide open condition. Head developed will be checked from the discharge pressure gauge reading. During the test, the pumps and drives shall run smoothly without any undue vibration, leakage through gland, temperature rise in the bearing parts, noise, flow pulsation etc.

d) All pressure vessels should be tested hydraulically at the specified test pressure, singly or in the system.

e) Painting shall be checked by dry type thickness gauges.

f) Visual check on all structural components, welding, painting etc. and if doubt arises, these will be tested again.

g) All test instruments and equipment shall be furnished by the Contractor to the satisfaction of the Employer.

h) Automatic starting of all the fire pumps by operating the test valves.

i) Automatic operation of the Jockey pump

j) Operation of the Deluge valve by breaking a detector as well as manual and remote operation of the deluge valve.

k) Operation of entire annunciation system.

Replacement of fused/damaged quartzoid bulb detectors during the test shall be responsibility of contractor.

3.02.02 After erection at site, the complete HVW spray protection and hydrant system shall be subject to tests to show satisfactory performance for which detailed procedure shall be submitted for Employer's approval.

Full flow tests with water shall be done for the system piping as a means of checking the nozzle layout, discharge pattern and coverage, any obstructions and determination of relation between design criteria and actual performance, also to ensure against clogging of the smaller piping and the discharge devices by foreign matter carried by the water.

Rigidity of pipe supports shall also be checked during the water flow.

3.02.03 All the detectors installed shall be tested for actuation by bringing a suitable source of heat/smoke near the detector and creating a stream of hot air/ smoke over the detector. The exact procedure of this test shall be detailed out by the Employer to the successful Bidder.

4.00.00 SPARE PARTS

The Contractor shall indicate in his scope of supply all the mandatory spares in the relevant schedules. The list of mandatory spares is indicated in ‘Section - Projects’.

5.00.00 HORIZONTAL CENTRIFUGAL PUMPS

This clause covers the design, performance, manufacturing, construction features and testing of horizontal centrifugal pumps used for the purpose of fire fighting.

5.01.00 The materials of the various components shall conform to the applicable BS/ASTM/DIN Standards.

5.01.01 In case of any contradiction with the aforesaid standards and the stipulations as per the technical specification as specified hereinafter, the stipulations of the technical specification shall prevail.

5.02.00 General Performance Requirements

5.02.01 The pump set shall be suitable for continuous operation at any point within the "Range of operation".

5.02.02 Pumps shall have a continuously rising head capacity characteristics from the specified duty point towards shut off point, the maximum being at shut off.

5.02.03 Pumps shall be capable of furnishing not less than 150% of rated capacity at a head of not less than 65% of the rated head. The shut off head shall not exceed 120% of rated head. Range of operation shall be 20% of rated flow to 150% of rated flow.

5.02.04 The pump-motor set shall be designed in such a way that there is no damage due to the reverse flow through the pump which may occur due to any mal-operation of the system.

5.02.05 **Drive Rating**

The drive rating shall not be less than the maximum power requirement at any point within the "Range of Operation" specified.

During starting under reverse flow condition, the motor shall be capable of bringing the pump to rated speed at normal direction with 90% rated voltage at motor terminals.

5.02.06 Pump set along with its drive shall run smooth without undue noise and vibration. Acceptable peak to peak vibration limits shall guided by applicable standards.

5.02.07 The Contractor under this specification shall assume full responsibility in the operation of the pump and drive as one unit.

5.03.00 **Design & Construction**

5.03.01 Pump casing may be axially or radially split. The casing shall be designed to withstand the maximum pressure developed by the pump at the pumping temperature.

5.03.02 Pump casing shall be provided with adequate number of vent and priming connections with valves, unless the pump is made self-venting & priming. Casing drain, as required, shall be provided complete with drain valves.

5.03.03 Under certain conditions, the pump casing nozzles will be subjected to reactions from external piping. Pump design must ensure that the nozzles are capable of withstanding external reactions not less than those specified in API-610.

5.03.04 Pump shall preferably be of such construction that it is possible to service the internals of the pump without disturbing suction and discharge piping connections.

5.03.05 **Impeller**

The impeller shall be secured to the shaft and shall be retained against circumferential movement by keying, pinning or lock rings. On pumps with overhung shaft impellers shall be secured to the shaft by an additional locknut or cap screw. All screwed fasteners shall tighten in the direction of normal rotation.

5.03.06 **Wearing Rings**

Replaceable type wearing rings shall be furnished to prevent damage to impeller and casing. Suitable method of locking the wearing ring shall be used.

5.03.07 **Shaft**

Shaft size selected shall take into consideration the critical speed, which shall be at least 20% away from the operating speed. The critical speed shall also be atleast 10% away from runaway speed.

5.03.08 **Shaft Sleeves**

Renewable type fine finished shaft sleeves shall be provided at the stuffing boxes/mechanical seals. Length of the shaft sleeves must extend beyond the outer faces of gland packing or seal and plate so as to distinguish between the leakage between shaft & shaft sleeve and that past the seals/gland.

5.03.09 Shaft sleeves shall be securely fastened to the shaft to prevent any leakage or loosening. Shaft and shaft sleeve assembly should ensure concentric rotation.

5.03.10 **Bearings**

Bearings of adequate design shall be furnished for taking the entire pump load arising from all probable conditions of continuous operation throughout its "Range of Operation" and also at the shut-off condition. The bearing shall be designed on the basis of 20,000 working hours minimum for the load corresponding to the duty point.

Bearings shall be easily accessible without disturbing the pump assembly. A drain plug shall be provided at the bottom of each bearing housing.

5.03.11 **Stuffing Boxes**

Stuffing box design shall permit replacement of packing without removing any part other than the gland. Stuffing boxes shall be sealed/cooled by the fluid being pumped and necessary piping, fittings, valves, instruments, etc. shall form an integral part of the pump assembly.

5.03.12 **Shaft Couplings**

All shafts shall be connected with adequately sized flexible couplings of suitable design. Necessary guards shall be provided for the

couplings.

5.03.13 **Base Plates & Sole Plate**

A common base plate mounting both for the pump and drive shall be furnished.

The base plate shall be of rigid construction, suitably ribbed and reinforced. Base plate and pump supports shall be so constructed and the pumping unit so mounted as to minimise misalignment caused by mechanical forces such as normal piping strain, hydraulic piping thrust etc. Suitable drain taps and drip lip shall be provided.

5.03.14 Material of Construction

All materials used for pump construction shall be of tested quality. Material of construction of the major parts of the pumps shall be as given below or superior as per relevant latest International standards:

a)	Casing	Casting Grade 17 of BS 1452
b)	Impeller	Bronze Grade LG2-C of BS1400
c)	Wearing ring	Bronze Grade LG2-C of BS1400
d)	Shaft	Mild Steel.
e)	Shaft sleeve	Bronze Grade LG2-C of BS1400
f)	Stuffing box	2.5% Nickel CI Grade 17 of BS 1452
g)	Gland	--- do ---

5.03.15 **Balancing**

All rotating components shall be statically and dynamically balanced at shop.

5.03.16 All the components of pumps of identical parameters supplied under this specification shall be interchangeable.

5.04.00 **Tests and Inspection**

5.04.01 The manufacturer shall conduct all routine tests required to ensure that the equipment furnished conform to the requirements of this specification and are in compliance with the requirements of applicable Codes and Standards. The particulars of the proposed tests and the procedures for the tests shall be submitted to the Employer/Engineer for approval before conducting the tests.

5.04.02 Where stage inspection is to be witnessed by Employer, in addition

to above, the Bidder shall submit to the Employer/Engineer at the beginning of the contract, the detailed PERT-Chart showing the manufacturing programme and indicating the period where Employer or his authorised inspecting agency are required at the shop.

5.04.03 **Material of Construction**

All materials used for pump construction shall be of tested quality. Materials shall be tested as per the relevant standards and test certificates shall be made available to the Employer/Engineer.

5.04.04 Where stage inspection is to be witnessed by Employer, all material test certificates shall be correlated and verified with the actual material used for construction before starting fabrication, by Employer's Inspector who shall stamp the material. In case mill test certificates for the material are not available, the Contractor shall carry out physical and chemical tests at his own cost from a testing agency approved by the Employer, as per the requirements of specified material standard. The samples for physical and chemical tests shall be drawn up in presence of Employer's inspector who shall also witness the tests.

5.04.05 Shaft shall be subjected to 100% ultrasonic test and machined portion of the impeller shall be subject to 100% DP test. On finished shaft DP test will also be carried out.

5.04.06 **Hydraulic test at shop**

All pressure parts shall be subjected to hydraulic testing at a pressure of 150% of maximum pressure generated by the pump at rated speed or 200% of total dynamic head whichever is higher, for a period not less than one (1) hour.

5.04.07 **Performance test at shop**

Pumps shall be subjected to routine tests to determine the performance of the pumps. These tests shall be conducted in presence of Employer/Engineer's representative as per the requirements of the ASME Power Test Code PTC 8.2/BS- 599/I.S.S., latest edition. Routine tests shall be done on all the pumps.

5.04.08 Performance tests shall be conducted to cover the entire range of operation of the pumps. These shall be carried out to span 150% of rated capacity upto pump shut-off condition. A minimum of five combinations of head and capacity are to be achieved during testing to establish the performance curves, including the design capacity point and the two extremities of the Range of operation specified.

5.04.09 Tests shall preferably be conducted alongwith the actual drives being supplied.

5.04.10 The Bidders shall submit in his proposal the facilities available at his works to conduct performance testing. If because of limitations of available facilities, a reduced speed test or model test has to be resorted to establish pump performance, the same has to be

highlighted in the offer.

5.04.11 In case of model testing, the stipulations of latest edition of apllicable standards shall be binding. Prototype or model tests, however, shall be conducted with the suction condition identical to the field conditions i.e. sigma values of prototype and model is to be kept same.

5.04.12 Prior to conducting model testing, calculations establishing model parameters, sizes and test procedure will be submitted to Employer/Engineer for approval.

5.04.13 All rotating components of the pumps shall be subjected to static and dynamic balancing tests.

5.04.14 The Employer or his authorised representative shall have full access to all tests. Prior to performance tests, the Contractor shall intimate the Employer allowing adequate time so that if the Employer so desires, his representative can witness the test.

5.04.15 Report and test certificates of the above tests shall be submitted to the Employer/Engineer for approval.

5.04.16 **Pre commissioning tests.**

After installation, pumps offered may be subjected to testing at field also by Employer. If the performances at field are not found to meet the requirement, then the equipment shall be rectified by the Contractor without any extra cost. Prior to performance testing, the procedure for such tests will be mutually agreed between Employer and Contractor. The Contractor shall furnish all necessary instruments, accessories and personnel for testing. Prior to testing, the calibration curves of all instruments and permissible tolerance limit of instruments shall be mutually agreed upon.

6.00.00 DIESEL ENGINES

This Clause covers the design, performance, manufacturing construction features and testing of compression ignition diesel engines, used primarily for driving centrifugal pumps, used for the purpose of fire fighting.

6.01.00 Design and Construction

General

6.01.01 The diesel engine shall be of multicylinder type four-stroke cycle with mechanical (airless) injection, cold starting type.

6.01.02 The continuous engine brake horse power rating (after accounting for all auxiliary power consumption) at the site conditions shall be atleast 20% greater than the requirement at the duty point of pump at rated RPM and in no case, less than the maximum power requirement at any condition of operation of pump.

6.01.03 Reference conditions for rated output of engine shall be as per ISO:3046, part I.

6.01.04 The engine shall be designed with regard to ease of maintenance, repair, cleaning and inspection.

6.01.05 All parts subjected to substantial temperature changes shall be designed and supported to permit free expansion and contraction without resulting in leakage, harmful distortion or misalignment.

6.01.06 **Starting**

The engine shall be capable of both automatic and manual start. The normal mode of starting is automatic but in the event of failure of automatic start or at the discretion of the operator, the engine can be started manually from the LCP.

Since the fire pumping unit driven by the diesel engine is not required to run continuously for long periods and the operation will not be frequent, special features shall be built into the engine to allow it to start within a very short period against full load even if it has remained idle for a considerable period.

6.01.07 If provision for manual start (cranking) is provided, all controls/ mechanisms, which have to be operated during the starting process, shall be within easy reach of the operator.

6.01.08 Automatic cranking shall be effected by a D.C. motor having high starting torque to overcome full engine compression. Starting power will be supplied from either of the two (2) sets of storage batteries. The automatic starting arrangement shall include a 'Repeat Start' feature for 3 attempts. The battery capacity shall be adequate for 3 (three) consecutive starts without recharging with a cold engine under full compression.

6.01.09 The batteries shall be used exclusively for starting the diesel engine and be kept fully charged all the time in position. Arrangement for both trickle and booster charge shall be provided.

Diesel engine shall be provided with two (2) battery charger units of air-cooled design. The charger unit shall be capable of charging one (1) set of battery at a time. Provision shall, however, be made so that any one of the charger units can be utilised for charging either of the two (2) batteries.

6.01.10 For detail design of battery and battery charger, sub- section Electrical may be referred to.

6.01.11 **Governing System:**

The engine shall be fitted with a speed control device, which will control the speed under all conditions of load.

6.01.12 The governor shall offer following features:

a) Engine should be provided with an adjustable governor capable of regulating engine speed within 5% of its rated speed under any condition of load between shut-off and maximum load conditions of the pumps. The governor shall be set to maintain rated pump speed at maximum pump load.

b) Engine shall be provided with an over speed shut- down device. It shall be arranged to shut-down the engine at a speed approximately 20% above rated engine speed and for manual reset, such that the automatic engine controller will continue to show an over speed signal until the device is manually reset to normal operating position (Vol.II, NFPA, 1978).

6.01.13 The governor shall be suitable for operation without external power supply.

6.01.14 **Fuel System**

The diesel engine will run on High Speed Diesel.

6.01.15 The engine shall be provided with fuel oil tank of 250 litres capacity. The fuel oil tank shall preferably be mounted near the engine. No fuel oil tank will be provided by the Employer.

6.01.16 The fuel oil tank shall be of welded steel constructed to relevant standards for mild steel drums. The outlet of the tank shall be above the inlet of fuel injection pump of the diesel engine to ensure adequate pressure at suction of injection pump.

6.01.17 The fuel oil tank shall be designed in such a way that the sludge and sediment settles down to the tank bottom and is not carried to the injection pump. A small sump shall be provided and fitted with drain plug to take out sludge/sediment and to drain oil. Adequate hand holes (greater than 80 mm size) shall be provided to facilitate maintenance.

6.01.18 Pipeline carrying fuel oil shall be gradually sloped from the tank to the injection pump. Any valve in the fuel feed pipe between the fuel tank and the engine shall be placed adjacent to the tank and it shall be locked in the open position. A filter shall be incorporated in this pipeline, in addition to other filters in the fuel oil system. Pipe joints shall not be soldered and plastic tubing shall not be used. Reinforced flexible pipes may also be used.

6.01.19 The complete fuel oil system shall be designed to avoid any air pocket in any part of the pipe work, fuel pump, sprayers/injectors, filter system etc. No air relief cock is permitted. However, where air relief is essential, plugs may be used.

6.01.20 A manual fuel pump shall be provided for priming and releasing of air from the fuel pipelines.

6.01.21 **Lubricating Oil System**

Automatic pressure lubrication shall be provided by a pump driven by the crank shaft, taking suction from a sump and delivering pressurised oil through cooler and fine mesh filters to a main supply header fitted in the bed plate casing. High pressure oil shall be supplied to the main and big end bearings, cam-shaft bearings, cam-shaft chain and gear drives, governor, auxiliary drive gears etc. Valve gear shall be lubricated at reduced pressure through a reducing valve and the cams by an oil bath.

6.01.22 **Cooling Water System**

Direct cooling or heat exchanger type cooling system shall be employed for the diesel engine. Water shall be tapped from the fire pump discharge. This water shall be led through duplex strainer, pressure breakdown orifice and then after passing through the engine, the water at the outlet shall be taken directly to the sump through an elevated funnel.

6.02.00 **Testing & Inspection**

6.02.01 The manufacturer shall conduct all tests required, to ensure that the equipment furnished conforms to the requirement of this sub-section and in compliance with requirements of applicable codes. The particulars of the proposed tests and the procedure for the tests shall be submitted to the Employer for approval before conducting the tests.

6.02.02 At manufacturer's works, tests shall be carried out during and after completion of manufacture of different component/parts and the assembly as applicable. Following tests shall be conducted.

6.02.03 Material analysis and testing.

6.02.04 Hydrostatic pressure testing of all pressure parts.

6.02.05 Static and dynamic balance tests of rotating parts at applicable over-speed and determination of vibration level.

6.02.06 MPI/DPT on machined parts of piston and cylinder.

6.02.07 Ultrasonic testing of crankshaft and connecting rod after heat treatment.

6.02.08 Dimensional check of close tolerance components like piston, cylinder bore etc.

6.02.09 Calibration tests of all fuel pumps, injectors, standard orifices, nozzles, instruments etc.

6.02.10 Over speed test of the assembly at 120% of rated speed.

6.02.11 Power run test.

6.02.12 Performance test of the diesel engine to determine its torque, power and specific fuel consumption as function of shaft speed. Performance test of the engine shall be carried for 12 hours out of which 1 hour at full load and one hour at 110% overload.

6.02.13 Measurement of vibration & noise.

(i) Measurement of vibration

The vibration shall be measured during full load test as well as during the overload test and limit shall be 100 microns.

(ii) Measurement of noise level

The equivalent 'A' weighted sound level measured at a distance of 1.5 M above floor level in elevation and 1.0 M horizontally from the base of the equipment, expressed in dB to a reference of 0.0002 microbar shall not exceed 93 dBA.

Above tests for vibration shall be repeated at site as pre-commissioning tests.

6.02.14 Adjustment of speed governor as per BS:5514.

6.02.15 Diesel engine shall be subjected to routine tests as per BS:5514.

7.00.00 PIPING, VALVES AND SPECIALITIES

This clause covers the design, manufacture, shop testing, erection, testing and commissioning of piping, valves and specialities.

7.02.00 Scope

The piping system which shall include but not be limited to the following:

7.02.01 Plain run of piping, bends, elbows, tees, branches, laterals, crosses, reducing unions, couplings, caps, expansion joints, flanges, blank flanges, thrust blocks, anchors, hangers, supports, saddles, shoes, vibration dampeners, sampling connections, hume pipes etc.

7.02.02 Gaskets, ring joints, backing rings, jointing material etc. as required. Also all welding electrodes and welding consumables including special ones, if any.

7.02.03 Instrument tapping connections, stubs etc.

7.02.04 Gate and globe valves to start/stop and regulate flow and swing check valves for one directional flow.

7.02.05 Basket strainers and Y-type strainers

7.02.06 Bolts, nuts, fasteners as required for interconnecting piping, valves and fittings as well as for terminal points. For pipe connections into Owner's R.C.C. works, Bidder will furnish all inserts.

7.02.07 Painting, anti-corrosive coatings etc. of pipes and equipment.

Adequate number of air release valves shall be provided at the highest points in the piping system to vent any trapped air in the system.

7.03.00 **Design**

7.03.01 Material of construction of various pipes shall be as follows :

(a) **Buried Pipes**

Mild steel black pipes as per ASTM A53 medium grade suitably lagged on the outside to prevent soil corrosion, as specified elsewhere.

(b) **Overground Pipes normally full of water**

Mild steel black pipes as per ASTM A53 medium grade.

(c) Overground pipes normally empty, but periodic charge of water and for detector line for HVW System**.**

Mild steel galvanised pipes as per ASTM A53 medium grade.

7.03.02 All fittings to be used in connection with steel pipe lines upto a size of 80 mm shall be as per ASTM A53 Mild steel tubulars and other wrought steel pipe fittings, Heavy grade. Fittings with sizes above 80 mm upto 150 mm shall be fabricated from ASTM A53 Heavy grade pipes or steel plates having thickness not less than those of ASTM A53 Heavy grade pipes. Fittings with sizes above 150 mm shall be fabricated as per ASTM A53 standard. All fitting used in GI piping shall be threaded type. Welding shall not be permitted on GI piping.

7.03.03 Pipe sizes shall not be less than the sizes indicated in the attached drawings.

7.03.04 For steel pipeline, welded construction should be adopted unless specified otherwise.

7.03.06 All piping system shall be capable of withstanding the maximum pressure arising from any condition of operation and testing including water hammer effects.

7.03.09 Gate/sluice valve shall be used for isolation of flow in pipe lines and **construction** shall be as per BS 5150. Valves shall be of rising spindle type and of PN 1.6 class

7.03.10 Gate Valves shall be provided with the following :

(a) Hand wheel.

(b) Position indicator.

(c) Locking facility (where necessary).

7.03.11 Gate valves shall be provided with back seating bush to facilitate gland removal during full open condition.

7.03.12 Globe valves shall be provided with contoured plug to facilitate regulation and control of flow. All other requirements should generally follow those of gate valve.

7.03.13 Non-return valves shall be swing check type. Valves will have a permanent "arrow" inscription on its body to indicate direction of flow of the fluid.

7.03.14 Whenever any valve is found to be so located that it cannot be approached manually from the nearest floor/gallery/platform hand wheel with floor stand or chain operator shall be provided for the same.

7.03.15 Valves below 50 mm size shall have screwed ends while those of 50 mm and higher sizes shall have flanged connections.

7.03.14 **Basket Strainer**

a) Basket strainers shall be of 30mesh and have the following materials of construction :

Body: Fabricated mild steel (Tested Quality). Strainer Wires: stainless steel (AISI : 316), 30 SWG, suitably reinforced.

b) Inside of basket body shall be protected by two (2) coats of heavy duty bitumastic paint.

c) Strainers shall be Simplex design. Suitable vent and drain connections with valves shall be provided.

d) Screen open area shall be at least 4 times pipe cross sectional area at inlet.

e) Pressure drop across strainer in clean condition shall not exceed 1.5 MWC at 410M3/hr (for 765kV/400kV substations) and 1 MWC at 273M3/hr flow (for 220kV & 132kV substations). Pressure drop test report of strainer of same design shall be furnished.

7.03.15 **Y-type On-line Strainer**

Body shall be constructed of mild steel (tested quality). Strainer wires shall be of stainless steel AISI:316, 30 SWG, 30 mesh.

Blowing arrangement shall be provided with removable plug at the

outlet. Screen open area shall be atleast 4 times pipe cross-sectional area at inlet.

Pressure drop test report of strainer of same design shall be furnished.

7.03.16 **Hydrant Valve (Outdoor) and Indoor Hydrant Valves (Internal Landing Valves).**

The general arrangement of outdoor stand post assembly, consisting of a column pipe and a hydrant valve with a quick coupling end shall be as per TAC requirement.

Materials of construction shall be as follows or superior :

a) Column pipe — M.S. ASTM A53 med. grade.

b) Hydrant Valve

i)	Body	Stainless steel**.**
ii)	Trim	Leaded tin bronze.
iii)	Hand Wheel	Cast Iron.
iv)	Washer, gasket, etc.	Rubber.
v)	Quick coupling connection	Leaded tin bronze
vi)	Spring	Phosphor Bronze.
vii)	Cap and chain	Leaded tin bronze

The general design of hydrant valve shall conform to relevant latest international standards.

7.03.17 **Hoses, Nozzles, Branch pipes and Hose boxes**

(a) Hose pipes shall be of reinforced rubber-lined canvas construction with nominal size of 63 MM (2 1/2") and lengths of 15 metre or 7.5 metre, as indicated elsewhere.

(b) Hosepipes shall be capable of withstanding an internal water pressure of not less than 35**.7** kg/cm^2 without bursting. It must also withstand a working pressure of 8.5 kg/cm^2 without undue leakage or sweating.

(c) Each hose shall be fitted with instantaneous spring lock type couplings at both ends. Hose shall be fixed to the coupling ends by copper rivets and the joint shall be reinforced by 1.5 mm galvanised mild steel wires and leather bands.

(d) Branch pipes shall be constructed of copper and have rings of leaded tin bronze at both ends. One end of the branch pipe will receive the quick coupling while the nozzles will be fixed to the other end.

(e) Nozzles shall be constructed of leaded tin bronze.

(f) Suitable spanners of approved design shall be provided in adequate numbers for easy assembly and dismantling of various components like branch pipes, nozzles, quick coupling ends etc.

(g) Hose pipes fitted with quick coupling ends, branch pipes, nozzles spanner etc. will be kept in a hose box, which will be located near point of use.

(h) All instantaneous couplings, as mentioned under clause Nos.3.03.19, 3.03.20 and 3.03.21 above shall be of identical design (both male and female) so that any one can be interchanged with another. One male, female combination shall get locked in by mere pushing of the two halves together but will provide leak tightness at a pressure of 8 kg/cm^2 of water. Designs employing screwing or turning to have engagement shall not be accepted.

7.04.00 **Fabrication & Erection**

7.04.01 The contractor shall fabricate all the pipe work strictly in accordance with the related approved drawings.

7.04.02 **End Preparation**

(a) For steel pipes, end preparation for butt welding shall be done by machining.

(b) Socket weld end preparation shall be sawing/machining.

(c) For tees, laterals, mitre bends, and other irregular details cutting templates shall be used for accurate cut.

7.04.03 **Pipe Joints**

(a) In general, pipes having sizes over 25 mm shall be joined by butt welding. Pipes having 25 mm size or less shall be joined by socket welding/screwed connections. Galvanised pipes of all sizes shall have screwed joints. No welding shall be permitted on GI pipes. Screwed joints shall have tapered threads and shall be assured of leak tightness without using any sealing compound.

(b) Flanged joints shall be used for connections to vessels, equipment, flanged valves and also on suitable straight lengths of pipe line of strategic points to facilitate erection and subsequent maintenance work.

7.04.04 **Overground Piping**

(a) Piping to be laid overground shall be supported on pipe rack/supports. Rack/supports details shall have to be approved by Employer/Engineer.

(b) Surface of overground pipes shall be thoroughly cleaned of mill scale, rust etc. by wire brushing. Thereafter one (1) coat of **red oxide primer** shall be applied. Finally two (2) coats of synthetic enamel paint of approved colour shall be applied.

7.04.05 **Buried Pipe Lines**

(a) Pipes to be buried underground shall be provided with protection against soil corrosion by coating and wrapping with two coats of coal tar hot enamel paint and two wraps of reinforced fibre glass tissue. The total thickness of coating and wrapping shall not be less than 3 mm. Alternatively corrosion resistant tapes can also be used for protection of pipes against corrosion.

(b) For Coating and wrapping, holiday testing to be performed inline with latest ASTM standards.

(c) Buried pipelines shall be laid with the top of pipe one meter below ground level.

(d) At site, during erection, all coated and wrapped pipes shall be tested with an approved Holiday detector equipment with a positive signalling device to indicate any fault hole breaks or conductive particle in the protective coating.

7.05.00 **General Instruction for Piping Design and Construction**

7.05.01 While erecting field run pipes, the contractor shall check, the accessibility of valves, instrument tapping points, and maintain minimum headroom requirement and other necessary clearance from the adjoining work areas.

7.05.02 Modification of prefabricated pipes, if any, shall have to be carried out by the contractor at no extra charge to the Employer.

7.05.03 **Welding**

(i) Welding shall be done by qualified welders only.

(ii) Before welding, the ends shall be cleaned by wire brushing, filing or machine grinding. Each weld-run shall be cleaned of slag before the next run is deposited.

(iii) Welding at any joint shall be completed uninterrupted. If this cannot be followed for some reason, the weld shall be insulated

for slow and uniform cooling.

(iv) Welding shall be done by manual oxyacetylene or manual shielded metal arc process. Automatic or semi-automatic welding processes may be done only with the specific approval of Employer/ Consultant.

(v) As far as possible welding shall be carried out in flat position. If not possible, welding shall be done in a position as close to flat position as possible.

(vi) No backing ring shall be used for circumferential butt welds.

(vii) Welding carried out in ambient temperature of 5°C or below shall be heat-treated.

(viii) Tack welding for the alignment of pipe joints shall be done only by qualified welders. Since tack welds form part of final welding, they shall be executed carefully and shall be free from defects. Defective welds shall be removed prior to the welding of joints.

Electrodes size for tack welding shall be selected depending upon the root opening.

(ix) Tacks should be equally spaced as follows **:**

for 65 NB and smaller pipes : 2 tacks

for 80 NB to 300 NB pipes : 4 tacks

for 350 NB and larger pipes : 6 tacks

(x) Root run shall be made with respective electrodes/filler wires. The size of the electrodes/filler wires. The size of the electrodes shall not be greater than 3.25 mm (10 SWG) and should preferably be 2.3 mm (12 SWG). Welding shall be done with direct current values recommended by the electrode manufacturers.

(xi) Upward technique shall be adopted for welding pipes in horizontally fixed position. For pipes with wall thickness less than 3 mm, oxyacetylene welding is recommended.

(xii) The root run of butt joints shall be such as to achieve full penetration with the complete fusion of root edges. The weld projection shall not exceed 3 mm inside the pipe.

(xiii) On completion of each run craters, weld irregularities, slag etc. shall be removed by grinding or chipping.

(xiv) Fillet welds shall be made by shielded metal arc process regardless of thickness and class of piping. Electrode size shall not exceed 10 SWG. (3.25 mm). At least two runs shall be

made on socket weld joints.

7.06.00 **Tests at Works**

7.06.01 **Pipes**

(i) Mechanical and chemical tests shall be performed as required in the codes/standards.

(ii) All pipes shall be subjected to hydrostatic tests as required in the codes/standards.

(iii) 10% spot Radiography test on welds of buried pipes shall be carried out as per ASME VIII.

7.06.02 **Valves**

(i) Mechanical and chemical tests shall be conducted on materials of the valve as required in the codes/standards.

(ii) All valves shall be tested hydrostatically for the seat as well as required in the code/standards for a period of ten minutes.

(iii) Air test shall be conducted to detect seat leakage.

(iv) Visual check on the valve and simple operational test in which the valve will be operated thrice from full open to full close condition.

(v) No repair work on CI valve body, bonnet or wedge shall be allowed.

7.06.03 **Strainers**

(i) Mechanical and chemical tests shall be conducted on materials of the strainer.

(ii) Strainers shall be subjected to a hydrostatic test pressure of 1.5 times the design pressure or 10 kg/cm2g whichever is higher for a period of one hour.

7.06.04 **Hydrant valves and Indoor Hydrant Valves (Internal Landing Valves)**

(i) The stand post assembly along with the hydrant valve (valve being open and outlet closed) shall be pressure tested at a hydrostatic pressure of 21 kg/cm2g to detect any leakage through defects of casting.

(ii) Flow test shall be conducted on the hydrant valves at a pressure of 7 kg/cm2g and the flow through the valve shall not be less than 900 litres/min.

(iii) Leak tightness test of the valve seat shall be conducted at a hydrostatic test pressure of 14 kg/cm2g.

7.06.05 **Hoses, Nozzles, Branch Pipes and Hose Boxes**

Reinforced rubber-lined canvas hoses shall be tested hydrostatically. Following tests shall be included as per relevant latest International standard.

a) Hydrostatic proof pressure test at 21.4 kgf/cm2g

b) Internal diameter

The branch pipe, coupling and nozzles shall be subjected to a hydrostatic test pressure of 21 kg/cm2g for a period of $2^1/_2$ minutes and shall not show any sign of leakage or sweating.

Dimensional checks shall be made on the hose boxes and nozzle spanners.

8.00.00 **AIR VESSELS**

8.01.00 Air vessels shall be designed and fabricated of mild steel as class-II vessels as per BS 5500 for a pressure of 14kg/cm^2 and shall be minimum 3 m^3 capacity.

8.02.00 Inside surface of the tank shall be protected by anti-corrosive paints/coatings/linings as required.

8.03.00 Outside surfaces of the vessels shall be provided with one (1) coat of red lead primer with two (2) coats of synthetic enamel paint of approved colour and characteristics.

8.04.00 **Tests & Inspection**

8.04.01 Air vessels shall be hydraulically tested at 21kg/cm2 for a period not less than one (1) hour.

8.04.02 All materials used for fabrication shall be of tested quality and test certificates shall be made available to the Owner.

8.04.03 Welding procedure and Welder's qualification tests will be carried out as per relevant Ienternational Standard.

8.04.04 NDE tests, which will include 100% Radiography on longitudinal seams and spot Radiography for circumferential seams, for pressure vessel will be carried out.

9.00.00 **HEAT DETECTORS/FIRE DETECTORS AND SPRAY NOZZLES**

9.00.01 **Intent of Specification**

This specification lays down the requirements of the smoke detectors, heat detectors and spray nozzles for use in various sub-

systems of the fire protection system.

9.00.02 **Codes and Standards**

All equipment supplied shall conform to internationally accepted codes and standards.

9.01.00 **Heat Detectors**, **Quartzoid bulb type.** (Used in HVW spray system)

a) Heat detectors shall be of any approved and tested type. Fusible chemical pellet type heat detectors are however not acceptable.

b) Temperature rating of the heat detector shall be selected by the Bidder taking into consideration the environment in which the detectors shall operate. Minimum set point shall, however, be 79^{o}C.

c) Heat detectors shall be guaranteed to function properly without any maintenance work for a period of not less than twenty five (25) years.

d) The heat detectors shall be mounted on a pipe network charged with water at suitable pressure. On receipt of heat from fire, the heat detector will release the water pressure from the network. This drop in water pressure will actuate the Deluge valve.

9.02.00 **HVW Spray Nozzles (Projectors)**

High velocity water spray system shall be designed and installed to discharge water in the form of a conical spray consisting of droplets of water travelling at high velocity which shall strike the burning surface with sufficient impact to ensure the formation of an emulsion. At the same time the spray shall efficiently cut off oxygen supply and provide sufficient cooling. Integral non-ferrous strainers shall be provided in the projectors ahead of the orifice to arrest higher size particle, which are not allowed to pass through the projectors.

9.03.00 **Fire Detectors (Used in fire detection and alarm system)**

9.03.01 Fire detectors shall be approved by FOC-London or similar international authorities.

9.03.02 Both smoke and heat type fire detectors shall be used. Bidder shall clearly indicate the mode of operation of detectors in his proposal.

9.03.03 The set point shall be selected after giving due consideration for ventilating air velocity and cable insulation.

9.03.04 Fire detectors shall be equipped with an integral L.E.D. so that it shall be possible to know which of the detectors has been operated. The detectors, which are to be placed in the space above the false ceiling or in the floor void shall not have the response indicators on the body but shall be provided with remote response indicators.

9.03.05 Approval from competent authority shall be made available for ionisation type smoke detectors. All required accessories shall also be included in the scope of supply.

9.03.06 Fire detectors shall be guaranteed to function properly without any maintenance work for a period of not less than ten (10) years.

10.00.00 PORTABLE AND WHEEL/ TROLLEY MOUNTED FIRE EXTINGUISHERS

10.00.01 This specification lays down the requirement regarding fire extinguishers of following types :

Portable fire extinguishers.

a) Pressurised water type.

b) Dry chemical powder type

c) Carbon Dioxide type

Wheel/ Trolley mounted fire extinguishers.

a) Mechanical foam type

10.00.02 All the extinguishers offered by the Bidder shall be of reputed make.

10.01.00 Design and Construction

10.01.01 All the portable extinguishers shall be of freestanding type and shall be capable of discharging freely and completely in upright position.

10.01.02 Each extinguisher shall have the instructions for operating the extinguishers on its body itself.

10.01.03 All extinguishers shall be supplied with initial charge and accessories as required.

10.01.04 Portable type extinguishers shall be provided with suitable clamps for mounting on walls or columns.

10.01.05 All extinguishers shall be painted with durable enamel paint of fire red colour conforming to relevant International Standards.

10.01.06 Pressurisation of water type fire extinguishers shall either be done by compressed air or by using gas cartridge. Both constant air pressure and the gas pressure type shall conform to their latest relevant International standards.

10.01.07 Dry chemical powder type portable extinguisher shall conform to its latest relevant International standards.

10.01.08 Carbon Dioxide type portable extinguisher and Carbon Dioxide type trolley mounted extinguisher shall conform to their latest relevant International standards.

10.01.09 Wheel/ trolley mounted fire extinguishers of 50 litre capacity Mechanical foam type shall conform to its **latest relevant International standards.**

10.02.00 **Tests and Inspection**

10.02.01 A performance demonstration test at site of five (5) percent or one (1) number whichever is higher, of the extinguishers shall be carried out by the Contractor. All consumable and replaceable items require for this test would be supplied by the Contractor without any extra cost to Employer.

10.02.02 Performance testing of extinguisher shall be in line of applicable International Standards. In case where no International Standard is applicable for a particular type of extinguisher, the method of testing shall be mutually discussed and agreed to before placement of order for the extinguishers.

10.03.00 **Painting**

Each fire extinguisher shall be painted with durable enamel paint of fire red colour conforming to relevant International Standards.

11.00.00 **INSTRUMENTS**

11.00.01 **Intent of Specification**

The requirements given in the sub-section shall be applicable to all the instruments being furnished under this specification.

11.00.02 All field mounted instruments shall be weather and dust tight, suitable for use under ambient conditions prevalent in the subject plant. All field mounted instruments shall be mounted in suitable locations where maximum accessibility for maintenance can be achieved.

11.01.00 **Local Instruments**

Pressure/ Differential Gauges & Switches.

11.01.01 The pressure sensing elements shall be continuous 'C' bourdon type.

11.01.02 The sensing elements for all gauges/switches shall be properly aged and factory tested to remove all residual stresses. They shall be able to withstand atleast twice the full scale pressure/vacuum without any damage or permanent deformation.

11.01.03 For all instruments, connection between the pressure sensing

element and socket shall be braced or hard soldered.

11.01.04 Gauges shall be of 150 mm diameter dial with die-cast aluminium, stoved enamel black finish case, aluminium screwed ring and clear plastic crystal cover glass. Upper range pointer limit stop for all gauges shall be provided.

11.01.05 All gauges shall be with stainless steel bourdon having rotary geared stainless steel movements.

11.01.06 Weatherproof type construction shall be provided for all gauges. This type of construction shall be fully dust tight, drip tight, weather resistant and splash proof with anti-corrosive painting conforming to NEMA- 4.

11.01.07 All gauges shall have micrometer type zero adjuster.

11.01.08 Neoprene safety diaphragm shall be provided on the back of the instruments casing for pressure gauges of ranges 0-10 Kg/cm^2 and above.

11.01.09 Scales shall be concentric, white with black lettering and shall be in metric units.

11.01.10 Accuracy shall be $\pm$ 1.0 percent of full range or better.

11.01.11 Scale range shall be selected so that normal process pressure is approximately 75 percent of full scale reading. For pressure gauges and pressure switches, the range shall not be less than 0 -16 Kg/cm^2

11.01.12 All gauges shall have 1/2 inch NPT bottom connection.

11.01.13 All instruments shall conform to their **latest relevant International standards.**

11.01.14 All instruments shall be provided with 3 way gauge isolation valve or cock. Union nut, nipple and tail pipe shall be provided wherever required.

11.01.15 Switch element contact shall have two (2) NO and two (2) NC contacts rated for 240 Volts, 10 Amperes A.C. or 220 Volts, 5 Amperes D.C. Actuation set point shall be adjustable throughout the range. ON-OFF differential (difference between switch actuation and de-actuation pressures) shall be adjustable. Adjustable range shall be suitable for switch application.

11.01.16 Switches shall be sealed diaphragm, piston actuated type with snap action switch element. Diaphragm shall be of 316 SS.

11.01.18 Necessary accessories shall be furnished.

11.02.00 **Timers**

11.02.01 The timers shall be electro-mechanical type with adjustable delay on pick-up or reset as required.

11.02.02 Each timer shall have two pairs of contacts in required combination of NO and NC.

11.03.00 **Level Gauges/Indicator/Switches**

11.03.01 **Level Gauges**

i) Gauge glasses shall be used for local level indication wherever shown in the flow diagram.

ii) Gauge glasses, in general, shall be flag glass type with bolted cover. Body and cover material shall be of carbon steel with rubber lining.

iii) Level coverage shall be in accordance with operating requirements. Maximum length of a single gauge glass shall not exceed 1.4 M. Should a larger gauge glass be required, multiple gauges of preferably equal length shall be used with 50 mm overlap in visibility.

iv) Reflex type gauge glasses shall be used for colourless liquids and transparent type gauge glasses shall be used for all liquids having colour.

v) Each gauge glass shall be complete with a pair of offset valves. Valves shall have union bonnet, female union level connection, flanged tank connection, and vent and drain plug.

vi) Offset valves shall have corrosion resistant ball-check to prevent fluid loss in the event of gauge glass breakage. Valve body shall have a working pressure of 200 percent of the maximum static pressure at the maximum process fluid temperature. Valve body materials shall be of carbon steel with rubber lining.

11.03.02 **Level Indicators**

i) Float type mechanical level gauges with linear scale type indicator shall be offered for measuring level of tanks wherever shown in the flow diagram.

ii) AISI-316 stainless steel float, guide rope and tape shall be used. Housing shall be of mild steel painted with anti-corrosive painting.

iii) The scale indicator shall be provided at a suitable height for ease of reading.

iv) Accuracy shall be + 1% of scale range or better.

11.03.03 **Level Switches**

i) Level switches shall be of ball float operated magnetic type complete with cage.

ii) Materials of construction shall be suitable for process and ambient conditions. The float material shall be AISI-316 stainless steel.

iii) Actuating switches shall be either hermetically sealed mercury type or snap acting micro-switches. Actuation set point shall be adjustable. ON-OFF differential (difference between switch actuation and de-actuation levels) shall be adjustable. Adjustable range shall be suitable for switch application. All switches shall be repeatable within + 1.0 percent of liquid level change required to activate switch. Contacts shall be rated for 50 watts resistive at 240 V A.C. Number of contacts shall be two NO and two NC for each level switch.

11.04.00 **Solenoid Valves**

11.04.01 The body of the valves shall be Forged brass or stainless steel.

11.04.02 The coil shall be continuous duty, epoxy moulded type Class-F, suitable for high temperature operation.

11.04.03 The enclosure shall be watertight, dust-tight and shall conform to NEMA-4 Standard.

11.04.04 The valves shall be suitable for mounting in any position.

11.05.00 **Switches, Lamps, Meters Etc.**

All electrical components on the panel namely push buttons, switches, lamps, meters etc. shall meet the requirements of sub-section Electrical enclosed with the specification.

11.06.00 All local instruments shall be inspected by Employer/Consultant as per the agreed quality plan.

11.07.00 Makes of control panel and local instruments, accessories shall be as per Employer's approval.

12.00.00 **ELECTRIC MOTORS**

12.01.00 **General**

12.01.01 This clause covers the requirements of three phase squirrel cage induction motors and single-phase induction motors.

12.01.02 The motors to be furnished, erected and commissioned as covered under this specification shall be engineered, designed, manufactured, erected, tested as per the requirements specified herein. These requirements shall however be read along with the requirements of the respective driven equipment being supplied under the specification of which this specification forms a part.

12.01.03 The motor supplied under this specification shall conform to the standards specified in GTR.

12.01.04 Terminal point for all motors supplied under this specification shall be at the respective terminal boxes.

12.01.05 Materials and components not specifically stated in this specification but are necessary for satisfactory operation of the motor shall be deemed to be included in the scope of supply of this specification.

12.01.06 Notwithstanding anything stated in this motor specification, the motor has to satisfy the requirement of the mechanical system during normal and abnormal conditions. For this the motor manufacturer has to co-ordinate with the mechanical equipment supplier and shall ensure that the motor being offered meets the requirements.

12.02.00 **Codes & Standards**

12.02.21 The design, manufacture, installation and performance of motors shall conform to the provisions of latest Electricity Act and Electricity Rules. Nothing in these specifications shall be construed to relieve the Contractor of his responsibility.

12.02.22 In case of contradiction between this specifications and IEC, the stipulations of this specification shall be treated as applicable.

12.02.23 National Electrical code for hazardous location and relevant NEMA standard shall also be applicable for motors located in hazardous location.

12.03.00 **Design Features**

12.03.01 **Rating and type**

(i) The induction motors shall be of squirrel cage type unless specified otherwise.

(ii) The motors shall be suitable for continuous duty in the specified ambient temperature.

(iii) The MCR KW rating of the motors for 50oC ambient shall not be less than the power requirement imposed at the motor shaft by the driven equipment under the most onerous operation conditions as defined elsewhere, when the supply frequency is 51.5 Hz (and the motor is running at 103% of its rated speed).

(iv) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously in the system having the following particulars :

a) Rated terminal voltage

From 0.2 to 200 KW 400V (3 Phase, solidly earthed)

Below 0.2 KW 230 V (1 Phase, solidly earthed)

Variation in voltage ± 6%.

b) Frequency 50 Hz ± 3%.

c) Any combination of (a) & (b)

12.03.02 Enclosure

Motors to be installed outdoor and semi-outdoor shall have hose proof enclosure equivalent to IP-55. For motors to be installed indoor, the enclosure shall be dust proof equivalent to IP-54.

12.03.03 **Cooling method**

Motors shall be TEFC (totally enclosed fan cooled) type.

12.03.04 **Starting requirements**

(i) **Induction motor**

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

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

c) The starting current of the motor at rated voltage shall not exceed six (6) times the rated full load current subject to tolerance as given in IEC 60034.

d) Motors when started with the driven equipment imposing full starting torque under the supply voltage condition specified under Clause 12.03.01 (iv) (a) shall be capable of withstanding at least two successive starts with coasting to rest between starts and motor initially at the rated load operating temperature. The motors shall also be suitable for three equally spread starts per hour, the motor initially at a temperature not exceeding the rated operating temperature.

e) The locked rotor withstand time under hot condition at 110% of rated voltage shall be more than the starting time with the driven equipment at minimum permissible voltage (clause 12.03.04 (i) (a) by at least two seconds or 15% of the accelerating time whichever is greater. In case it is not possible to meet the above requirement the Bidder shall offer

centrifugal type speed switch mounted on the motor shaft which shall remain closed for speeds lower than 20% and open for speeds above 20% of the rated speed. The speed switch shall be capable of withstanding 120% of the rated speed in either direction of rotation.

12.03.05 **Running requirements**

(i) When the motors are operating at extreme condition of voltage and frequency given under clause no.12.03.01 (iv) the maximum permissible temperature rise over the ambient temperature of 50^{o}C shall be within the limits specified in IEC 60034 after adjustment due to increase ambient temperature specified herein.

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

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

(iv) Induction motors shall be so designed as to be capable of withstanding the voltage and torque stresses developed due to the difference between the motor residual voltage and incoming supply voltage during fast changeover of buses. The necessary feature incorporated in the design to comply with this requirement shall be clearly indicated in the proposal.

(v) Motors shall be capable of developing the rated full load torque even when the supply voltage drops to 70% of rated voltage. Such operation is envisaged for a period of one second. The pull out torque of the induction motors to meet this requirement shall not be less than 205% of full load torque.

(vi) The motors shall be capable of withstanding for 10 seconds without stalling or abrupt change in speed (under gradual increase of torque) an excess torque of 60 percent of their rated torque, the voltage and frequency being maintained at their rated value.

(vii) Guaranteed performance of the motors shall be met with tolerances specified in respective standards.

12.04.00 **Construction Features**

12.04.01 **Stator**

(i) **Stator frame**

The stator frames and all external parts of the motors shall be rigid fabricated steel or of casting. They shall be suitably annealed to

eliminate any residual stresses introduced during the process of fabrication and machining.

(ii) **Stator core**

The stator laminations shall be made from suitable grade magnetic sheet steel varnished on both sides. They shall be pressed and clamped adequately to reduce the core and teeth vibration to minimum.

(iii) **Insulation and winding**

All insulated winding conductor shall be of copper. The overall motor winding insulation for all 400 volts motors shall be of epoxy thermosetting type i.e., class 'F' but limited to class-B operating from temperature rise consideration. Other motors may be of conventional class-B type. The windings shall be suitable for successful operation in hot, humid, tropical climate with the ambient temperature of 50^{o}C.

12.04.02 **Rotor**

(i) Rotors shall be so designed as to keep the combined critical speed with the driven equipment away from the running speed by atleast 20%.

(ii) Rotors shall also be designed to withstand 120% of the rated speed for 2 minutes in either direction of rotation.

12.04.03 **Terminal box leads**

(i) For motors of 400 Volts and below a single terminal box may be provided for power and accessories leads.

(ii) Terminal boxes shall be of weatherproof construction designed for outdoor service. To eliminate entry of dust and water, gaskets of neoprene or approved equivalent shall be provided at cover joints and between box and motor frame.

(iii) Terminal box shall be suitable for top and bottom entry of cables.

(iv) Unless otherwise approved, the terminal box shall be capable of being turned through 360o in steps in 90o.

(v) The terminals shall be complete with all accessories for connecting external cables. They shall be designed for the current carrying capacity and shall ensure ample phase to phase to ground clearances.

(vi) Suitable tinned brass compression type cable glands and cable lugs shall be supplied by the Contractor to match Employer's cable.

(vii) Terminal box for single core cable shall be of non- magnetic material.

(viii) Marking of all terminals shall be in accordance with IEC / International standard..

12.04.04 **Rating Plates**

(i) Rating plates shall be provided for all motors giving the details as called for in IEC 60034 (for three phase squirrel cage induction motors).

(ii) In addition to above, the rating plate shall indicate the following :

a) Temperature rise in oC under normal working conditions.

b) Phase sequence corresponding to the direction of rotation for the application.

c) Bearing identification number (in case of ball/ roller bearing) and recommended lubricants.

12.04.05 **Other Constructional Features**

(i) Two independent earthing points shall be provided on opposite sides of the motor for bolted connection of Employer's earthing conductor to be specified to the successful Bidder.

(ii) Motor weighing more than 25 kg. shall be provided with eyebolts, lugs or other means to facilitate lifting.

12.05.00 **Paint and Finish**

12.05.01 Motor external parts shall be finished and painted to produce a neat and durable surface, which would prevent rusting and corrosion. The equipment shall be thoroughly degreased, all sharp edges and scales removed and treated with one coat of primer and two coats of grey enamel paint.

12.05.02 Motor fans shall also be painted to withstand corrosion.

12.05.03 All fasteners used in the construction of the equipment shall be either of corrosion resistant material or heavy cadmium plated.

12.05.04 Current carrying fasteners shall be either of stainless steel or high tensile brass.

12.06.00 **Tests at Manufacturers Works**

12.06.01 Motors shall be subject to routine tests in accordance with IEC 60034.

12.06.02 In addition, the following tests shall also be carried out :

a) 20% over speed test for 2 minutes on all rotors.

b) Measurement of vibration.

c) Measurement of noise level.

d) Phase sequence and polarity checks relative to mechanical rotation.

12.06.03 **Tests after installation at site**

(i) After installation and commissioning at site, the motors alongwith the driven equipment shall be subject to tests to ascertain their conformity with the requirement of this specification and those of the driven equipment specification and the performance data quoted by the Bidder.

(ii) In case of non-conformity of the motor with these specifications and performance requirement, the Engineer may at his discretion reject or ask for necessary rectification/replacement as detailed in general Terms and Conditions of Contract (GCC) Volume-I.

13.00.00 **BATTERY & BATTERY CHARGERS**

This clause covers the design, performance, manufacturing, construction features and testing of Battery and Battery charger used primarily for starting the diesel engine driving the fire water pumps. Battery Chargers shall be housed in Diesel Engine Panel.

13.01.00 **General Information**

13.01.01 The equipment specified hereinafter are required for starting the diesel engines and other operation of the plant as required.

13.01.02 For each diesel engine there shall be two (2) sets of Battery and two (2) sets of Battery Charger.

13.01.03 The D.C. voltage shall be obtained normally after necessary rectification by battery charger. The Battery Charging system shall be capable of meeting the following requirements :

13.01.04 Float charging the Battery.

13.01.05 Boost Charging the Battery.

13.01.06 The battery shall be large enough to crank the engine **3** times without charging in between and without getting drained to an extent which will affect its life.

13.01.07 The Bidder shall indicate the battery voltage and battery capacity in Ampere- Hour at ten (10) hour discharge rate. The battery voltage at

any time during operation shall not be less than the minimum voltage required for operation of the D.C. loads.

13.02.00 **General Design**

The Battery shall be located indoor

13.02.01 **Battery**

(i) The cells shall be lead-acid type. The Battery shall be automotive type.

(ii) The cells shall be sealed in type with anti-splash type vent plug.

(iii) The cell terminal posts shall be provided with connector bolts and nuts, effectively coated with lead to prevent corrosion. Lead or lead coated copper connectors shall be furnished to connect up cells of battery set.

(iv) Positive and Negative terminal posts shall be clearly and indelibly marked for easy identification.

(v) The electrolyte shall be of battery grade Sulphuric Acid. Water for storage batteries conforming to relevant standards shall be used in the preparation of the electrolyte.

13.02.02 **Battery Charger**

(i) The Bidder shall furnish the battery charging scheme complete with all necessary accessories such as transformers, switches, fuses, starters, contactors, diodes, ammeters, voltmeters and other devices as required for trouble free operation. All devices and equipment shall conform to relevant International Standard or shall be Superior to it.

(ii) The scheme of the battery charger shall be such that the battery can be charged automatically as well as manually.

(iii) The boost charger shall have sufficient capacity to restore a fully discharged Battery to a state of full charge in eight (8) hours with some spare margin over maximum charging rate. Suitable provision shall be kept so that, for a particular engine, any of the two (2) charger units can be used for charging any of the two (2) batteries.

(iv) The instruments, switches and lamps shall be flush/semi-flush mounted on the front panel. Name plate of approved type shall be provided for each of these equipment.

(v) The panel shall be complete with internal wiring and input-output terminal block. Terminal blocks shall be clip on type of suitable rating. All equipment and wire terminals shall be identified by symbols corresponding to applicable schematic/wiring diagram.

(vi) Space heaters of adequate capacity shall be provided to prevent moisture condensation in the panel.

13.03.00 **Testing**

13.03.01 The Battery Charger shall also be subjected to the following tests at manufacturer's works as per IEC 60146.

13.03.02 Insulation test.

13.03.03 Connection checking.

13.03.04 Measurement of voltage regulation.

13.03.05 Auxiliary of devices.

13.03.06 Alternating current measurement.

13.03.07 Performance test.

13.03.08 Temperature rise test.

13.03.09 Following acceptance tests shall be carried out in batteries as per IEC/International standard.

a) Marking and packing

b) Verification of dimensions

c) Test for capacity

d) Test for voltage during discharge

Battery and battery charger shall be checked for auto charging and providing sufficient power for three consecutive starting kicks to diesel engine within five minutes with A.C. supply switched off.

14.00.00 **CONTROL & ANNUNCIATION PANELS**

14.01.00 **Intent of Specification**

The following requirement shall be applicable to the control and annunciation panels furnished under these specifications.

14.02.00 **General Information**

14.02.01 The equipment specified herein are required for controlling, metering, monitoring and indication of electrical systems of the plant offered.

14.02.02 The selection and design of all the equipment shall be so as to

ensure reliable and safe operation of the plant and shall be subjected to approval by the Employer.

14.02.03 The reference ambient temperature outside the panel shall be taken as 50oC and relative humidity 100%.

14.03.00 **Equipment to be Furnished**

Control & annunciation panels shall be furnished complete with all accessories and wiring for safe and trouble free operation of the plant. Details are included in sub-section General.

14.04.00 **Constructional Details**

14.04.01 The panel frames shall be fabricated using suitable mild steel structural sections or pressed and shaped cold-rolled sheet steel of thickness not less than 2.5 mm. Frames shall be enclosed in cold-rolled sheet steel of thickness not less than 1.6 mm. Stiffeners shall be provided wherever necessary.

14.04.02 Panels shall be of free standing type and shall be provided with hinged door with locking arrangement. The access doors, cutest and covers shall be equipped with neoprene/synthetic rubber gaskets (conforming to IEC 60149) all around and the latches sufficiently strong to hold them in alignment when closed. The panels to be installed outdoor or semi outdoor shall have a degree of protection of IP:55 and those installed indoor shall have a degree of protection of IP:52 as per IEC 60947.

14.04.03 If a panel consists of a number of panels, each panel should be mounted side by side and bolted together to form a compact unit, when two panels meet, the joints shall be smooth, close fittings and un-obstructive.

14.04.04 Removable eye bolt or lifting lugs shall be provided on all panels to facilitate easy lifting.

14.04.05 The heights of all operating equipment on the panel shall be between 800 mm to 1600 mm from the finished floor level. The proper supporting arrangement shall be provided by the Contractor.

14.04.06 Cable entries to the panel may be from bottom or top. The cable entry required will be intimated to the successful Bidder. A suitable removable gland plate of 3 mm thick shall be mounted not less than 200 mm above the floor level.

14.04.07 All equipment mounted on the front face of the panels shall be flush or semi-flush type. All equipment shall be so located that their terminal and adjustment are readily accessible for inspection or maintenance and their removal and replacement can be done without interruption of service to other equipment. The contractor shall submit the panel general arrangement drawings clearly bringing out internal mounting details, dimensions of equipment, clearance between the equipment and the edges of the panel, for approval.

14.05.00 **Name Plates and Labels**

14.05.01 Each panel shall be provided with prominent, engraved identification plates for all front mounted equipment. Panel identification name plate shall be provided at front and rear as required.

14.05.02 All name plates shall be of non-rusting metal or 3 ply lamicold, with white engraved lettering on black background. Inscription and lettering sizes shall be subjected to Employer's approval.

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

14.06.00 **AC/DC Power Supply**

14.06.02 The Employer will provide one feeder each for AC and DC to the panel. The Contractor shall make for his own arrangements for providing these power supplies to different panels.

14.06.02 The Contractor shall provide suitable isolating switch fuse unit in the control panel for receiving the above incoming AC and DC supplies. Fuse and link shall be provided for isolating of individual circuit without disturbing other circuits.

14.07.00 **Wiring**

14.07.01 All inter panel wiring and connections between panels (if there is group of panels) including all bus wiring for AC & DC supplies shall be provided by the Contractor.

14.07.02 All internal wiring shall be carried out with 1100 V grade, single core, 1.5 square mm or larger stranded copper wires having colour-coded PVC insulation. CT circuits shall be wired with 2.5 square mm copper wires, otherwise similar to the above.

14.07.03 Extra-flexible wire shall be used for wiring to devices mounted on moving parts such as doors.

14.07.04 Spare contacts of auxiliary relays, timers and switches shall be wired out to the terminal blocks as required by the Employer/Engineer at the time of detailed engineering.

14.08.00 **Terminal Blocks**

14.08.01 Terminal Blocks shall be of 650V grade, rated for 10 Amps and in one-piece moulding. It shall be complete with insulating barriers, clip-on-type terminals, and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring diagrams. It shall be similar to 'Elmex-Standard' type terminals.

14.08.02 Terminal blocks shall be arranged with at least 100 mm clearance

between two sets of terminal block.

14.08.03 The terminal blocks shall have at least 20% spare terminals.

14.09.00 **Grounding**

A continuous copper bus 25 x 3 mm size shall be provided along the bottom of the panel structure. It shall run continuously throughout the length of the panel and shall have provision at both ends for connection to the station grounding grid (25 x 6 mm MS Flat).

14.10.00 **Space Heater and Lighting**

14.10.01 Space heaters shall be provided in the panels for preventing harmful moisture condensation.

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

14.10.03 Free standing panel shall have a 230V AC, plug point and a fluorescent light operated by door switch.

14.11.00 **Control and Selector Switches**

14.11.01 Control and selector switches shall be of rotary type, with escutcheon plates clearly marked to show the function and positions.

14.11.02 Control/selector switches shall be spring return or stay put type as per the requirements. Handles of control/selector switches shall be black in colour. Shape and type of handles shall be to the approval of the Employer.

14.11.03 The contact ratings shall be at least the following :

i) Make and carry continuously 10 Amp.

ii) Breaking current at 240V DC 1Amp. (Inductive)

iii) Breaking current at 240V DC 5 Amp. at 0.3 p.f. lagging

14.12.00 **Push Buttons**

14.12.01 Push buttons shall be spring return, push to actuate type and rated to continuously carry and break 10A at 230V AC and 0.5A (Inductive) at 220V DC. The push buttons shall have at least 1 NO and 1 NC contact. All contact faces shall be of silver or silver alloy.

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

14.12.03 The colour of buttons shall be as follows :

Green For motor START, Breaker CLOSE, Valve/ damper OPEN.

Red For motor TRIP, Breaker OPEN, Valve/ damper CLOSE.

Black For all annunciation functions, overload reset and miscellaneous.

14.12.04 Red push buttons shall always be located to the left of green push buttons. In case of clinker grinder etc. the push buttons would be black-red-green from left to right.

14.13.00 **Indicating Lamps**

14.13.01 Indicating lamps shall be of the panel mounting, filament type and of low-watt consumption. Lamps shall be provided with series resistors preferably built-in- the lamps assembly. The lamps shall have escutcheon plates marked with its function, wherever necessary.

14.13.02 Lamp shall have translucent lamp covers of the following colours :

Red for motor OFF, Valve/damper OPEN, Breaker CLOSED.

Green for motor ON, Valve/damper CLOSED, Breaker OPEN.

White for motor AUTO-TRIP.

Blue for all healthy conditions (e.g. control supply, lub oil pressure and also for spring charged).

Amber for all ALARM conditions (e.g. pressure low, over load and also for 'service' and 'Test' position indication).

14.13.03 Bulbs and lamps covers shall be easily replaceable from the front of the panel.

14.13.04 Indicating lamps should be located directly above the associated push button/control switches. Red lamps shall variably be located to the right of the green lamp. In case a white lamp is also provided, it shall be placed between the red and green lamps. Blue and amber lamps should normally be located above the red and green lamps.

14.14.00 **Fuses**

14.14.01 All fuses shall be of HRC cartridge plug-in-type and shall be of suitable rating, depending upon circuit requirements.

14.14.02 All fuses shall be mounted on fuse carriers, which shall be mounted on fuse-bases.

14.15.00 **Contactors**

14.15.01 Contactors shall be of air break, electromagnetic type rated as per requirement.

14.15.02 Operating coils of AC contactors shall be of 230V AC or 220V DC as required. AC contactors shall operate satisfactorily between 85% to 110% of the rated voltage. The Contactor shall not drop out at 70% of the rated voltage.

14.15.03 DC contactors shall have a coil voltage of 220V DC and shall be suitable for satisfactory continuous operation at 80% to 110% of the rated voltage.

14.16.00 **Relays and Timers**

14.16.01 All auxiliary relays & timers shall be of proven design and of reputed make. Contacts of relays and timers shall be of solid silver or silver cadmium oxide or solid silver faced. Timers shall have the provision to adjust the delay on pick-up or reset as required.

14.16.02 All relays and timers shall have at least two NO and two NC contacts.

14.16.03 All relays and timers shall be suitable for 230V AC and 220V DC as required. DC relays shall operate satisfactorily between 70% to 110% and AC relays shall be suitable for voltage variation between 80% to 110%.

14.17.00 **Indication Instruments**

14.17.01 All indicating and integrating meters shall be flush mounted on panel front. The instruments shall be of at least 96 mm square size with 90 degree scales and shall have an accuracy class of 2.0 or better. The covers and cases of instruments and meters shall provide a dust and vermin proof construction.

14.17.02 All instruments shall be compensated for temperature errors and factory calibrated to directly read the primary quantities. Means shall be provided for zero adjustment removing or dismantling the instruments.

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

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

14.18.00 **Annunciation System**

14.18.01 The annunciation system shall be complete with all necessary relays, flashers and other accessories required for the proper operation of the equipment and shall be completely solid state. The control circuit shall be mounted on plug-in type glass epoxy printed circuit boards. Audible alarms for the system shall be mounted inside the panel. One set of acknowledge, test and reset push buttons shall be mounted on the panel.

14.18.02 Indications shall be engraved on Acrylic inscription plate window and

shall be visible clearly when the indication lamp is lighted (black letters on white background). Each window shall be provided with two lamps.

14.18.03 Audible hooter shall sound when a trouble contact operates and shall continue to sound until the acknowledge button is pressed. In addition to the hooters provided on annunciation panels, a hooter shall be provided outside FFPH which shall sound in any fire alarm condition.

14.18.04 Indication lamps shall flash when trouble contact operates and shall continue flashing until acknowledge button is pressed.

14.18.05 After acknowledge button is pressed, the hooter and flashing shall stop but the indication lamp shall remain lighted.

14.18.06 After trouble is cleared indication lamps shall be ready and shall go off only when reset.

14.18.07 Silencing the hooter in conjunction with one trouble contact shall not stop and hooter sounding if another trouble contact operates.

14.18.08 When test button is pressed, all lamps shall flash and hooter shall sound.

14.18.09 Annunciator systems shall operate on 220V DC Systems.

14.18.10 The annunciation system shall include alarm for AC control system failure (working on DC supply), DC supply failure (working on AC supply) and test facilities for these alarms.

14.18.11 List of annunciations required on the panels has been listed elsewhere. The Contractor shall also provide additional annunciations if desired by the Employer/Engineer during Vendor drawing review stage and for such additional annunciations no extra charges shall be claimed by the Contractor, if the number of such additions are within 10% of the number stipulated in this specification.

14.18.12 20% spare windows shall be provided on the panel.

14.19.00 **Painting**

14.19.01 **Painting procedure adopted shall conform to requirements given in GTR**. The paint thickness shall not be less than **60** microns. Finished parts shall be coated by peelable compound by spraying method to protect the finished surface from scratches, grease, dirt and oily spots during testing, transportation handling and erection.

14.20.00 **Tests**

14.20.01 Following tests/inspection shall be carried out by the Contractor in the presence of Employer's representative :

(A) Factory Tests

1. Compliance with approved drawings, data and specification.

2. Visual check for workmanship.

3. Wiring continuity and functional checks.

4. Calibration of instruments, relays and metres wherever required by inspector.

5. HV test

6. Insulation resistance measurement before and after HV test.

(B) Inspection/Testing at site :

1. IR test before and after HV test

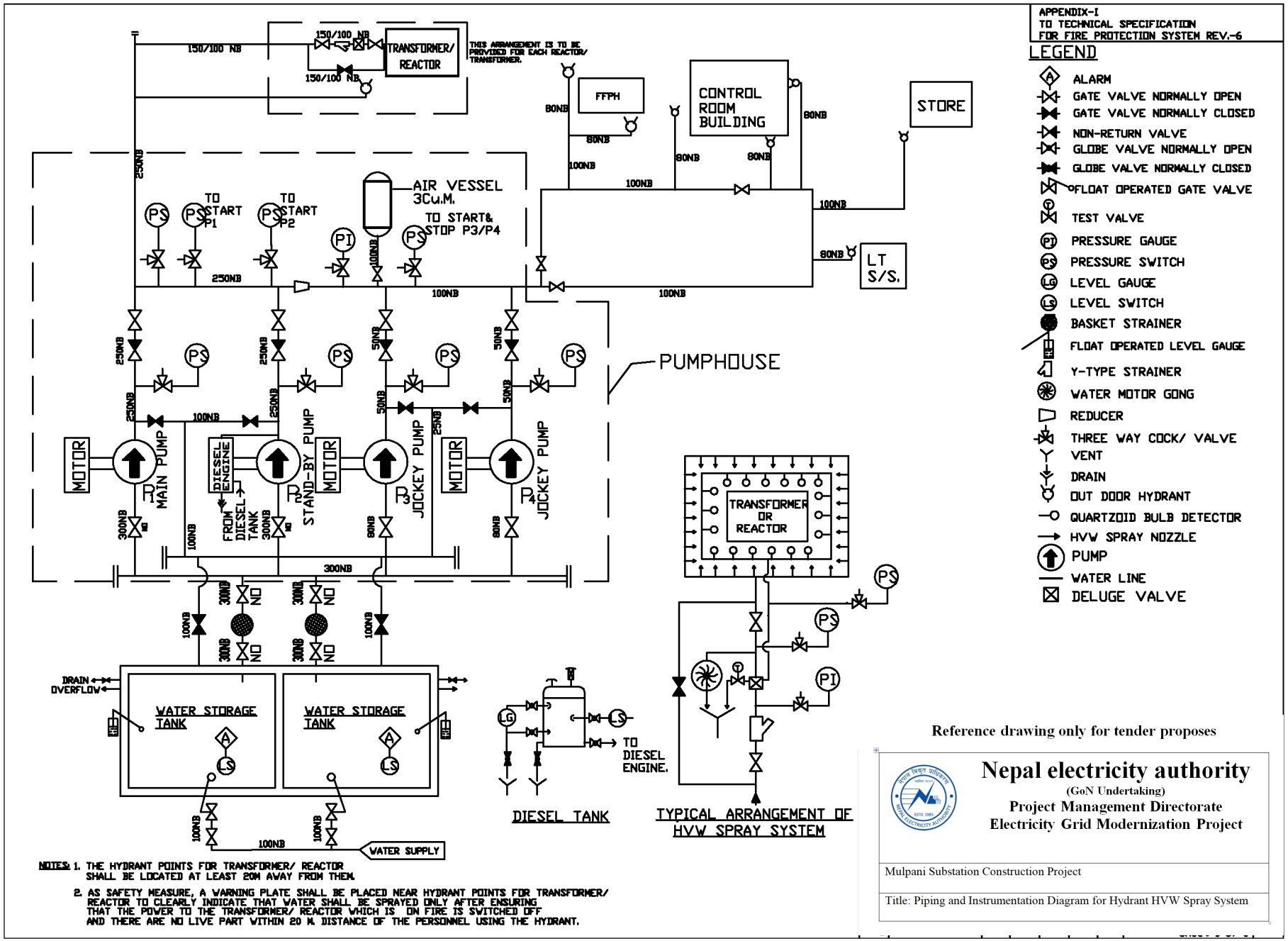
2. HV Test

3. Functional Testing.

(C)

1. The Fire detection and annunciation panel shall be subjected to functional tests.

2. The Annunciation System shall be routine tested


APPENDIX-I
TO TECHNICAL SPECIFICATION
FOR FIRE PROTECTION SYSTEM REV.-6
LEGEND
ALARM
GATE VALVE NORMALLY OPEN
GATE VALVE NORMALLY CLOSED
NON-RETURN VALVE
GLOBE VALVE NORMALLY OPEN
GLOBE VALVE NORMALLY CLOSED
FLOAT OPERATED GATE VALVE
TEST VALVE
PRESSURE GAUGE
PRESSURE SWITCH
LEVEL GAUGE
LEVEL SWITCH
BASKET STRAINER
FLOAT OPERATED LEVEL GAUGE
Y-TYPE STRAINER
WATER MOTOR GONG
REDUCER
THREE WAY COCK/ VALVE
VENT
DRAIN
OUT DOOR HYDRANT
QUARTZOID BULB DETECTOR
HVW SPRAY NOZZLE
PUMP
WATER LINE
DELUGE VALVE
150/100 NB
TRANSFORMER/ REACTOR
THIS ARRANGEMENT IS TO BE PROVIDED FOR EACH REACTOR/ TRANSFORMER.
FFPH
CONTROL ROOM BUILDING
STORE
LT S/S.
AIR VESSEL 3Cu.M.
TO START P1
TO START P2
TO START& STOP P3/P4
PUMPHOUSE
MOTOR
MAIN PUMP
DIESEL ENGINE
STAND-BY PUMP
JOCKEY PUMP
FROM DIESEL TANK
TRANSFORMER OR REACTOR
WATER STORAGE TANK
DRAIN
OVERFLOW
WATER SUPPLY
TO DIESEL ENGINE.
DIESEL TANK
TYPICAL ARRANGEMENT OF HVW SPRAY SYSTEM
NOTES: 1. THE HYDRANT POINTS FOR TRANSFORMER/ REACTOR SHALL BE LOCATED AT LEAST 20M AWAY FROM THEM.
2. AS SAFETY MEASURE, A WARNING PLATE SHALL BE PLACED NEAR HYDRANT POINTS FOR TRANSFORMER/ REACTOR TO CLEARLY INDICATE THAT WATER SHALL BE SPRAYED ONLY AFTER ENSURING THAT THE POWER TO THE TRANSFORMER/ REACTOR WHICH IS ON FIRE IS SWITCHED OFF AND THERE ARE NO LIVE PART WITHIN 20 M. DISTANCE OF THE PERSONNEL USING THE HYDRANT.
Reference drawing only for tender proposes
Nepal electricity authority
(GoN Undertaking)
Project Management Directorate
Electricity Grid Modernization Project
Mulpani Substation Construction Project
Title: Piping and Instrumentation Diagram for Hydrant HVW Spray System

• CHAPTER 9: POWER AND CONTROL CABLE

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CHAPTER 9: POWER & CONTROL CABLES

1. POWER & CONTROL CABLES[FOR WORKING VOLTAGES UP TO AND INCLUDING 1100 V]

CRITERIA FOR SELECTION OF POWER & CONTROL CABLES

1.1.1. Aluminium conductor XLPE insulated armoured cables shall be used for main power supply purpose from LT Aux. Transformers to control room, between distribution boards and for supply for colony lighting from control room.

1.1.2 Aluminium conductor PVC insulated armoured power cables shall be used for various other applications in switchyard area/control room except for control/protection purposes.

1.1.3 For all control/protection/instrumentation purposes PVC insulated armoured control cables of minimum 2.5 sq. mm. size with stranded Copper conductors shall be used.

1.1.4 Employer has standardised the sizes of power cables for various feeders. Bidders are to estimate the quantity of cables and quote accordingly. The minimum sizes of power cables to be used per feeder in different application shall be as follows:

S.No.	From	To	Cable size	Cable type
1.	Main Switch Board	LT Transformer	2-1C X 630 mm^2 per phase 1-1C X 630 mm^2 for neutral	XLPE
2.	Main Switch Board	AC Distribution Board	2-3½C X 300 mm^2	XLPE
3.	Main Switch Board	Oil Filtration Unit	1-3½C X 300 mm^2	XLPE
4.	Main Switch Board	Colony Lighting	1-3½C X 300 mm^2	XLPE
5.	Main Switch Board	HVW pump LCP	1-3½C X 300 mm^2	XLPE
6.	Main Switch Board	Main Lighting distribution board	2-3½C X 300 mm^2	XLPE
7.	AC Distribution Board	D.G. Set AMF Panel	2-3½C X 300 mm^2	XLPE
8.	AC Distribution Board	Emergency Lighting distribution board	1-3½C X 70 mm^2	PVC

9.	AC Distribution Board	ICT MB	1-3½C X 70 mm^2	PVC
10.	AC Distribution Board	Bay MB	1-3½C X 70 mm^2	PVC
11.	Bay MB	AC Kiosk	1- 3 ½ x 70 mm^2	PVC
12.	AC Distribution Board	Battery Charger	1-3½C X 70 mm^2	PVC
13.	DCDB	Battery	2-1C X 150 mm^2	PVC
14.	DCDB	Battery Charger	2-1C X 150 mm^2	PVC
15.	DCDB	Protection/PLCC panel	1-4C X 16 mm^2	PVC
16.	Main Lighting DB	Lighting panels(Indoor)	1-3½C X 35 mm^2	PVC
17.	Main Lighting DB	Lighting panels (outdoor)	1-3½C X 70 mm^2	PVC
18.	Main Lighting DB	Receptacles (Indoor)	1-3½C X 35 mm^2	PVC
19.	Main Lighting DB	Receptacles (Outdoor)	1-3½C X 70 mm^2	PVC
20.	Lighting Panel	Sub lighting panels	1-4C X 16 mm^2	PVC
21.	Lighting Panel	Street Lighting Poles	1-4C X 16 mm^2	PVC
22.	Lighting Panel/ Sub lighting panels	Lighting Fixtures (Outdoor)	1-2C X 6 mm^2	PVC
23.	Bay MB	Equipments	1-4C X 16 mm^2 /1-4C X 6 mm^2 /1-2C X 6 mm^2	PVC

1.1.5 Bidder may offer sizes other than the sizes specified in clause 1.1.4. In such case and for other application where sizes of cables have not been indicated in the specification, sizing of power cables shall be done keeping in view continuous current, voltage drop & short-circuit consideration of the system. Relevant calculations shall be submitted by bidder during detailed engineering for purchaser's approval.

1.1.6 Cables shall be laid as per relevant IEC/International Standards.

1.1.7 While preparing cable schedules for control/protection purpose following shall be ensured:

1.1.7.1 Separate cables shall be used for AC & DC.

1.1.7.2 Separate cables shall be used for DC1 & DC2.

1.1.8 For different cores of CT & CVT separate cable shall be used

1.1.9 Atleast one (1) cores shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.

1.1.10 For control cabling, including CT/VT circuits, 2.5 sq.mm. size copper cables shall be used per connection. However, if required from voltage drop/VA burden consideration additional cores shall be used. Further for potential circuits of energy meters separate connections by 2 cores of 2.5 sq.mm. size shall be provided.

1.1.11 Technical data requirement sheets for cable sizes are being enclosed at Annex-I.

1.2. TECHNICAL REQUIREMENTS

1.2.1. General

1.2.1.1. The cables shall be suitable for laying in racks, ducts, trenches, conduits and underground buried installation with uncontrolled back fill and chances of flooding by water.

1.2.1.2. They shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions. The XLPE /PVC insulated L.T. power cables of sizes 240 sq. mm. and above shall withstand without damage a 3 phase fault current of at least 45 kA for at least 0.12 second, with an initial peak of 105 kA in one of the phases at rated conductor temperature (70 degC for PVC insulated cables and 90 degC for XLPE insulated cables). The armour for these power cables shall be capable of carrying 45 kA for at least 0.12 seconds without exceeding the maximum allowable temperature of PVC outer sheath.

1.2.1.3. The XLPE insulated cables shall be capable of withstanding a conductor temperature of 250°C during a short circuit without any damage. The PVC insulated cables shall be capable of withstanding a conductor temperature of 160°C during a short circuit.

1.2.1.4. The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All Aluminium used in the cables for conductors shall be of H2 grade. In case of single core cables armours shall be of H4 grade Aluminium.

1.2.1.5. The fillers and inner sheath shall be of non-hygroscopic, fire retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

1.2.1.6. Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.

1.2.1.7. Strip wire armouring method shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

1.2.1.8. The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

1.2.1.9. All the cables shall pass fire resistance test as per IEC: 60502 (Part-I)

1.2.1.10. The normal current rating of all PVC insulated cables shall be as per IEC: 60502.

1.2.1.11. Repaired cables shall not be accepted.

1.2.1.12. Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

1.2.2. **XLPE Power Cables**

1.2.2.1. The XLPE insulated cables shall be of FR type, C1 category conforming to IEC: 60502 (Part-I) and its amendments read alongwith this specification. The conductor shall be stranded aluminium circular/sector shaped and compacted. In multicore cables, the core shall be identified by red, yellow, blue and black coloured strips or colouring of insulation. A distinct inner sheath shall be provided in all multicore cables. For XLPE cables, the inner sheath shall be of extruded PVC to type ST-2 of IEC: 60502. When armouring is specified for single core cables, the same shall consist of aluminium wires/strips. The outer sheath shall be extruded PVC to Type ST-2 of IEC: 60502 for all XLPE cables.

1.2.3. **PVC Power Cables**

1.2.3.1. The PVC (70°C) insulated power cables shall be of FR type, C1 category, conforming to IEC: 60502 (Part-I) and its amendments read alongwith this specification and shall be suitable for a steady conductor temperature of 70°C. The conductor shall be stranded aluminium. The Insulation shall be extruded PVC to type-A of IEC: 60502. A distinct inner sheath shall be provided in all multicore cables. For multicore armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC to Type ST-1 of IEC: 60502 for all cables.

1.2.4. **PVC Control Cables**

1.2.4.1. The PVC ***(70°C) insulated*** control cables shall be of FR type C1 category conforming to IEC: 60502 (Part-1) and its amendments, read alongwith this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC to type A of IEC: 60502. A distinct inner sheath shall be provided in all cables whether armoured or not. The over sheath shall be extruded PVC to type ST-1 of IEC: 60502 and shall be grey in colour .

1.2.4.2. Cores shall be identified as per IEC: 60502 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of cores shall be done by printing legible Hindu Arabic Numerals on all cores as per IEC: 60502 (Part-1).

2. HV POWER CABLES[FOR WORKING VOLTAGES FROM 3.3 kV AND INCLUDING 33 kV]

2.1. *HV* POWER CABLE FOR AUXILIARY POWER SUPPLY

The HV cable of 1Cx185 mm^2 (Aluminium Conductor) or 1Cx120mm^2 (Copper Conductor) of voltage class as specified for 630 kVA LT transformer for interconnecting 630kVA LT transformer to the NEA feeder shall be, XLPE insulated, armoured cable conforming to IEC: 60502 (Part-2).
Terminating accessories shall conform to IEC 61442-1997/IEC60502-4 1998.

2.2. Bidder may offer sizes other than the sizes specified in clause 2.1. In such case sizing of power cables shall be done keeping in view continuous current, voltage drop & short-circuit consideration of the system. Relevant calculations shall be submitted by bidder during detailed engineering for purchaser's approval.

2.3. Constructional Requirements

Cable shall have compacted circular Aluminium conductor, Conductor screened with extruded semi conducting compound, XLPE insulated, insulation screened with extruded semi conducting compound, armoured with non-magnetic material, followed by extruded PVC outer sheath (Type ST-2), with FR properties.

2.4 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of the cable.

2.5 The cables shall have outer sheath of a material with an Oxygen Index of not less than 29 and a Temperature index of not less than 250°C.

2.6 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

3 CABLE DRUMS

3.1 Cables shall be supplied in returnable wooden or steel drums of heavy construction. Wooden drum shall be properly seasoned sound and free from defects. Wood preservative shall be applied to the entire drum.

3.2 Standard lengths for each size of power and control cables shall be 500/1000 meters. The cable length per drum shall be subject to a tolerance of plus or minus 5% of the standard drum length. The owner shall have the option of rejecting cable drums with shorter lengths. Maximum, One (1) number

nonstandard lengths of cable size(s) may be supplied in drums for completion of project.

3.3 A layer of water proof paper shall be applied to the surface of the drums and over the outer most cable layer.

3.4 A clear space of at least 40 mm shall be left between the cables and the lagging.

3.5 Each drums shall carry the manufacturer's name, the purchaser's name, address and contract number and type, size and length of the cable, net and gross weight stencilled on both sides of drum. A tag containing the same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

3.6 Packing shall be sturdy and adequate to protect the cables, from any injury due to mishandling or other conditions encountered during transportation, handling and storage. Both cable ends shall be sealed with PVC/Rubber caps so as to eliminate ingress of water during transportation and erection.

4 TYPE TESTS

4.1 All cables shall conform to all type, routine and acceptance tests listed in the relevant IEC.

4.2 XLPE INSULATED POWER CABLES (For working voltages up to and including 1100V):-

4.2.1 Following type tests (on one size in a contract) as per IEC: 60502 (Part 1) including its amendments shall be carried out as a part of acceptance tests on XLPE insulated power cables for working voltages up to and including 1100 V:

a) Physical tests for insulation
   i) Hot set test
   ii) Shrinkage test
b) Physical tests for outer sheath
   i) Shrinkage test
   ii) Hot deformation
   iii) Heat shock test
   iv) Thermal stability

4.2.2 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Chapter 2: GTR for the following tests-

a) Water absorption (gravimetric) test.
b) Ageing in air oven
c) Loss of mass in air oven

d) Short time current test on power cables of sizes 240 sqmm and above on
   i) Conductors.
   ii) Armours.
e) Test for armouring wires/strips.
f) Oxygen and Temperature Index test.
g) Flammability test.

4.3 PVC INSULATED POWER & CONTROL CABLES (For working voltages up to and including 1100V)-

4.3.1 Following type tests (on one size in a contract) as per IEC: 60502 (Part 1) including its amendments shall be carried out as a part of acceptance tests on PVC insulated power & control cables for working voltages up to and including 1100 V:

a) Physical tests for insulation and outer sheath
   i) Shrinkage test
   ii) Hot deformation
   iii) Heat shock test
   iv) Thermal stability
b) High voltage test.

4.3.2 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Chapter 2: GTR for the following-

a) High voltage test.
b) Ageing in air oven.
c) Loss of mass in air oven.
d) Short time current test on power cables of sizes 240 sqmm and above on
   i) Conductors.
   ii) Armours.
e) Test for armouring wires/strips.
f) Oxygen and Temperature Index test.
g) Flammability test.

4.4 XLPE INSULATED HV POWER CABLES(For working voltages from 3.3 kV and including 33 kV)-

4.4.1 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Chapter 2: GTR for XLPE insulated HV power cables (as per IEC: 60502 Part-2).

4.5 Terminating/jointing accessories as per IEC 60840:1999/ IEC62067

TECHNICAL SPECIFICATION FOR

AIR CONDITIONING SYSTEM

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TECHNICAL SPECIFICATION FOR

AIR CONDITIONING SYSTEM

1 GENERAL

1.1 This specification covers supply, installation, testing and commissioning and handing over to POWERGRID of Air conditioning system for the control room building and switch-yard panel rooms.

1.2 Air conditioning units for control room building shall be set to maintain the inside DBT at 24 ^{o} C ± 2^{o}C and the air conditioning system for switch-yard panel rooms shall be set to maintain DBT inside switch-yard panel rooms below 24^{o}C.

1.3 Controllers shall be provided in Control room and Battery room for controlling and monitoring the AC units in these rooms as detailed in clause no.2.3.4.

1.4 Each switch-yard panel room shall be provided with temperature transducer to monitor the temperature of the panel room. The Temperature transducer shall have the following specification:

Sensor	:	Air temperature sensor (indoor use)
Output	:	4 to 20mA
Temperature range	:	-5^{o}C to 60^{o}C
Resolution	:	0.1^{o}C
Accuracy	:	0.5^{o}C or better.

2 AIR CONDITIONING SYSTEM FOR CONTROL ROOM BUILDING & relay room.

Air conditioning requirement of control room building shall be met using High wall type split AC units of 2TR.

2.1 Scope

The scope of the equipment to be furnished and services to be provided under the contract are outlined hereinafter and the same is to be read in conjunction with the provision contained in other sections/ clauses. The scope of the work under the contract shall be deemed to include all such items, which although are not specifically mentioned in the bid documents and/or in Bidder's proposal, but are required to make the equipment/system complete for its safe, efficient, reliable and trouble free operation.

2.1.1 Required number of High wall type split AC units of 2TR capacity

each complete with air cooled outdoor condensing unit having hermetically sealed compressor and high wall type indoor evaporator unit with cordless remote controller.

2.1.2 Copper refrigerant piping complete with insulation between the indoor and outdoor units as required.

2.1.3 First charge of refrigerant and oil shall be supplied with the unit.

2.1.4 GSS/Aluminium sheet air distribution ducting for distributing conditioned dehumidified air along with supply air diffusers and return air grilles with volume control dampers and necessary splitters etc., suitable fixtures for grilles/diffusers and supports for ducting complete with insulation.

2.1.5 Local start/stop facility for local starting/ stopping of all electrical equipment/ drives.

2.1.6 All instruments and local control panels alongwith controls and interlock arrangements and accessories as required for safe and trouble free operation of the units.

2.1.7 PVC drain piping from the indoor units upto the nearest drain point.

2.1.8 Supply and erection of Power and control cable and earthing.

2.1.9 MS Brackets for outdoor condensing units, condensers as required.

2.2 Technical specifications.

2.2.1 High wall type split AC units

2.2.1.1 The split AC units shall be complete with indoor evaporator unit, outdoor condensing units and cordless remote control units.

2.2.1.2 Outdoor unit shall comprise of hermetically/semi hermetically sealed compressors mounted on vibration isolators, propeller type axial flow fans and copper tube aluminium finned coils all assembled in a sheet metal casing. The casing and the total unit shall be properly treated and shall be weatherproof type. They shall be compact in size and shall have horizontal discharge of air.

2.2.1.3 The indoor units shall be high wall type. The indoor unit shall be compact and shall have elegant appearance. They shall have low noise centrifugal blowers driven by suitable motors and copper tube aluminium finned cooling coils. Removable and washable polypropylene filters shall be provided. They shall be complete

with multi function cordless remote control unit with special features like programmable timer, sleep mode and soft dry mode etc.

2.2.1.4 Cooling capacity of 2TR AC units shall not be less than 22000btu/hr. and shall have energy efficiency rating of 3star or above.

2.2.2 Controllers shall be provided in Control room and Battery room, one controller for each room, to control and monitoring of AC units and shall have the following facilities;

- Standby units shall come in to operation automatically whenthe running main unit fails
- Main and standby units shall be changed over periodically which shall be finalised during detailed engineering.
- Following alarms shall be provided:

a. Compressor On/OFF condition of each unit
b. Compressor failure of each unit
c. Power OFF to AC unit
d. High temperature in room.

2.3 The Split AC units shall be of Carrier, Voltas, Blue Star, Hitachi, Daikin, LG, National, O'General or Samsung make.

2.4 **Warranty**

All compressors shall have minimum 5 years Warranty from the date of commissioning.

3 AIR CONDITIONING SYSTEM FOR SWITCHYARD PANEL ROOMS.

3.1 Air conditioning system shall be provided in the switchyard panel rooms used for housing control and protection panels. These panel rooms will be located in the switchyard area and generally unmanned. Therefore, the air-conditioning system shall be rugged, reliable, maintenance free and designed for long life.

3.2 Air conditioning system is required for maintaining the temperature below 24^{o}C for sub-station control and protection panels. This shall be achieved using Packaged AC units with free cooling arrangement as per clause 3.4. The system shall be designed for 24 Hours, 365 Days of the year operation to maintain the inside Switchyard panel rooms temperature for proper operation of the critical equipment.

3.3 Number and rating of the units for each panel room shall be as follows:

i. For panel room of length not more than 6 metres.: 2 nos. (1 working + 1 standby) AC units of 2TR capacity each.
ii. For panel room of length more than 6 metres.: 2 nos. (1 working + 1 standby) AC units of 3TR capacity each.

3.4 Technical specification for Packaged AC units with Free Cooling.

3.4.1 Each AC unit shall be complete with air cooled condensing unit with scroll compressor, direct expansion type evapourating unit and microprocessor controller. AC units shall be provided with free cooling arrangement. In free cooling mode, the refrigerant cycle of AC unit shall be switched off and outside air (after filtration) shall be circulated inside the conditioned space through the operation of dampers provided with suitable sensors. This mode shall come into operation in the following conditions;

i. When the ambient temperature is below a preset value, which is to be decided during detailed engineering.
ii. In case of failure of refrigeration system of both the units.

3.4.2 One of the air-conditioners shall be running at a time and shall maintain the required temperature. On failure of the running air-conditioner, the other air-conditioner shall start automatically. To ensure longer life of the system and to keep the AC units healthy, change over of the standby unit shall be done periodically through the controller. Further, if inside temperature of the room reaches 35^{o}C due to any emergency condition, the standby air-conditioner shall also start running to maintain the temperature less than 24^{o}C and system shall generate an alarm for such a situation. After achieving this temperature, the standby unit shall again shut off. However any hunting situation shall be reported. No heating or humidification is envisaged for the air conditioning system inside the Switchyard panel rooms.

3.4.3 Packaged AC units with free cooling shall be designed for high sensitive cooling with sensible heat factor of 90% or above.

3.4.4 Each air conditioner shall be completely self-contained. All components of the units shall be enclosed in a powder coated cabinet. The unit shall be assembled, wired, piped, charged with refrigerant and fully factory tested as a system to ensure trouble free installation and start up. Suitable isolation or other by-passing arrangement shall be provided such that any unit/component could be maintained/ repaired without affecting the running standby unit.

3.4.5 The AC units shall be mounted on the wall and the maintenance of unit shall be possible from outside the Switchyard panel room.

3.4.6 Required Features of Various Components

The compressor shall be very reliable, trouble free and long life i.e. hermetically sealed Scroll type of reputed make suitable for continuous operation. Compressor should be installed on vibration isolated mountings or manufacturer's recommended approved mounting. Valve shall be provided for charging/topping up of refrigerant. The bidder shall furnish details of their compressor indicating the MTBF, life of compressor and continuous run time of compressor without failure. The contractor shall also furnish details of all accessories i.e. refrigeration system, evaporator coil, condenser coil, evaporator blower, filter, cabinet, indoor supply and return grill etc. during detailed engineering.

3.5 **Warranty**

All compressors shall have minimum 5 years Warranty from the date of commissioning

3.6 For owner's remote monitoring purposes, necessary digital inputs shall be provided for 'ON' and 'OFF' condition of each compressor.

CHAPTER 11: DIESEL GENERATOR SET

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CHAPTER 11: DIESEL GENERATOR SET

1.1. SCOPE OF SUPPLY

1.1.1. The scope covers supply of. Diesel Generator set of stationary type having a net electrical output of 250/100kVA capacity at specified site conditions of 50^{o} C ambient temperature and 100% relative humidity on FOR site basis. DG set shall be equipped with:

(i) Diesel engine complete with all accessories.
(ii) An alternator directly coupled to the engine through coupling, complete with all accessories.
(iii) Automatic voltage regulator.
(iv) Complete starting arrangement, including two nos. batteries & chargers.
(v) Base frame, foundation bolts etc.
(vi) Day tank of 990 Litre capacity.
(vii) Engine Cooling and lubrication system.
(viii) Engine air filtering system.
(ix) Exhaust silencer package.
(x) Set of GI pipes, valves, strainers, unloading hose pipes as required for fuel transfer system from storage area to fuel tank including electrically driven fuel pump.
(xi) All lubricants, consumable, touch up paints etc. for first filing, testing & commissioning at site. The fuel oil for first commissioning will also be provided by the contractor.
(xii) AMF panel for control, metering and alarm.
(xiii) Enclosure for silent type D.G. Set

1.2. SCOPE OF SERVICE

1.2.1. The Contractor shall provide following services:

a) Design, manufacture, shop testing including assembly test.
b) Despatch, transportation to site.
c) Erection, testing & commissioning with all equipments/materials required for the purpose.
d) Drawings, data, design calculations and printed erection, operation & maintenance manual.
e) Certification and compliance for meeting noise level & emission parameters and other requirements in accordance with latest Notification of MOEF.

1.3. TECHNICAL REQUIREMENTS

1.3.1. The rating of DG sets are as follows :

DG set net out put after considering deration for engine and alternator separately due to temperature rise in side the enclosure and on account of power reduction due to auxiliaries shall be 250/100kVA, 1500RPM, 0.8Pf, 400V, 3 phase, 50Hz. The above ratings are the minimum requirements.

1.3.1.1. DG sets shall also be rated for 110% of full load for 1 hour in every twelve hrs of continuous running.

1.3.2. The output voltage, frequency and limits of variation from open circuit to full load shall be as follows :

a) Voltage variation ±10% of the set value provision shall exist to adjust the set value between 90% to 110% of nominal Generator voltage of 400V.

b) Frequency 50Hz ±2.5%

1.3.3. The Diesel Generator and other auxiliary motor shall be of H class with temperature rise limited to Class-F for temperature rise consideration.

1.3.4. NOISE LEVEL & EMISSION PARAMETERS : These shall be as per latest Notification of MOEF

1.4. PLANT DESIGN

1.4.1. DIESEL ENGINE

1.4.1.1. The engine shall comply with the BS 5514/ISO 3046; latest edition

1.4.1.2. Diesel engine shall be turbo charged multicylinder V-type in line type with mechanical fuel injection system.

1.4.1.3. The engine with all accessories shall be enclosed in a enclosure to make it work Silently (within permissible noise level) without any degradation in its performance.

1.4.1.4. The Diesel Engines shall be directly water cooled. Cooling of water through radiator and fan as envisaged.

1.4.1.5. The fuel used shall be High Speed Diesel oil (HSD) or Light Diesel Oil (LDO).

1.4.2. AIR SUCTION & FILTRATION

1.4.2.1. Suction of air shall be from indoor for ventilation and exhaust flue gasses will be let out to outside atmosphere, Condensate traps shall be provided on the exhaust pipe.

1.4.2.2. Filter shall be dry type air filter with replaceable elements.

1.4.3. FUEL AND LUBRICATING OIL SYSTEM

1.4.3.1. The engine shall have closed loop lubricating system. No moving parts shall require lubrication by hand prior to the start of engine or while it is in operation.

1.4.4. ENGINE STARTING SYSTEM

1.4.4.1. Automatic electric starting by DC starter motor shall be provided.

1.4.5. FUEL INJECTION AND REGULATOR

1.4.5.1. The engine shall be fitted with electronic governor.

1.4.5.2. The engine shall be fitted with a heavy, dynamically balanced fly wheel suitable for constant speed governor duty.

1.4.6. **ALTERNATOR**

1.4.6.1. The alternator shall comply with IEC 60034; latest edition.

1.4.6.2. The alternator shall be of continuously rated duty, suitable for 400 V, 3 phase, 50 Hz. Power development having brush-less, synchronous, self-excited, self-regulating system.

1.4.6.3. The alternator shall be drip-proof, screen protected as per IP-23 degree of Protection.

1.4.6.4. The rotor shall be dynamically balanced to minimize vibration.

1.4.6.5. The alternator shall be fitted with shaft mounted centrifugal fan.

1.4.6.6. It shall have the winding of class H but limited to Class-F for temperature rise consideration.

1.4.6.7. The Alternator regulator shall be directly coupled to the engine and shall be complete with the excitation system, automatic voltage regulation of +/- 1%, voltage adjusting potentiometer and under/over speed protection.

1.4.6.8. **TERMINAL BOX**

1.4.6.8.1. Six (6) output terminals shall be provided in alternator terminal box. Terminals shall be Suitable for 1 No. of single core, 630 mm^2 XLPE cables per phase for 250kVA DG set and 3½Core 300 mm^2 XLPE cable for 100kVA DG set. The neutral shall be formed in AMF panel. The generator terminal box shall be suitable to house necessary cables and should be made of non-magnetic material.

1.4.6.9. The alternator with all accessories shall be enclosed in a enclosure to make it work Silently (within permissible noise level)

1.4.7. **COUPLING**

1.4.7.1. The engine and alternator shall be directly coupled by means of self-aligning flexible flange coupling to avoid misalignment.

1.4.7.2. The coupling shall be provided with a protecting guard to avoid accidental contract.

1.4.8. **MOUNTING ARRANGEMENT**

1.4.8.1. The engine and alternator shall be mounted on a common heavy duty, rigid fabricated steel base frame constructed from ISMC of suitable sections.

1.4.8.2. Adequate number of anti-vibration mounting pads shall be fixed on the common base frame on which the engine and the alternator shall be mounted to isolate the vibration from passing on to the common base frame or the foundation of the D.G. Set.

1.4.9. **PERIPHERALS**

1.4.9.1. **FUEL TANK**

1.4.9.1.1. The Fuel tank of 990 Litre capacity shall be provided on a suitably fabricated steel platform. The tank shall be complete with level indicator marked in litres, filling inlet with removable screen, an outlet, a drain plug, an air vent, an air breather and necessary piping. The tank shall be painted with oil resistant paint and shall be erected in accordance with **Nepal Explosive Act.** Fuel tank shall be kept outside of enclosure. The fuel piping shall be carried out to connect the D.G set kept inside.

1.4.9.1.2. For transferring fuel to Fuel tank transfer pump is envisaged. The capacity of transfer pump shall be adequate to fill the day tank in about 30 minutes. Fuel pump shall be electrically driven.

1.4.9.2. **BATTERY and BATTERY CHARGER**

1.4.9.2.1. Two nos. 24V batteries complete with all leads, terminals and stand shall be provided. Each battery shall have sufficient capacity to give 10 nos. successive starting impulse to the diesel engine.

1.4.9.2.2. The battery charger shall be complete with transformer, suitable rating (400 V, 3 Ph., 50 Hz./230V, 1Ph., 50 Hz) rectifier circuit, charge rate selector switch for "trickle"/'boost' charge, D.C. ammeter & voltmeter, annunciation panel for battery charge indication / loading / failures.

1.4.9.2.3. The charger shall float and Boost Charge the battery as per recommendation of manufacturer of battery. The charger shall be able to charge a fully discharged battery to a state of full charge in 8 Hrs. with 25% spare capacity.

1.4.9.2.4. Manual control for coarse and fine voltage variation shall be provided. Float charger shall have built-in load limiting features.

1.4.9.2.5. Ripple shall not be more than 1%(r.m.s) to get smooth DC voltage shall be provided.

1.4.9.2.6. Charger shall be provided with Out-put Voltmeter & Ammeter.

1.4.9.2.7. Changeover scheme for selecting battery and battery charger by changeover switch should be provided.

1.5. **CONTROL AND INSTRUMENTATION**

1.5.1. Each D.G. Set shall be provided with suitable instruments, interlock and protection arrangement, suitable annunciation and indications etc. for proper start up, control, monitoring and safe operation of the unit. One local AMF control panel alongwith each D.G. set shall be provided by the Supplier to accommodate these instruments, protective relays, indication lamps etc. The AMF Panel shall have IP-52 degree of Protection as per IEC: 60529.

1.5.2. The D.G. sets shall be provided with automatic start facility to make it possible to take full load within 30 seconds of Power Supply failure.

1.5.3. Testing facility for automatic operation of D.G. Set shall be provided in AMF panel.

1.5.4. A three attempt starting facility using two impulse timers and summation timer for engine shall be proved and if the voltage fails to develop within 40 sec. from receiving the first impulse, the set shall block and alarm to this effect shall be provided in the AMF panel.

1.5.5. Following instruments shall be provided with Diesel Engine

a) Lub oil pressure gauge
b) Water temperature thermometers
c) Engine tachometer/HR
d) Any other instruments necessary for DG Set operation shall be provided.

1.5.6. DG set shall be capable of being started/ stopped manually from remote as well as local. (Remote START/STOP push button shall be provided in 400V ACDB). However, interlock shall be provided to prevent shutting down operation as long as D.G. Circuit breaker is closed.

1.5.7. The diesel generator shall commence a shutdown sequence whenever any of the following conditions appear in the system :

a) Overspeed
b) Overload
c) High temperature of engine and cooling water.
d) High temperature inside enclosure
e) Low lube oil pressure
f) Generator differential protection
g) Short circuit protection
h) Under voltage
i) Over voltage
j) Further interlocking of breaker shall be provided to prevent parallel operation of DG set with normal station supply.

1.5.8. Following indication lamps for purposes mentioned as under shall be provided in AMF panel :

1.5.8.1. Pilot indicating lamp for the following :

a) Mains ON
b) Alternator ON
c) Charger ON/OFF
d) Breaker ON/OFF
e) Main LT Supply ON/OFF

1.5.8.2. Visual annunciation shall be provided for set shut down due to :

a) engine overheating
b) low oil pressure
c) lack of fuel
d) Set failed to start in 30 secs after receiving the first start impulse
e) high cooling water temperature
f) Low level in daily service fuel tank
g) Overspeed trip
h) Audio & visual Annunciation for alternator fault.

1.5.9. Thermostatically controlled space heaters and cubicle illumination operated by Door Switch shall be provided in AMF panel. Necessary isolating switches and fuses shall also be provided.

1.5.10. AMF panel shall have facility for adjustment of speed and voltage including fine adjustments in remote as well as in local mode.

Following shall also be provided in AMF panel:

a) Frequency meter

b) 3 Nos. single phase CT's for metering

c) 3 Nos. (Provided by LT swgr manufacturer) single phase CT's with KPV 300V & RCT 0.25 ohm for differential protection of DG Set on neutral side only for 250kVA.

d) .One (1) DC Ammeter (0-40A)

e) One (1) DC Voltmeter (0-30V)

f) One (1) Voltmeter Selector switch

g) One (1) AC Ammeter

h) One (1) AC Voltmeter

i) Three (3) Timers (24V DC)

j) Two (2) Auto/Manual Selector Switch

k) Two (2) Auto/test/Manual Selector Switch

l) Eleven (11) Aux. Contactors suitable for 24V DC

m) One (1) Motorised potentiometer for voltage adjustment

n) Two (2) Set Battery charger as specified in Technical Specification

o) One (1) Set Phase & Neutral busbars.

p) Any other item required for completion of Control scheme shall be deemed to be included.

1.6. D.G. SET ENCLOSURE

1.6.1. General requirements

1.6.1.1. Diesel engine, alternator, AMF panel, Batteries and Chargers shall be installed outdoor in a suitable weather-proof enclosure which shall be provided for protection from rain, sun, dust etc. Further, in addition to the weather proofing, acoustic enclosures shall also be provided such that the noise level of acoustic enclosure DG set shall meet the requirement of MOEF The diesel generator sets should also conform to Nepal Environment (Protection) Rules. An exhaust fan with louvers shall be installed in the enclosure for temperature control inside the enclosure. The enclosure shall allow sufficient ventilation to the enclosed D.G. Set so that the body temperature is limit to 50°C. The air flow of the exhaust fan shall be from inside to the outside the shelter. The exhaust fan shall be powered from the DG set supply output so that it starts with the starting of the DG set and stops with the stopping of the DG set. The enclosure shall have suitable viewing glass to view the local parameters on the engine.

1.6.1.2. Fresh air intake for the Engine shall be available abundantly; without making the Engine to gasp for air intake. A chicken mess shall be provided for air inlet at suitable location in enclosure which shall be finalised during detailed engineering.

1.6.1.3. The Enclosure shall be designed and the layout of the equipment inside it shall be such that there is easy access to all the serviceable parts.

1.6.1.4. Engine and Alternator used inside the Enclosure shall carry their manufacturer's Warranty for their respective Models and this shall not degrade their performance.

1.6.1.5. Exhaust from the Engine shall be let off through Silencer arrangement to keep the noise level within desired limits. Interconnection between silencer and engine should be through stainless steel flexible hose/ pipe.

1.6.2. All the Controls for Operation of the D.G. Set shall be easily assessable. There should be provision for emergency shut down from outside the enclosure.

1.6.3. Arrangement shall be made for housing the Battery set in a tray inside the Enclosure.

1.6.4. **CONSTRUCTION FEATURES:**

1.6.4.1. The enclosure shall be fabricated from at least 14 Gauge CRCA sheet steel and of Modular construction for easy assembling and dismantling. The sheet metal components shall be pre-treated by Seven Tank Process and Powder coated (PURO Polyester based) both-in side and out side – for long life. The hard-ware and accessories shall be high tensile grade. Enclosure shall be given a lasting anti-rust treatment and finished with pleasant environment friendly paint. All the hardware and fixtures shall be rust proof and able to withstand the weather conditions.

1.6.4.2. Doors shall be large sized for easy access and provided with long lasting gasket to make the enclosure sound proof. All the door handles shall be lockable type.

1.6.4.3. The Enclosure shall be provided with anti-vibration pads (suitable for the loads and vibration they are required to carry) with minimum vibration transmitted to the surface the set is resting on.

1.6.4.4. High quality rock wool of required density and thickness shall be used with fire retardant thermo – setting resin to make the Enclosure sound proof.

1.6.5. Provision for Neutral/Body Earthing

1.6.5.1. Points shall be available at two side of the enclosure with the help of flexible copper wires from alternator neutral, and electrical panel body respectively. The earthing point shall be isolated through insulator mounted on enclosure.

1.7. **INSTALLATION ARRANGEMENT**

1.7.1. DG set enclosed in enclosure shall be installed on Concrete Pedestal 300mm above FGL.

1.8. **DOCUMENTS**

1.8.1. Following drawings and data sheet shall be submitted for approval:
(i) Data sheet for Engine, Alternator, Battery, AMF panel and Enclosure
(ii) GA drawing of DG set
(iii) Layout of DG set in the enclosure along with sections
(iv) GA and schematic of AMF panel
(v) Arrangement of inclined roof and pedestal.

1.8.2. The D G Set shall be supplied with
(i) D G Set test certificate

(ii) Engine Operation & maintenance Manual.
(iii) Engine Parts Catalogue.
(iv) Alternator Operation, maintenance & Spare parts Manual.
(v) Alternator test certificate.

1.9. **TESTS**

a) The Diesel generator sets shall be tested for routine and acceptance tests as per the relevant IEC standards.

1.10. **COMMISSIONING CHECKS**

In addition to the checks and test recommended by the manufacturer, the Contractor shall carryout the following commissioning tests to be carried out at site.

1. Load Test

The engine shall be given test run for a period of atleast 6 hours. The set shall be subjected to the maximum achievable load as decided by Purchaser without exceeding the specified DG Set rating:

During the load test, half hourly records of the following shall be taken:

a) Ambient temperature.
b) Exhaust temperature if exhaust thermometer is fitted.
c) Cooling water temperature at a convenient point adjacent to the water output from the engine jacket.
d) Lubricating oil temperature where oil cooler fitted.
e) Lubricating oil pressure.
f) Colour of exhaust gas
g) Speed
h) Voltage, wattage and current output.
i) Oil tank level

The necessary load to carryout the test shall be provided by the purchaser.

2. Insulation Resistance Test for Alternator

Insulation resistance in mega-ohms between the coils and the frame of the alternator when tested with a 500V megger shall not be less than IR=2x(rated voltage in KV)+1

3. Check of Fuel Consumption

A check of the fuel consumption shall be made during the load run test. This test shall be conducted for the purpose of proper tuning of the engine.

4. Insulation Resistance of Wiring

Insulation resistance of control panel wiring shall be checked by 500V Megger. The IR shall not be less than one mega ohm.

5. Functional Tests

a) Functional tests on control panel.

b) Functional test on starting provision on the engine.
c) Functional tests on all Field devices.
d) Functional tests on AVR and speed governor.

6. Measurement of Vibration

   The vibration shall be measured at load as close to maximum achievable load and shall not exceed 250microns.

7. Noise Level shall be less than 75dBA at a distance of one meter.

8. The tests shall be carried out with the DG set operating at rated speed and at maximum achievable load. Necessary correction for Test environment condition & background noise will be applied as per applicable IEC/International Standards.

CHAPTER: SWITCHYARD ERECTION

Table of contents

1.0 GENERAL

The detailed scope of work includes design, engineering, manufacture, testing at works, supply on FOR destination site basis, insurance, handling, storage, erection testing and commissioning of various items and works as detailed herein.

This Chapter covers the description of the following items.

A. Supply of

- String insulators and hardware
- AAC / ACSR conductor
- Galvanised Steel Earthwire
- Aluminium Tubular Bus Bars
- Spacers
- Bus post insulators
- Earthing & Earthing materials
- Lightning protection materials
- Cabling material
- Other items

B. Erection Of all items

1.1 String Insulators & Hardware

The insulators for suspension and tension strings shall conform to IEC-60383 and long rod insulators shall conform to IEC-60433. Insulator hardware shall conform to equivalent international standard. Composite long rod insulator shall conform to IEC: 61109.

1.1.1 Construction Features

1.1.1.1 For porcelain insulators

a) Suspension and tension insulators shall be wet process porcelain with ball and socket connection. Insulators shall be interchangeable and shall be suitable for forming either suspension or tension strings. Each insulator shall have rated strength markings on porcelain printed and applied before firing.

b) Porcelain used in insulator manufacture shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

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

1.1.1.2 **For glass insulators**

It shall be made of toughened glass. Glass used for the shells shall be sound, free from defects, flows bubbles, inclusions, etc and be of uniform toughness over its entire surface. All exposed glass surfaces shall be smooth.

1.1.1.3 When operating at normal rated voltage there shall be no electric discharge between conductor and insulator which would cause corrosion or injury to conductors or insulators by the formation of substances due to chemical action. No radio interference shall be caused when operating at normal rated voltage.

1.1.1.4 The design of the insulator shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. All ferrous parts shall be hot dip galvanized. The zinc used for galvanizing shall be of grade Zn-99.95. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains bulky white deposits and blisters.

1.1.1.5 Bidder shall make available data on all the essential features of design including the method of assembly of discs and metal parts, number of discs per insulator string insulators, the manner in which mechanical stresses are transmitted through discs to adjacent parts, provision for meeting expansion stresses, results of corona and thermal shock tests, recommended working strength and any special design or arrangement employed to increase life under service conditions.

1.1.1.6 Clamps for insulator strings and Corona Control rings shall be of aluminium alloy as stipulated for clamps and connectors.

1.1.1.7 Insulator hardware shall be of forged steel. Malleable cast iron shall not be accepted except for insulator disc cap. The surface of hardware must be clean, smooth, without cuts, abrasion or projections. No part shall be subjected to excessive localized pressure. The metal parts shall not produce any noise generating corona under operating conditions.

1.1.1.8 The tension Insulator hardware assembly shall be designed for minimum 12000 kg tensile load for below 765kV. Earth wire tension clamp shall be designed for minimum 1000 kg tensile load with a factor of safety of two (2).

1.1.1.9 The tension string assemblies shall be supplied alongwith suitable turn buckle. Sag compensation springs if required may also be provided.

1.1.1.10 All hardware shall be bolted type.

1.2 Long Rod Porcelain Insulators

1.2.1 As an alternative to disc insulator, Bidder can offer long rod porcelain insulators strings, with suitable hardware. The combination should be suitable for application specified and should offer the identical/equivalent parameters as would be available from insulator string comprising disc insulators and hardware

combination.

1.2.2 All constructional features specified at Clause 1.1.1 of this Chapter shall also apply to the long rod insulator string.

1.3 **Tests**

In accordance with the stipulations of the specification, the suspension and tension strings, insulator and hardware shall be subjected to the following type tests, acceptance tests and routine tests:

1.3.1 **Type Tests on Insulator Strings:** The test reports for following type tests shall be submitted for approval as per clause 9.0 of Chapter 2 - GTR.

a) Power frequency voltage withstand test with corona control rings under wet condition as per IEC- 60383.

b) Lightning Impulse voltage withstand test with corona control rings under dry condition as per IEC-60383

c) Voltage distribution test (Dry)

The voltage across each insulator unit shall be measured by sphere gap method. The result obtained shall be converted into percentage. The voltage across any disc shall not exceed 13% for 220KV suspension and tension insulator strings, 20% and 22% for 132KV suspension and tension insulator strings respectively.

e) Corona Extinction Voltage test (Dry) :- (As per Annexure – C)

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 156kV (rms) for 220kV line to ground under dry condition. There shall be no evidence of Corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC 60383.

f) RIV Test (Dry)

Under the conditions as specified under (e) above the insulator string alongwith complete hardware fittings shall have a radio interference voltage level below 1000 microvolts at 1 MHz when subjected to 50 Hz AC line to ground voltage of 156kV for 220kV string under dry conditions. The test procedure shall be in accordance with IEC 60437.

g) Mechanical strength test

The complete insulator string alongwith its hardware fitting excluding arcing horn, corona control ring, grading ring, tension/suspension clamps shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string

components shall not show any visual deformation and it shall be possible to dismantle them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.3.2 **Type Tests on Insulators**

Type test report for Thermal Mechanical Performance tests as per IEC - 60575, Clause 3 / IEC: 61109, clause 5.1 (for composite long rod insulators) shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

1.3.3 **Acceptance Tests for Insulators:**

a) Visual examination as per IEC-60383/ IEC-61109 clause no. 7.2 (for composite long rod insulators).

b) Verification of Dimensions as per IEC- 60383.

c) Temperature cycle test as per IEC- 60383.

d) Puncture Test as per IEC-60383 (Applicable only for porcelain insulators).

e) Galvanizing Test as per IEC- 60383.

f) Mechanical performance test as per IEC-60575 Cl. 4 / IEC-61109 clause no. 7.2 (for composite long rod insulators).

g) Test on locking device for ball and socket coupling as per IEC-60372(2).

h) Porosity test as per IEC- 60383 (Applicable only for porcelain insulators).

i) Thermal shock test as per IEC-60383 (Applicable only for glass insulators)

1.3.4 **Acceptance Test on Hardware Fitting**

a) Visual Examination as per Cl. 5.10 of IS:2486 (Part-I).

b) Verification of Dimensions as per Cl. 5.8 of IS : 2486 (Part-I)

c) Galvanising/Electroplating tests as per Cl. 5.9 of IS : 2486 (Part-I).

d) Slip strength test as per Cl 5.4 of IS-2486 (part-I)

e) Shore hardness test for the Elastometer (if applicable as per the value guaranteed by the Bidder).

f) Mechanical strength test for each component (including corona control rings and arcing horns).

The load shall be so applied that the component is stressed in the same way as it would be in actual service and the procedure as given in 1.2.13.1 (g) above should be followed.

g) Test on locking devices for ball and socket coupling as per IEC -60372(2).

1.3.5 **Routine Test on Insulator**

a) Visual Inspection as per IEC-60383

b) Mechanical Routine Test as per IEC-60383

c) Electrical Routine Test as per IEC-60383

1.3.6 **Routine Test on hardware Fittings**

a) Visual examination as per IEC-61109 (for composite long rod insulators).

b) Mechanical strength Test as per IEC-61109 (for composite long rod insulators).

1.3.7 **Test during manufacture on all Components as applicable on insulator**

a) Chemical analysis of zinc used for galvanising:

Samples taken from the zinc ingot shall be chemically analyzed. The purity of zinc shall not be less than 99.95%.

b) Chemical Analysis, mechanical hardness tests and magnetic particle inspection for malleable casting:

The chemical analysis, hardness tests and magnetic particle inspection for malleable casting will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding tests will be as discussed and mutually agreed to by the Contractor and Owner in Quality Assurance Program.

1.3.8 Test during manufacture on all components as applicable on hardware fittings:

a) Chemical analysis of zinc used for galvanising:

Samples taken from the zinc ingot shall be chemically analyzed. The purity of zinc shall not be less than 99.95%

b) Chemical analysis, hardness tests and magnetic particle for forgings:

The chemical analysis, hardness tests and magnetic particle inspection for forgings will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding tests will be as discussed and

mutually agreed to by the Contractor and Owner in Quality Assurance Programme.

c) Chemical analysis and mechanical hardness tests and magnetic particle inspection for fabricated hardware:

The chemical analysis, hardness tests and magnetic particle inspection for fabricated hardware will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding tests will be as discussed and mutually agreed to by the Contractor and Owner in Quality Assurance programme.

1.4 Parameters

1.4.1 Disc Insulators

Sl. No.	Description	For 220/132kV
a)	Type of insulators	Anti Fog type
b)	Size of insulator units (mm)	255x145 or 280x145
c)	Electro mechanical strength	120 kN
d)	Creepage distance of individual insulator units (minimum and as required to meet total creepage distance)	430 mm
e)	Markings	
i)	For Porcelain insulators	Markings on porcelain
ii)	For toughened glass insulators	Markings shall be done on initial parts
f)	Power frequency puncture withstand voltage	1.3 times the actual wet flashover voltage

1.4.2 INSULATOR STRING

Sl. No.	Description	220kV	132kV
a)	Power frequency withstand voltage of the complete string with corona control ring (wet) – KV rms	460	275
b)	Lightning impulse withstand Voltage of string with corona control rings (dry) - kVp	± 1050	± 650
c)	Switching surge withstand voltage of string with corona control rings (wet) - kVp	NA	NA
d)	Minimum corona extinction voltage level of string with Corona Control rings (dry) - kV rms	156	NA

e)	Maximum RIV level in micro volts of string with Corona Control rings at 508 kV (rms) for 765 kV, 320 kV (rms) for 400 kV string and 156 kV for 220 kV string across300 Ohms resistor at 1 MHz	1000	NA
f)	Minimum total creepage distance of the insulator string (mm)	6125	3625
g)	Total no. of discs per strings	15	10

For tension application, double insulator strings for 220 KV and single insulator strings for 132 kV system shall be used. For suspension purpose single suspension insulator string shall be used for 220 KV & 132 kV system.

1.4.2.1 **INSULATOR STRING (11 KV)**

a) Power frequency withstand voltage of the complete string with Corona Control ring (wet) - kV rms : 28

b) Lightning impulse withstand Voltage of string with corona control rings (dry) – kVp : ±75

c) Power frequency puncture with-stand voltage for a string insulator : 1.3 times actual wet flashover voltage of the unit

d) Total creepage distance of the complete insulator string (mm) : 300

1.5 COMPOSITE LONG ROD INSULATOR

As an alternative to disc insulator/long rod porcelain, Bidder can also offer composite long rod insulators with suitable hardware.

1.5.1 Details of Composite Long Rod Insulators

1.5.1.1 Contractor shall offer such composite insulators which have proven use under foggy/ humid operational conditions in polluted industrial environment combined with smoke and dust particles. The Bidder shall furnish evidence in the form of certification from the power utilities that the similar type of product supplied to them had been performing satisfactory. The Bidder shall also submit certified test report for an accelerated ageing test of 5000 hours such as that described in Appendix-C of IEC-61109 or test at multiple stresses of 5000 hrs as described in annexure –B of IEC-62217.

1.5.1.2 Insulators shall have sheds of the “open aerodynamic profile without any under ribs” with good self-cleaning properties. Insulator shed profile, spacing projection etc. shall be strictly in accordance with the recommendation of IEC-60815.

1.5.2 Ball and socket shall be 20 mm designation for 120 kN & 24 mm designation for 210 kN Insulators in accordance with the standard dimensions stated in IEC:60120. Insulators shall be interchangeable and shall be suitable for forming

either suspension or tension strings. Each insulator shall have rated strength markings on each composite insulator rod unit. no negative tolerance shall be applicable to creepage distance of composite insulators

1.5.3 All ferrous parts shall be hot dip galvanized to give a minimum average coating of zinc equivalent to 610 gm/sq.m. and shall be in accordance with the latest edition of equivalent International standard. The zinc used for galvanizing shall be of purity of 99.95%. The zinc coating shall be uniform, adherent, smooth, reasonably bright continuous and free from imperfections such as flux, ash rust stains, bulky white deposits and blisters. The galvanized metal parts shall be guaranteed to withstand at least six successive dips each lasting for one (1) minute duration under the standard preece test. The galvanizing shall be carried out only after any machining.

1.5.4 ***Materials***

1.5.4.1 ***Core***

It shall be a glass-fiber reinforced (FRP rod) epoxy resin rod of high strength. The rod shall be resistant to hydrolysis. Glass fibers and resin shall be optimized. The rod shall be electrical grade corrosion resistant (ECR), boron free glass and shall exhibit both high electrical integrity and high resistance to acid corrosion.

1.5.4.2 **Housing & Weathersheds**

The FRP rod shall be covered by a sheath of a silicone rubber compound of a thickness of minimum 3mm. The housing & weathersheds should have silicon content of minimum 30% by weight. It should protect the FRP rod against environmental influences, external pollution and humidity. It shall be extruded or directly molded on the core. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core.

The weathersheds of the insulators shall be of alternate shed profile. The weathersheds shall be vulcanized to the sheath (extrusion process) or molded as part of the sheath (injection moulding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection moulding shall be at high temperature & high pressure. Any seams/ burrs protruding axially along the insulator, resulting from the injection moulding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to IEC60587. The strength of the weathershed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

1.5.4.3 **End Fittings**

End fittings transmit the mechanical load to the core. They shall be made of malleable cast iron/ spheroidal graphite or forged steel. They shall be connected to the rod by means of a controlled compression technique. The manufacturer shall have in-process Acoustic emission arrangement or some other arrangement to ensure that there is no damage to the core during crimping. This

verification shall be in-process and done on each insulator. The system of attachment of end fitting to the rod shall provide superior sealing performance between housing and metal connection. The gap between fitting and sheath shall be sealed by a flexible silicone rubber compound. The sealing shall stick to both housing and metal end fitting. The sealing must be humidity proof and durable with time.

End fittings shall have suitable provisions for fixing grading rings at the correct position as per design requirements.

1.5.4.4 **Grading Rings**

Grading rings shall be used at both ends of each composite insulator unit for reducing the voltage gradient on and within the insulator and to reduce radio and TV noise to acceptable levels. The size and placement of the metallic grading rings shall be designed to eliminate dry band arcing/corona cutting/ exceeding of permissible electrical stress of material.

1.5.2 **Tests and Standards**

1.5.2.1 **Type Tests**

The test reports for following type tests on long rod units, components, materials or complete strings shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

1.5.2.1.1 On the complete composite Long Rod Insulator String with Hardware Fittings:-

a) Power frequency voltage withstand test with corona control rings/grading ring and arcing horns (if provided) under wet condition as per IEC:60383-1993/

b) Switching surge voltage withstand test under wet condition as per IEC:60383-1993.

c) Impulse voltage withstand test under dry condition as per IEC:60383-1993

d) Corona and RIV test under dry condition.

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 156kV (rms) for 220kV line to ground under dry condition. There shall be no evidence of Corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC 60383.

Under the conditions as specified above the insulator string alongwith complete hardware fittings shall have a radio interference voltage level below 1000 microvolts at 1 MHz when subjected to 50 Hz AC line to ground voltage of 156kV for 220kV under dry conditions. The test procedure shall be in accordance with IEC 60437.

e) Mechanical Strength test

The complete insulator string alongwith its hardware fitting excluding arcing horn, corona control ring, grading ring, tension/suspension clamps shall be subjected to a load equal to 50% of the specified minimum ultimate tensile

strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to dismantle them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

f) Salt-fog pollution withstand test as per IEC: 60507. The salinity level for composite long rod insulators shall be 160 Kg/m3 NACL.

1.5.2.1.2 ***On Composite Insulator Units***

a) Tests on interfaces and connections of metal fittings as per IEC: 61109-2008.

b) Assembled core load time test as per IEC: 61109-2008.

c) Damage limit proof test and test of tightness of interface between end firings and insulator housing as per IEC: 61109-2008

d) High Pressure washing test

The washing of a complete insulator of each E&M rating is to be carried out at 3800 kPa with nozzles of 6 mm diameter at a distance of 3m from nozzles to the insulator, The washing shall be carried out for 10minutes. There shall be no damage to the sheath or metal fitting to housing interface.

e) Brittle fracture resistance test

The test arrangement shall be according to Damage limit proof test with simultaneous application of 1N-HNO3 acid directly in contact with naked FRP rod. The contact length of acid shall not be less than 40mm and thickness around the core not less than 10mm.The rod shall withstand 80% of SML for 96 hours.

f) Dye penetration test as per IEC: 61109-2008

g) Water diffusion test as per IEC: 61109-2008

h) Tracking and erosion test as per IEC: 61109-2008.

i) Hardness test as per IEC: 61109-2008.

j) Accelerated weathering test as per IEC: 61109-2008.

k) Flammability test as per IEC: 61109-2008.

l) Silicone content test

Minimum content of silicone as guaranteed by supplier shall be verified through FT-IR spectroscopy & TGA analysis or any other suitable method mutually agreed between Employer & Supplier in Quality Assurance Programme.

m) Recovery of Hydrophobicity test

1. The surface of selected samples shall be cleaned with isopropyl alcohol. Allow the surface to dry and spray with water. Record the HC classification. Dry the sample surface.

2. Treat the surface with corona discharges to destroy the hydrophobicity. This can be done utilizing a high frequency corona tester, Holding the electrode approximately 3mm from the sample surface, slowly move the electrode over an area approximately 1" x 1". Continue treating this area for 2 – 3 minutes, operating the tester at maximum output.

3. Immediately after the corona treatment, spray the surface with water and record the HC classification. The surface should be hydrophilic, with an HC value of 6 or 7. If not, dry the surface and repeat the corona treatment for a longer time until an HC of 6 or 7 is obtained. Dry the sample surface.

4. Allow the sample to recover and repeat the hydrophobicity measurement at several time intervals. Silicone rubber should recover to HC 1 – HC 2 within 24 to 48 hours, depending on the material and the intensity of the corona treatment.

n) Torsion test

Three complete insulators of each E&M rating shall be subjected to a torsional load of 55Nm. The torsional strength test shall be made with test specimen adequately secured to the testing machine. The torsional load shall be applied to the test specimen through a torque member so constructed that the test specimen is not subjected to any cantilever stress. The insulator after torsion test must pass the Dye Penetration Test as per IEC 61109.

o) Accelerated ageing test of 5000hrs as described in appendix-C of IEC 61109 or Test at multiple stresses of 5000 hrs as described in Annex-B of IEC -62217

1.5.2.2 ***Acceptance Tests:***

1.5.2.2.1 ***For Composite Long Rod Insulators***

a.	Verification of dimensions	IEC : 61109-2008
b.	Galvanizing test	IEC : 60383
c.	Verification of end fittings	IEC : 61109-2008
d.	Recovery of Hydrophobicity	As per above
e.	Verification of tightness of interface between end fittings and insulator housing and of specified mechanical load	IEC : 61109-2008
f.	Silicone content test	As per above
g.	Brittle fracture resistance test	As per above

h.	Dye penetration test	IEC : 61109-2008
i.	Water diffusion test	IEC : 61109-2008

In the event of failure of the sample to satisfy the acceptance test(s) specified in 4.2 above, the retest procedure shall be as per IEC 61109.

1.5.2.3 **Routine Tests**

1.5.2.3.1 **For Composite Long Rod Insulator Units**

a)	Visual Examination	As per IEC:61109-2008
b)	Mechanical routine test	As per IEC:61109 -2008

1.5.3 ***Guaranteed Technical Particulars***

1.5.3.1 ***Electrical system Data***

Sl.	**Parameters**	**Unit**	**System Voltage**	
1.	Nominal Voltage	kV	**220**	**132**
2.	Maximum system voltage	kV	245	145
3.	BIL (Impulse)	kV (Peak)	±1050	±650
4.	Power frequency withstand voltage (Wet)	kV (rms)	460	275
5.	Switching surge withstand voltage (Wet)	kV (rms)	NA	NA
6.	Minimum Corona extinction voltage at 50 Hz AC system under dry condition	kV (rms) phase to earth	156	NA
7.	Radio interference voltage at one MHz for phase to earth voltage of 508 KV under dry condition.	Micro Volts	1000 (Max)	NA
8.	Minimum creepage distance .	mm	6125	3625
9.	Electromechanical strength of Insulator Unit.	kN	120	120

2.0 **AAC / ACSR CONDUCTOR**

2.1 **Details of AAC Conductor**

2.1.1 The contractor shall supply the conductor as per the standard guaranteed technical particulars enclosed in Annexure-B of the technical specification, Chapter 12 – Switchyard Erection and separate approval is not required during detailed engineering.

Owner has also standardised the guaranteed technical particulars for the

conductors which are enclosed in Annexure-E of the technical specification, Chapter 12 – Switchyard Erection. The contractor shall supply the conductor as per the standard guaranteed technical particulars.

2.1.2 The details of the AAC Bull conductor are tabulated below:

Sl. No.	**Description**	**Unit**	**AAC BULL**
a)	Stranding and wire diameter	mm	61/4.25
b)	Number of Strands		
	1st Aluminium Layer	Nos.	1
	2nd Aluminium Layer	Nos.	6
	3rd Aluminium Layer	Nos.	12
	4th Aluminium Layer	Nos.	18
	5th Aluminium Layer	Nos.	24
c)	Total sectional area	Sq.mm	865.36
d)	Overall diameter	mm	38.25
e)	Approximate weight	kg/ km	2400
f)	Calculated d.c. resistance at 20oC	ohm/km	0.0334
g)	Minimum UTS	kN	139

2.1.3 The details of Aluminium strand are as follows:

Sl. No.	**Description**	**Unit**	**AAC BULL**
a)	Minimum breaking load of strand before stranding	KN	2.23
b)	Minimum breaking load of strand after stranding	KN	2.12
c)	Maximum D.C. resistance of strand at 20 deg. Centigrade	Ohm/KM	3.651

2.2 **Details of ACSR Conductor**

2.2.1 The details of the ACSR Moose conductors shall be as per the standard guaranteed technical particulars enclosed in Annexure-A are tabulated below:

ACSR MOOSE CONDUCTOR:

Sl. No.	Description	Unit	ACSR MOOSE
a)	Stranding and wire diameter	mm	54/3.53 (Al)+ 7/3.53 (Steel)
b)	Number of Strands		
	Steel centre	Nos.	1
	1st Steel Layer	Nos.	6
	1st Aluminium Layer	Nos.	12
	2nd Aluminium Layer	Nos.	18

	3rd Aluminium Layer	Nos.	24
c)	Sectional area of Aluminium	Sq. mm	528.5
d)	Total sectional area	Sq. mm	597.00
e)	Overall diameter	mm	31.77
f)	Approximate weight	kg/ km	2004
g)	Calculated d.c. resistance at 20oC	ohm/ km	0.05552
h)	Minimum UTS	kN	161.2

2.2.2 The details of Aluminium strand are as follows:

ACSR MOOSE CONDUCTOR:

Sl. No.	Description	Unit	ACSR MOOSE
a)	Minimum breaking load of strand before stranding	KN	1.57
b)	Minimum breaking load of strand after stranding	KN	1.49
c)	Maximum D.C. resistance of strand at 20 deg. Centigrade	Ohm /KM	2.921

2.2.3 The details of steel strand are as follows:

ACSR MOOSE CONDUCTOR:

Sl. No.	**Description**	**Unit**	**ACSR MOOSE**
a)	Minimum breaking load of strand before stranding	KN	12.86
b)	Minimum breaking load of strand after stranding	KN	12.22
c)	Minimum number of twists to be withstood in torsion test when tested on a gauge length of 100 times diameter of wire	Nos.	18 (Before stranding) 16 (Before stranding

2.3 Workmanship

2.3.1 The finished conductor shall be smooth, compact, uniform and free from all imperfections including kinks (protusion of wires), wire cross over, over riding, looseness (wire being dislocated by finger/hand pressure and/or unusual bangle noise on tapping), material inclusions, white rust, powder formation or black spot (on account of reaction with trapped rain water etc.), dirt, grit etc.

2.3.2 All the Aluminium and steel strands shall be smooth, uniform and free from all

imperfections, such as spills and splits, diemarks, scratches, abrasions, etc., after drawing.

2.3.3 The steel strands shall be hot dip galvanised and shall have a minimum zinc coating of 260 gms/sq.m. after stranding of the uncoated wire surface. The zinc coating shall be smooth, continuous and of uniform thickness, free from imperfections and shall withstand minimum three dips in standard Preece test. The finished strands and the individual wires shall be of uniform quality and have the same properties and characteristics as prescribed in ASTM designation : B 498-74.

2.3.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands in the event of cutting of composite core wire. Care shall be taken to avoid, damages to galvanisation during pre-forming and post-forming operation.

2.4 Joints in Wires

2.4.1 Aluminium Wires

Joints in aluminium wires shall be as per relevant International standard.

2.4.2 Steel Wires

There shall be no joint of any kind in the finished wire entering into the manufacture of the strand. There shall also be no strand joints or strand splices in any length of the completed stranded steel core of the conductor.

2.5 Tolerances

The manufacturing tolerances shall be as per relevant International standard.

A. AAC Bull and AAC Tarantala conductor:

a)	Diameter of Aluminium and Steel Strands						
		AAC BULL			AAC TARANTALA		
		Standard	Maximum	Minimum	Standard	Maximum	Minimum
	Aluminium	4.25 mm	4.29 mm	4.21 mm	5.23	5.28	5.18

b)	Lay ratio of Conductor					
			AAC BULL		AAC TARANTALA	
			Maximum	Minimum	Maximum	Minimum
	Aluminium	6 wire layer	16	10	16	10
		12 wire layer	16	10	16	10
		18 wire layer	16	10	16	10
		24 wire layer	14	10	-	-

B. ACSR Bersimis and ACSR Moose conductor:

a)	Diameter of Aluminium and Steel Strands						
		ACSR BERSIMIS			ACSR MOOSE		
		Standard	Maximum	Minimum	Standard	Maximum	Minimum
	Aluminium	4.57 mm	4.61 mm	4.53 mm	3.53 mm	3.55 mm	3.51 mm
	Steel	2.54 mm	2.57 mm	2.51 mm	3.53 mm	3.60 mm	3.46 mm

b)	Lay ratio of Conductor						
			ACSR BERSIMIS		ACSR MOOSE		
			Maximum	Minimum			
	Steel	6 wire layer	18	13	18	16	
	Aluminium	8/12 wire layer	17	10	14	12	
		14/18 wire layer	16	10	13	11	
		20/24 wire layer	14	10	12	10	

2.6 Materials

2.6.1 Aluminium

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity not less than 99.5% and a copper content not exceeding 0.04%.

2.6.2 Steel

The steel wire strands shall be drawn from high carbon steel wire rods and shall conform to the following chemical composition:

Element	% Composition
Carbon	0.50 to 0.85
Manganese	0.50 to 1.10
Phosphorous	Not more than 0.035
Sulphur	Not more than 0.045
Silicon	0.10 to 0.35

2.6.3 **Zinc**

The zinc used for galvanising shall be electrolytic High Grade Zinc of 99.95% purity.

2.7 **Standard Length**

2.7.1 The conductor shall be supplied as required. No joint shall be allowed within a single span of stringing, jumpers and equipment interconnection.

2.8 Tests :

2.8.1 The following type, acceptance & routine tests and tests during manufacturing shall be carried out on the conductor.

2.8.2 **Type Tests**

In accordance with the stipulation of specification, the following type tests reports of the conductor shall be submitted for approval as per clause 9.2 of Chapter 2 -GTR.

a) UTS test on stranded conductor.

b) Corona extinction voltage test (dry)

(c) Radio Interference voltage test (dry)

(d) DC resistance test on stranded conductor

2.8.3 **Acceptance Tests**

a) Visual check for joints, scratches etc. and lengths of conductor

b) Dimensional check on steel and aluminium strands

c) Check for lay ratios of various layers

d) Galvanising test on steel strands

e) Torsion and Elongation test on steel strands

f) Breaking load test on steel and aluminium strands

g) Wrap test on steel and aluminium strands

h) DC resistance test on aluminium strands

i) UTS test on welded joint of aluminium strands

NOTE:

All the above tests except test mentioned at (a) shall be carried out on aluminium and steel strands after stranding only.

2.8.4 **Routine Tests**

a) Check to ensure that the joints are as per specification.

b) Check that there are no cuts, fins etc. on the strands.

c) All acceptance test as mentioned in Clause 2.7.3 above to be carried out on each coil.

2.8.5 **Tests During Manufacture**

a) Chemical analysis of zinc used for galvanising

b) Chemical analysis of aluminium used for making aluminium strands

c) Chemical analysis of steel used for making steel strands

2.8.6 **Sample Batch for Type Testing**

The Contractor shall offer material for selection of samples for type testing, only after getting quality assurance plans approved from Owner's Quality Assurance Department. The sample shall be manufactured strictly in accordance with the Quality Assurance Plan approved by Owner.

3.0 Galvanised Steel Earth wire

3.1 Details of Earth wire

3.1.1 The contractor shall supply the earthwire as per the standard guaranteed technical particulars enclosed in Annexure-E of the technical specification, Chapter 12 – Switchyard Erection and separate approval is not required during detailed engineering.

Owner has also standardised the guaranteed technical particulars for the earthwire which are enclosed in Annexure-E of the technical specification, Chapter 12 – Switchyard Erection. The contractor shall supply the earthwire as per the standard guaranteed technical particulars.

3.1.2 The basic details of the earth wire are tabulated below:

Sl.No.	Description	Unit	Value
1.	Stranding & Wire diameter	mm	7/3.66 (steel)
2.	Strands a) Steel Core b) Outer layer	 No. No.	 1 (one) 6 (six)
3.	Total sectional area	Sq. mm.	73.65

Other technical details are furnished in of Annexure -E of this Specification.

3.2 Workmanship

3.2.1 All steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions and kinks after drawing and also after stranding.

3.2.2 The finished material shall have minimum brittleness as it will be subjected to

appreciable vibration while in use.

3.2.3 The steel strands shall be hot dip qalvanised (and shall have minimum Zinc coating of 275 gms/sq.m) after stranding of the uncoated wire surface. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections and shall withstand three and a half dips after stranding in standard Preece test. The steel wire rod shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands shall be of uniform quality and have the same properties and characteristics as prescribed in ASTM designation B498-74.

3.2.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands while cutting of composite earth wire. Care shall be taken to avoid damage to galvanisation during preforming and postforming operation.

3.2.5 To avoid susceptibility towards wet storage stains (white rust), the finished material shall be provided with a protective coating of boiled linseed oil.

3.3 Joints in Wires

There shall be no joint of any kind in the finished steel wire strand entering into the manufacture of the earth wire. There shall be no strand joints or strand splices in any length of the completed stranded earth wire.

3.4 Tolerances

The manufacturing tolerance to the extent of the following limits only shall be permitted in the diameter of the individual steel strands and lay length of the earth wire:

	Standard	Maximum	Minimum
Diameter	3.66 mm	3.75 mm	3.57 mm
Lay length	181 mm	198 mm	165 mm

3.5 **Materials**

3.5.1 Steel

The steel wire strands shall be drawn from high carbon steel rods and shall conform to the following requirements as to the chemical composition.

Element	% Composition
Carbon	Not more than 0.55
Manganese	0.4 to 0.9
Phosphorous	Not more than 0.04
Sulphur	Not more than 0.04
Silicon	0.15 to 0.35

3.5.2 Zinc

The zinc used for galvanising shall be electrolytic High Grade Zinc of 99.95% purity. It shall conform to and satisfy all the requirements of IS: 209 -1979/ Equivqlent BS standard.

3.6 Standard Length

3.6.1 The earth wire shall be supplied in standard drum length of manufacturer.

3.8 **TESTS**

3.8.1 The following type, routine & acceptance tests and tests during manufacturing shall be carried out on the earthwire.

3.8.2 **TYPE TESTS**

In accordance with the stipulation of specification, the following type tests reports of the earthwire shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

a) UTS test

b) DC resistance test

3.8.3 **ACCEPTANCE TESTS**

a) Visual check for joints, scratches etc. and length of Earthwire

b) Dimensional check

c) Galvanising test

d) Lay length check

e) Torsion test

f) Elongation test

g) Wrap test

h) DC resistance test

i) Breaking load test

j) Chemical Analysis of steel

3.8.4 **ROUTINE TESTS**

a) Check that there are no cuts, fins etc. on the strands.

b) Check for correctness of stranding.

3.8.5 **TESTS DURING MANUFACTURE**

a) Chemical analysis of zinc used for galvanising

b) Chemical analysis of steel

3.8.6 **SAMPLE BATCH FOR TYPE TESTING**

The Contractor shall offer material for sample selection for type testing, only after getting quality assurance programme approved by the Owner. The samples for type testing shall be manufactured strictly in accordance with the Quality Assurance Programme approved by the Owner.

4.0 TUBULAR BUS CONDUCTORS

4.1 General

The contractor shall supply the aluminium tubes as per the standard guaranteed technical particulars enclosed in Annexure- E of the technical specification, Chapter 12 – Switchyard Erection and separate approval is not required during detailed engineering.

Owner has also stardardised the guaranteed technical particulars for the aluminium tube which are enclosed in Annexure- E of the technical specification, Chapter 12 – Switchyard Erection. The contractor shall supply the aluminium tube as per the standard guaranteed technical particulars.

4.2 Constructional Features

4.2.1 For outside diameter (OD) & thickness of the tube there shall be no minus tolerance, other requirements being as per relevant International standard.

4.2.2 The aluminium tube shall be supplied in suitable cut length to minimize wastage.

4.2.3 The welding of aluminium tube shall be done by the qualified welders duly approved by the owner.

4.3 Tests

In accordance with stipulations of the specification, Routine tests shall be conducted on tubular bus conductors. Also the wall thickness and ovality of the tube shall be measured. In addition to the above tests, 0.2% proof tests on both parent metal and Aluminium tube after welding shall be conducted.

4.4 Technical Parameters

Sl. No.	Description	4” AL. TUBE
1.	Size	4" IPS (EH Type)
2.	Outer diameter	114.2 mm
3.	Thickness	8.51 mm
4.	Cross-sectional area	2825.61 sq.mm
5.	Weight	7.7 kg/m

5.0 EARTHING CONDUCTORS

5.1 General

All conductors buried in earth and concrete shall be of mild steel. All conductors

above ground level and earthing leads shall be of galvanised steel, except for cable trench earthing.

5.2 **Constructional Features**

5.2.1 **Galvanised Steel**

a) The minimum weight of the zinc coating shall be 618 gm/sq. m. and minimum thickness shall be 85 microns.

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

5.3 **Tests**

In accordance with stipulations of the specifications galvanised steel shall be subjected to four one minute dips in copper sulphate solution as per IS : 2633// Equivqlent BS standard.

6.0 **SPACERS**

6.1 **General**

The spacers are to be located at a suitable spacing to limit the short circuit forces as per IEC -60865. Wherever Employer's 220kV & 132kV standard gantry structures are being used, the spacer span(s) for different conductor / span configurations and corresponding short circuit forces shall be as per Annexure-D. For strung buses, flexible type spacers shall be used whereas for jumpers and other connections rigid type spacers shall be used.

Wherever Employer's 220kV & 132kV standard gantry structures are not being used, necessary spacer span calculation shall be provided by the contractor during detailed engineering for the approval of Employer.

6.2 **Constructional Features**

6.2.1 No magnetic material shall be used in the fabrication of spacers except for GI bolts and nuts.

6.2.2 Spacer design shall be made to take care of fixing and removing during installation and maintenance.

6.2.3 The design of the spacers shall be such that the conductor does not come in contact with any sharp edge.

6.3 **Tests**

Each type of spacers shall be subjected to the following type tests, acceptance

tests and routine tests:

6.3.1 Type Tests: Following type test reports shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

a) **Clamp slip tests**

The sample shall be installed on test span of twin conductor bundle string or quadruple conductor bundle string (as applicable) at a tension of 44.2 kN. One of the clamps of the sample when subjected to a longitudinal pull of 2.5 kN parallel to the axis of the conductor shall not slip on the conductor. The permanent displacement between the conductor and the clamp of sample measured after removal of the load shall not exceed 1.0 mm. Similar tests shall be performed on the other clamps of the same sample.

b) Fault current test.

c) Corona Extinction Voltage Test (Dry).

This test shall be performed on 220 kV equipment as per procedure mentioned at Annexure - C, Minimum Corona Extinction voltage shall be 156 kV (rms) line to ground for 220 kV spacers.

d) RIV Test (Dry)

This test shall be performed as per procedure mentioned at Annexure - C, Maximum RIV level at 156 kV (rms) line to ground for 220 kV spacers shall be 1000 micro volts, across 300 ohm resistor at 1 MHz

e) Resilience test (if applicable)

f) Tension Test

g) Log decremant test (if applicable)

h) Compression test

i) Galvanising test

6.3.2 **Acceptance Test**

a) Visual examination

b) Dimensional verification

c) Movement test

d) Clamp slip test

e) Clamp bolt torque test (if applicable)

f) Assembly torque test

g) Compression test

h) Tension test

i) Galvanising test

j) Hardness test for neoprene (if applicable)

The shore hardness of different points on the elastometer surface of cushion grip clamp shall be measured by shore hardness meter. It shall be between 65 to 80.

k) Ultimate Tensile Strength Test

The UTS of the retaining rods shall be measured. It shall not be less than 35 kg/Sq. mm.

6.3.3 **Routine test**

a) Visual examination

b) Dimensional verification

7.0 **BUS POST INSULATORS**

The post insulators shall conform in general to latest IEC-60168, IEC 60273 and IEC-60815.

7.1 **Constructional Features**

7.1.1 Post type insulators shall consist of a porcelain part permanently secured in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand any shocks to which they may be subjected to by the operation of the associated equipment. Only solid core insulators will be acceptable.

7.1.2 Porcelain used shall be homogeneous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

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

7.1.4 The insulator shall have alternate long and short sheds with aerodynamic profile, The shed profile shall also meet the requirements of IEC-60815 for the specified pollution level.

7.1.5 When operating at normal rated voltage there shall be no electric discharge between conductor and insulators which would cause corrosion or injury to conductors or insulators by the formation of substance produced by chemical action.

7.1.6 The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.

7.1.7 All ferrous parts shall be hot dip galvanised. The zinc used for galvanising shall be grade Zn 99.95. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux ash, rust stains, bulky white deposits and blisters. The metal parts shall not produce any noise generating corona under the operating conditions.

7.1.8 a) Every bolt shall be provided with a steel washer under the nut so that part of the threaded portion of the bolts is within the thickness of the parts bolted together.

b) Flat washer shall be circular of a diameter 2.5 times that of bolt and of suitable thickness. Where bolt heads/nuts bear upon the beveled surfaces they shall be provided with square tapered washers of suitable thickness to afford a seating square with the axis of the bolt.

c) All bolts and nuts shall be of steel with well formed hexagonal heads forged from the solid and shall be hot dip galvanised. The nuts shall be good fit on the bolts and two clear threads shall show through the nut when it has been finally tightened up.

7.1.9 Bidder shall make available data on all the essential features of design including the method of assembly of shells and metals parts, number of shells per insulator, the manner in which mechanical stresses are transmitted through shells to adjacent parts, provision for meeting expansion stresses, results of corona and thermal shock tests, recommended working strength and any special design or arrangement employed to increase life under service conditions.

7.2 **Tests**

In accordance with the stipulations of the specification, the post insulators shall be subject to type, acceptance, sample and routine tests as per IEC-60168.

7.2.1 In addition to acceptance/sample/routine tests as per IEC-60168, the following tests shall also be carried out.

a) Ultrasonic test as an acceptance test

b) Soundness test, metallurgical tests and magnetic test on MCI caps and pedestal tests as acceptance test.

c) All hot dip galvanised components shall be subject to check for uniformity of thickness and weight of zinc coating on sample basis.

d) The bending test shall be carried out at 50% minimum failing load in four directions as a routine test and at 100% minimum failing load in four directions as an acceptance test.

e) Acceptance norms for visual defects allowed at site and also at works shall be agreed in the Quality plan.

7.2.2 In accordance with the stipulation of specification, the following type tests reports of the post insulators shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

a) Power frequency withstand test (dry & wet)

b) Lightning impulse test (dry)

c) Measurement of R.I.V (Dry)

d) Corona extinction voltage test (Dry)

.

e) Test for deflection under load

f) Test for mechanical strength.

7.3 **Technical Parameters of Bus Post Insulators.**

Sl. No.	Description	245 kV	145 kV
a)	Type	Solid Core	Solid Core
b)	Voltage Class (kV)	245	145
c)	Dry and wet one minute power frequency withstand voltage(kV rms)	460	275
d)	Dry lightning impulse withstand Voltage (kVp)	± 1050	±650
e)	Wet switching surge withstand voltage (kVp)	—-	—-
f)	Max. radio interference voltage (in microvolts) at voltage of 508 kV (rms) , 305 kV (rms) and 156 (rms) for 765 kV, 400 kV &220 kV respectively between phase to ground.	500	500
g)	Corona extinction voltage (kV rms) (min.)	156	105
h)	***Cantilever Strength***		
(i)	Total minimum cantilever strength (Kg)	800	600
(ii)	***Total minimum breaking strength (Kg)***	***1000***	***720***
i)	Minimum torsional moment	As per IEC-273	As per IEC-273
j)	Total height of insulator (mm)	2300	
k)	P.C.D Top (mm)	127	***127***
	Bottom (mm)	254	***254***
l)	No. of bolts		
	Top	4	***4***
	Bottom	8	***8***
m)	Diameter of bolt/holes (mm)		
	Top	M16	***M16***
	Bottom dia	18	***18***
n)	Pollution level as per IEC-815	Heavy(III)	Heavy(III)
o)	Minimum total creepage distance for Heavy Pollution (mm)	6125	3165

7.3.1 11kV Bus Post Insulators.

a) Type Solid Core

b)	Voltage class (kV)	12
c)	Dry and wet one minute power frequency withstand voltage(kV rms)	28
d)	Dry lightning impulse withstand Voltage (kVp)	±75
e)	Total minimum cantilever strength (Kg)	450
f)	Minimum torsional moment	As per IEC-273
g)	Total height of insulator (mm)	As per requirement
h)	Pollution level as per IEC-815	Heavy(III)
i)	Minimum creepage distance for Heavy Pollution (mm)	300

7.3.2 If corona extinction voltage is to be achieved with the help of corona ring or any other similar device, the same shall be deemed to be included in the scope of the Contractor. Material of Corona ring shall be aluminium/aluminium alloy of 63401W grade or equivalent.

8.0 GROUNDING SYSTEM

8.1 GENERAL

This specification covers the design, supply, delivery, installation and testing of the complete grounding system as described below.
The complete station grounding work shall be in accordance with the recommendation in the "Guide for Safety in Substation Grounding" IEEE No. 80 and the requirements of this section.

8.2 GROUNDING INSTALLATION FEATURES

8.2.1 The installation shall be complete in all respects for efficient and trouble free service. All work shall be carried out in a first class neat workman like manner. Grounding conductors shall be handled carefully to avoid kinking and cutting of the conductors during laying and installation.All exposed ground conductors runs shall be taken in a neat manner, horizontal, vertical and parallel to building walls or columns and shall not be laid haphazardly.

8.2.2 For all connections made to equipment or to the structures, the grounding conductor, connectors and equipment enclosures shall have good clean contact surfaces. Grounding conductor connection to all electrical equipment, switchgear, transformers, motors, panels, conduit system, equipment enclosures, cable trays, distribution boards, equipment frames, bases, steel structure, etc. shall be by pressure type or bolting type connectors.

8.2.3 All lap, cross and tee connections between two grounding conductors shall be

made by thermowelding process or compression type connector. The various joints shall have adequate mechanical strength as well as necessary electrical conductivity not less than that of the parent conductors of the joints. All accessories for grounding installation shall be of quality and design approved by the Employer. The earthing connection between earthing pad of equipment/structures shall be made by two earthing leads.

8.2.4 Ground conductors, when crossing underground trenches, directly laid underground pipe and equipment foundation, if any, shall be at least 300mm below the bottom elevation of such trenches/pipes.

8.2.5 The maximum size of each grid of grounding mat shall not exceed 4X4 meters. The terminals for connecting ground mat and equipment shall be terminated whenever necessary. (The new grounding shall be bonded with existing grounding network.) at Dhalkebar and Hitauda Substations.

8.3 GROUNDING CONDUCTOR

8.3.1 Main Ground Grid

The main ground system shall consist of a grounding grid buried minimum 0.6 meter below grade level. The grounding grid shall consist of copper flat conductor cable or stranded copper wire of minimum size (cross sectional area) 160sq. mm.

8.3.2 Ground Electrodes

The ground electrodes shall be 16mm diameter and 3.0 meter long (min.) copper clad steel. Theseshall be driven into ground and connected to the main ground grid.

8.3.3 Risers

The risers shall consist of copper conductor of adequate size (but not less than 160 sq. mm.) connected at one end to the main ground mat and at the other end to the equipment.

8.4 DESIGN REQUIREMENTS

8.4.1 The Contractor shall measure the soil resistivity in presence of the Employer. Based on the resistivity the contractor shall calculate the total length of buried ground conductor, number of grounding electrode and their depth and spacing to achieve a grounding system resistance of less than 1.0 (One) Ohm.

8.4.2 The Contractor shall calculate the cross-section considering the maximum fault level of 40 kA.

8.4.3 The Contractor shall submit the details of calculations of the grounding system for the Employer's approval. The earthing system shall be of single earthing system for the whole substation i.e. all earthings shall be connected to main earthing grid.

8.5 TESTS

On completion of the installation, either wholly or in sections, it shall be tested in compliance with relevant Code by the Contractor in presence of the Employer. The cost of any test including labor, material and equipment charges shall be borne by the Contractor. If the ground grid resistance can not be obtained as per his design, then additional grounding conductors shall be buried in the earth, or if

necessary, buried in treated soil to obtain the required low ground resistance without any additional cost.

8.6 **LIGHTNING PROTECTION**

The outdoor equipment of the substation and the substation building shall be protected against lightning. The lightning protection shall be achieved by an overhead lightning shield system of galvanized steel wire of 7/3.35 mm, which shall be connected to the main grounding grid by steel conductor of 7/3.35 mm. Lighting mast with electrode length of 2.5mtr (maximum) may be used in sqitchyard area for lighting protection as per requirement. The above electrode may be connected to the main grounding grid by steel conductor of 7/3.35 mm . The design of the lightning protection system shall be subject to the approval of the Employer.

8.7 **DRAWINGS**

After award of the Contract, the Contractor shall furnish the grounding layout drawing with dimensions showing the location of grounding grids, electrodes, test link chambers and risers, backed up by necessary calculations for Employer's approval. The work shall have to be started at site only after getting approval from the Employer. If alteration is required for any work done before getting Employer's approval, the same shall have to be done by the Contractor at no extra cost to the Employer.

STATION GROUNDING SYSTEM

DESCRIPTION	UNIT	REQD
1. Main ground grid conductor material		Copper
2. Main ground grid conductor size	Sq.mm	≥ 160
3. Cross section of riser conductors	Sq mm	≥ 160
4. Ground electrodes		
-Material		Copper clad steel
-Diameter	mm	≥16
-Length	meter	3
5. Material of risers		Copper
6. Earthing system designed for	ohm	≤ 1

9.0 **Main Bus Bars (Applicable for Aluminium tube)**

The brief description of the bus switching scheme, bus bar layout and equipment connection to be adopted are indicated elsewhere in the specification. The bus bar arrangements are shown in drgs enclosed with the bid documents.

9.1 The Contractor shall furnish supporting calculations where applicable for the bus bars/conductors to show adequacy of design parameters for:

a) Fibre-stress

b) Cantilever strength of post insulators

c) Aeolain vibrations

d) Vertical deflection of bus bars

e) Short circuit forces in bundle conductor and spacer location for each span of ACSR conductor stringing as per layout drawings.

9.1.1 The welds in the aluminium tubes shall be kept to the minimum and there shall not be more than one weld per span. The procedure and details of welding shall be subject to Owner's approval. Material for welding sleeve shall be same as that of Aluminium tube. Welding sleeve shall be of 600mm length

9.1.2 Corona bells shall be provided wherever the bus extends beyond the clamps and on free ends, for sealing the ends of the tubular conductor against rain and moisture and to reduce the electrostatic discharge loss at the end points. There shall be a small drain hole in the corona bell. The material of Corona bell shall be Aluminium alloy similar to that of clamps & connectors.

9.1.3 To minimise the vibrations in the aluminium tubes, damping conductor shall be provided inside the aluminium tubes. For this purpose, the cut pieces of ACSR conductor which otherwise are considered wastages, shall be used as damping conductor.

9.1.4 Details of past experience of the persons proposed to be employed for Aluminium tube welding and the test reports of the welded pieces to prove the electrical and mechanical characteristics shall also be furnished along with the bid. Welding at site shall be done by adopting a qualified procedure and employing qualified welders as per ASME-Section IX.

10.0 BAY EQUIPMENT

10.1 The disposition of various bay equipments shall be as per single line diagrams and layout drawings.

10.2 Bay Marshalling Kiosk:-

One no. of bay marshalling kiosk shall be provided for each 220 kV and 132 kV bay under present scope. In addition to the requirements specified elsewhere in the specification, the bay marshalling kiosk shall have two distinct compartments for the following purpose:-

(i) To receive two incoming 400V, 3 phase, 63Amps, AC supply with auto changeover and MCB unit and distribute minimum six outgoing 400V, 3 phase, 16 Amps AC supplies controlled by MCB.

(ii) To distribute minimum ten outgoing 230V, 10 Amps single phase supplies to be controlled by MCB to be drawn from above 3 phase incomers.

(iii) 200 nos. terminal blocks in vertical formation for interlocking facilities for substations without automation system.

(iv) Necessary Terminal Blocks for terminating cables from ACDB and switchyard panel rooms.

11.0 EQUIPMENT ERECTION DETAILS

11.1 For equipment interconnection, the surfaces of equipment terminal pads, Aluminium tube, conductor & terminal clamps and connectors shall be properly cleaned. After cleaning, contact grease shall be applied on the contact surfaces of equipment terminal pad, Aluminium tube/conductor and terminal clamps to avoid any air gap in between. Subsequently bolts of the terminal pad/terminal connectors shall be tightened and the surfaces shall be cleaned properly after equipment interconnection.

11.2 Muslin or leather cloth shall be used for cleaning the inside and outside of hollow insulators.

11.3 All support insulators, circuit breaker interrupters and other fragile equipment shall preferably be handled with cranes having suitable booms and handling capacity.

11.4 Bending of Aluminium tube and compressed air piping if any should be done by a bending machine and through cold bending only. Bending shall be such that inner diameter of pipe is not reduced.

11.5 Cutting of the pipes wherever required shall be such as to avoid flaring of the ends. Hence only a proper pipe cutting tool shall be used. Hack saw shall not be used.

11.6 Handling of equipment shall be done strictly as per manufacturer's/supplier's instructions/instruction manual.

11.7 Handling equipment, sling ropes etc. should be tested periodically before erection for strength.

11.8 The slings shall be of sufficient length to avoid any damage to insulator due to excessive swing, scratching by sling ropes etc.

12.0 STORAGE

12.1 The Contractor shall provide and construct adequate storage shed for proper storage of equipments, where sensitive equipments shall be stored indoors. All equipments during storage shall be protected against damage due to acts of nature or accidents. The storage instructions of the equipment manufacturer/Owner shall be strictly adhered to.

13.0 CABLING MATERIAL

13.1 CABLE TAGS AND MARKERS

13.1.1 Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.

13.1.2 The tag shall be of aluminium with the number punched on it and securely attached to the cable conduit by not less than two turns of 20 SWG GI wire. Cable tags shall be of rectangular shape for power cables and of circular shape for control cables.

13.1.3 Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanised iron plate.

13.1.4 Location of underground cable joints shall be indicated with cable marker with an additional inscription “Cable joints”.

13.1.5 The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road and drain crossings.

13.1.6 Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry and at each end & turning point in cable tray/trench runs. Cable tags shall be provided inside the switchgear, motor control centres, control and relay panels etc., wherever required for cable identification, where a number of cables enter together through a gland plate.

13.2 **Cable Supports and Cable Tray Mounting Arrangements**

13.2.1 The Contractor shall provide embedded steel inserts on concrete floors/walls to secure supports by welding to these inserts or available building steel structures.

13.2.2 The supports shall be fabricated from standard structural steel members.

13.2.3 Insert plates will be provided at an interval of 750 mm wherever cables are to be supported without the use of cable trays, such as in trenches, while at all other places these will be at an interval of 2000 mm.

13.2.4 Vertical run of cables on equipment support structure shall be supported on perforated cable trays of suitable width which shall be suitably bolted/clamped with the equipment support structure.

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13.3 **Cable Termination and Connections**

13.3.1 The termination and connection of cables shall be done strictly in accordance with cable and termination kit manufacturer’s instructions, drawing and/or as directed by the Owner.

13.3.2 The work shall include all clamping, fittings, fixing, plumbing, soldering, drilling, cutting, taping, heat shrinking (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job.

13.3.3 Supply of all consumable material shall be in the scope of Contractor.

13.3.4 The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The Contractor shall be responsible for drilling of gland plates, painting and touching up. Holes shall not be made by gas cutting.

13.3.5 Control cable cores entering control panel/switchgear/MCCB/MCC/ miscellaneous panels shall be neatly bunched, clamped and tied with nylon strap or PVC perforated strap to keep them in position.

13.3.6 The Contractor shall tag/ferrule control cable cores at all terminations, as

instructed by the Owner. In panels where a large number of cables are to be terminated and cable identification may be difficult, each core ferrule may include the complete cable number as well.

13.3.7 Spare cores shall be similarly tagged with cable numbers and coiled up.

13.3.8 All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively closed.

13.3.9 Double compression type nickel plated (coating thickness not less than 10 microns) brass cable glands shall be provided by the Contractor for all power and control cables to provide dust and weather proof terminations.

13.3.10 They shall comprise of heavy duty brass casting, machine finished and nickel plated, to avoid corrosion and oxidation. Rubber components used in cable glands shall be neoprene and of tested quality. Cable glands shall be of approved make.

13.3.11 The cable glands shall also be suitable for dust proof and weather proof termination. The test procedure, if required, has to be discussed and agreed to between Owner and cable gland manufacturer.

13.3.12 If the cable-end box or terminal enclosure provided on the equipment is found unsuitable and requires modification, the same shall be carried out by the Contractor, as directed by the Owner.

13.3.13 Crimping tool used shall be of approved design and make.

13.3.14 Cable lugs shall be tinned copper solderless crimping type conforming to IS-8309 & 8394/ Equivqlent International standard. Bimetallic lugs shall be used depending upon type of cables used.

13.3.15 Solderless crimping of terminals shall be done by using corrosion inhibitory compound. The cable lugs shall suit the type of terminals provided.

13.4 STORAGE AND HANDLING OF CABLE DRUMS

13.4.1 Cable drums shall be unloaded, handled and stored in an approved manner and rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum.

14.0 DIRECTLY BURIED CABLES

14.1 The Contractor shall construct the cable trenches required for directly buried cables. The scope of work shall include excavation, preparation of sand bedding, soil cover, supply and installation of brick or concrete protective covers, back filling and ramming, supply and installation of route markers and joint markers. The Bidder shall ascertain the soil conditions prevailing at site, before submitting the bid.

14.2 The cable (power and control) between LT station, control room, DG set location and fire lighting pump house shall be laid in the buried cable trenches. In addition to the above, for lighting purpose also, buried cable trench can be used

in outdoor area.

14.3 Cable route and joint markers and RCC warning covers shall be provided wherever required. The voltage grade of cables shall be engraved on the marker.

15.0 **INSTALLATION OF CABLES**

15.1 Cabling in the control room shall be done on ladder type cable trays for vertical runs while cabling in switchyard area shall be done on angles in the trench.

15.2 All cables from bay cable trench to equipment's including and all interpole cables (both power and control) for all equipment, shall be laid in PVC pipes of minimum 50 mm nominal outside diameter which shall be buried in the ground at a depth of 250mm below finish formation level. Separate PVC pipes shall be laid for control and power cables. Cable pull boxes of adequate size shall be provided if required.

15.3 Cables shall be generally located adjoining the electrical equipment through the pipe insert embedded in the floor. In the case of equipments located away from cable trench either pipe inserts shall be embedded in the floor connecting the cable trench and the equipment or in case the distance is small, notch/opening on the wall shall be provided. In all these cases necessary bending radius as recommended by the cable manufacturer shall be maintained.

15.4 Cable racks and supports shall be painted after installation with two coats of metal primer (comprising of red oxide and zinc chromate in a synthetic medium) followed by two finishing coats of aluminium paint.

15.5 Suitable arrangement should be used between fixed pipe / cable trays and equipment terminal boxes, where vibration is anticipated.

15.6 Power and control cables in the cable trench shall be laid in separate tiers. The order of laying of various cables shall be as follows, for cables other than directly buried.

a) Power cables on top tiers.

b) Control instrumentation and other service cables in bottom tiers.

15.7 Single core cables in trefoil formation shall be laid with a distance of three times the diameter of cable between trefoil centre lines. All power cables shall be laid with a minimum centre to centre distance equal to twice the diameter of the cable of higher size of cables.

15.8 Trefoil clamps for single core cables shall be of pressure die cast aluminium (LM-6), Nylon -6 or fibre glass and shall include necessary fixing GI nuts, bolts, washer etc. These are required at every 2 metre of cable runs.

15.9 Power and control cables shall be securely fixed to the trays/supports with self locking type nylon ties with deinterlocking facility at every 5 metre interval for horizontal run. Vertical and inclined cable runs shall be secured with 25 mm wide and 2 mm thick aluminium strip clamps at every 2m.

15.10 Cables shall not be bent below the minimum permissible limit. The permissible limits are as follows:

Table of Cable and	Minimum bending radius
Power cable	12 D
Control cable	10 D

D is overall diameter of cable

15.11 Where cables cross roads, drains and rail tracks, these shall be laid in reinforced spun concrete or steel pipes buried at not less than one metre depth.

15.12 In each cable run some extra length shall be kept at a suitable point to enable one (for LT cables)/two (for H.T. cables) straight through joints to be made in case the cable develop fault at a later date.

15.13 Selection of cable drums for each run shall be so planned as to avoid using straight through joints. Cable splices will not be permitted except where called for by the drawings, unavoidable or where permitted by the Owner. If straight through joints are unavoidable, the Contractor shall use the straight through joints kit of reputed make.

15.14 Control cable terminations inside equipment enclosures shall have sufficient lengths so that changing of termination in terminal blocks can be done without requiring any splicing.

15.15 Metal screen and armour of the cable shall be bonded to the earthing system of the station, wherever required by the Owner.

15.16 Rollers shall be used at intervals of about two metres while pulling cables.

15.17 All due care shall be taken during unreeling, laying and termination of cable to avoid damage due to twist, kinks, sharp bends, etc.

15.18 Cable ends shall be kept sealed to prevent damage. In cable vault, fire resistant seal shall be provided underneath the panels.

15.19 Inspection on receipt, unloading and handling of cables shall generally be in accordance with relevant international standard.

15.20 Wherever cable pass through floor or through wall openings or other partitions, GI/PVC wall sleeves with bushes having a smooth curved internal surface so as not to damage the cable, shall be supplied, installed and properly sealed by the Contractor at no extra charges.

15.21 Contractor shall remove the RCC/Steel trench covers before taking up the work and shall replace all the trench covers after the erection-work in that particular area is completed or when further work is not likely to be taken up for some time.

15.22 Contractor shall furnish three copies of the report on work carried out in a particular week, indicating cable numbers, date on which laid, actual length and route, testing carried out, terminations carried out, along with the marked up copy of the cable schedule and interconnection drawing wherever any modifications are made.

15.23 Contractor shall paint the tray identification number on each run of trays at an interval of 10 m.

15.24 In case the outer sheath of a cable is damaged during handling/installation, the Contractor shall repair it at his own cost to the satisfaction of the Owner. In case any other part of a cable is damaged, the same shall be replaced by a healthy cable at no extra cost to the Owner, i.e. the Contractor shall not be paid for installation and removal of the damaged cable.

15.25 All cable terminations shall be appropriately tightened to ensure secure and reliable connections. The Contractor shall cover the exposed part of all cable lugs whether supplied by him or not with insulating tape, sleeve or paint.

15.26 **Cable trays**

i) The cable trays shall be of G.S.sheet and minimum thickness of sheet shall be 2mm.

ii) The Contractor shall perform all tests and inspection to ensure that material and workmanship are according to the relevant standards.

A 2.5 metre straight section of 300mm, 600mm wide cable tray shall be simply supported at two ends. A uniform distributed load of 76 kg/m shall be applied along the length of the tray. The maximum deflection at the mid-span shall not exceed 7mm.

15.27 **Conduits, Pipes and Duct Installation**

15.27.1 Contractor shall supply and install all rigid conduits, mild steel pipes,flexible conduits, hume pipes etc. including all necessary sundry materials such as tees, elbows, check nuts, bushing, reducers, enlargers, coupling cap, nipples, gland sealing fittings, pull boxes etc as specified and to be shown in detailed drawing. The size of the conduit/pipe shall be selected on the basis of 40% fill criterion.

15.27.2 Contractor shall have his own facility for bending, cutting and threading the conduits at site. Cold bending should be used. All cuts & threaded ends shall be made smooth without leaving any sharp edges. Anticorrosive paint shall be applied at all field threaded portions.

15.27.3 All conduit/pipes shall be extended on both sides of wall/floor openings. The fabrication and installation of supports and the clamping shall be included in the scope of work by Contractor.

15.27.4 When two lengths of conduits are joined together through a coupling, running threads equal to twice the length of coupling shall be provided on each conduit to facilitate easy dismantling of two conduits.

15.27.5 Conduit installation shall be permanently connected to earth by means of special approved type of earthing clamps. GI pull wire of adequate size shall be laid in all conduits before installation.

15.27.6 Each conduit run shall be painted with its designation as indicated on the drawings such that it can be identified at each end.

15.27.7 Embedded conduits shall have a minimum concrete cover of 50 mm.

15.27.8 Conduit run sleeves shall be provided with the bushings at each end.

15.27.9 Metallic conduit runs at termination shall have two locknuts and a bushing for connection. Flexible conduits shall also be suitably clamped at each end with the help of bushings. Bushings shall have rounded edges so as not to damage the cables.

15.27.10 Where embedded conduits turn upwards from a slab or fill, the termination dimensions shown on the drawings, if any, shall be taken to represent the position of the straight extension of the conduit external to and immediately following the bend. At least one half of the arc length of the bend shall be embedded.

15.27.11 All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed in an approved manner to prevent damage to threaded portions and entrance of moisture and foreign material.

15.27.12 For underground runs, Contractor shall excavate and back fill as necessary.

15.27.13 Contractor shall supply, unload, store and install conduits required for the lighting installation as specified. All accessories/fittings required for making the installation complete, including but not limited to pull out boxes, ordinary and inspection tees and elbow, checknuts, male and female bushings (brass or galvanised steel), caps, square headed male plugs, nipples, gland sealing fittings ,pull boxes, conduits terminal boxes, gaskets and box covers, saddle terminal boxes, and all steel supporting work shall be supplied by the Contractor. The conduit fittings shall be of the same material as conduits.

15.27.14 All unarmoured cables shall run within the conduits from lighting panels to lighting fixtures, receptacles etc.

15.27.15 Size of conduit for lighting shall be selected by the Contractor during detailed engineering.

15.27.16 Exposed conduits shall be run in straight lines parallel to building columns, beams and walls. Unnecessary bends and crossings shall be avoided to present a neat appearance.

15.27.17 Conduit supports shall be provided at an interval of 750mm for horizontal runs and 1000mm for vertical runs.

15.27.18 Conduit supports shall be clamped on the approved type spacer plates or brackets by saddles or U- bolts. The spacer plates or brackets in turn, shall be securely fixed to the building steel by welding and to concrete or brick work by grouting or by nylon rawl plugs. Wooden plug inserted in the masonary or concrete for conduit support is not acceptable.

15.27.19 Embedded conduits shall be securely fixed in position to preclude any movement. In fixing embedded conduit, if welding or brazing is used, extreme care should be taken to avoid any injury to the inner surface of the conduit.

15.27.20 Spacing of embedded conduits shall be such as to permit flow of concrete between them.

15.27.21 Where conduits are placed alongwith cable trays, they shall be clamped to supporting steel at an interval of 600mm.

15.27.22 For directly embedding in soil, the conduits shall be coated with an asphalt-base compound. Concrete pier or anchor shall be provided wherever necessary to support the conduit rigidly and to hold it in place.

15.27.23 Conduit shall be installed in such a way as to ensure against trouble from trapped condensation.

15.27.24 Conduits shall be kept, wherever possible, at least 300mm away from hot pipes, heating devices etc. when it is evident that such proximity may reduce the service life of cables.

15.27.25 Slip joints shall be provided when conduits cross structural expansion joints or where long run of exposed conduits are installed, so that temperature change will cause no distortion due to expansion or contraction of conduit run.

15.27.26 For long conduit run, pull boxes shall be provided at suitable intervals to facilitate wiring.

15.27.27 Conduit shall be securely fastened to junction boxes or cabinets, each with a lock nut inside and outside the box.

15.27.28 Conduits joints and connections shall be made thoroughly water-tight and rust proof by application of a thread compound which insulates the joints. White lead is suitable for application on embedded conduit and red lead for exposed conduit.

15.27.29 Field bends shall have a minimum radius of four (4) times the conduit diameter. All bends shall be free of kinks, indentations of flattened surfaces. Heat shall not be applied in making any conduit bend. Separate bends may be used for this purpose.

15.27.30 The entire metallic conduit system, whether embedded or exposed, shall be electrically continuous and thoroughly grounded. Where slip joints are used, suitable bounding shall be provided around the joint to ensure a continuous ground circuit.

15.27.31 After installation, the conduits shall be thoroughly cleaned by compressed air before pulling in the wire.

15.27.32 Lighting fixtures shall not be suspended directly from the junction box in the main conduit run.

16.0 JUNCTION BOX

a) The Contractor shall supply and install junction boxes complete with terminals as required. The brackets, bolts, nuts, screws etc required for erection are also included in the scope of the Contractor.

b) Junction boxes having volume less than 1600 cubic centimeters may be installed without any support other than that resulting from connecting conduits where two or more rigid metallic conduits enter and accurately position the box. Boxes shall be installed so that they are level, plumb and properly aligned to present a pleasing appearance.

c) Boxes with volumes equal to or greater than 1600 cubic cm, and smaller boxes terminating on less than two rigid metallic conduits or for other reasons not rigidly held, shall be adequately supported by auxiliary steel of standard steel shapes or plates to be fabricated and installed. The Contractor shall perform all drilling, cutting, welding, shimming and bolting required for attachment of supports.

17.0 TESTING AND COMMISSIONING

17.1 An indicative list of tests for testing and commissioning is given below. Contractor shall perform any additional test based on specialities of the items as per the field Q.P./instructions of the equipment Contractor or Owner without any extra cost to the Owner. The Contractor shall arrange all equipments instruments and auxiliaries required for testing and commissioning of equipments alongwith calibration certificates and shall furnish the list of instruments to the Owner for approval.

17.2 GENERAL CHECKS

(a) Check for physical damage.

(b) Visual examination of zinc coating/plating.

(c) Check from name plate that all items are as per order/specification.

(d) Check tightness of all bolts, clamps and connecting terminals using torque wrenches.

(e) For oil filled equipment, check for oil leakage, if any. Also check oil level and top up wherever necessary.

(f) Check ground connections for quality of weld and application of zinc rich paint over weld joint of galvanised surfaces.

(g) Check cleanliness of insulator and bushings.

(h) All checks and tests specified by the manufacturers in their drawings and manuals as well as all tests specified in the relevant code of erection.

(i) Check for surface finish of grading rings (Corona control ring).

(j) Pressure test on all pneumatic lines at 18.5 times the rated pressure shall be conducted.

17.3 **STATION EARTHING**

a) Check soil resistivity

b) Check continuity of grid wires

c) Check earth resistance of the entire grid as well as various sections of the same.

d) Check for weld joint and application of zinc rich paint on galvanised surfaces.

e) Dip test on earth conductor prior to use.

17.4 **AAC/ ACSR STRINGING WORK, TUBULAR BUS WORK AND POWER CONNECTORS**

a) Physical check for finish

b) Electrical clearance check

c) Testing of torque by torque wrenches on all bus bar power connectors and other accessories.

d) Millivolt drop test on all power connectors.

e) Sag and tension check on conductors.

17.5 **ALUMINIUM TUBE WELDING**

a) Physical check

b) Millivolt drop test on all joints.

c) Dye penetration test & Radiography test on 10% sample basis on weld joints.

c) Test check on 5% sample joints after cutting the weld piece to observe any voids etc.

17.6 INSULATOR

Visual examination for finish, damage, creepage distance etc.

17.7 All pre/commissioning activities and works work for substation equipment shall be carried out in accordance with owner's "Pre- Commissioning procedures and formats for substation bay equipments" by the contractor. This document shall be provided to the successful contractor during detailed engineering stage.

ANNEXURE – A

A. SHORT CIRCUIT FORCES AND SPACER SPAN FOR 220 kV GANTRY STRUCTURE

Sl. No.	Max. Span	Conductor Configuration	Ph-Ph Spacing	Normal Tension	SCF per Phase	Spacer span
I.	**For Fault Level of 40 kA for 1 sec.**					
1.	54 mtr	QUAD ACSR	4.5 mtr	4 T	5.00 T	2.5 mtr
2.	54 mtr	TWIN ACSR	4.5 mtr	2 T	3.50 T	2.5 mtr
3.	74 mtr	TWIN ACSR	4.5 mtr	4 T	5.00 T	2.5 mtr
4.	54 mtr	QUAD ACSR	4.0 mtr	4 T	5.70 T	2.5 mtr
5.	54 mtr	TWIN ACSR	4.0 mtr	2 T	3.50 T	2.5 mtr
6.	74 mtr	TWIN ACSR	4.0 mtr	4 T	5.70 T	2.5 mtr
7.	48 mtr	QUAD ACSR	4.0 mtr	4 T	5.30 T	2.5 mtr
8.	52 mtr	QUAD ACSR	4.0 mtr	4 T	5.35 T	2.5 mtr
9.	68 mtr	TWIN ACSR	4.0 mtr	4 T	5.20 T	2.5 mtr
10.	56 mtr	QUAD ACSR	4.0 mtr	4 T	5.50 T	2.5 mtr
11.	72 mtr	TWIN ACSR	4.0 mtr	4 T	5.27 T	2.5 mtr

NOTE: ACSR conductor as mentioned above indicates that it is suitable for ACSR MOOSE conductor.

B. SHORT CIRCUIT FORCES AND SPACER SPAN FOR 132 kV GANTRY STRUCTURE

Sl. No.	Max. Span	Conductor Configuration	Ph-Ph Spacing	Normal Tension	SCF per Phase	Spacer span
I.	**For Fault Level of 31.5kA for 1 sec.**					
1.	36 mtr	Twin Moose/ Zebra ACSR	3 mtr	1 T	2.15 T	2.5 mtr
2.	31.5 mtr	Twin Moose/ Zebra ACSR	2.7mtr	1 T	2.15 T	2.5 mtr
3.	48 mtr	Single Moose/ Zebra ACSR	3 mtr	1 T	2.05 T	NA
4.	42 mtr	Single Moose/ Zebra ACSR	2.7 mtr	1 T	2.03 T	NA

ANNEXURE-B

STANDARD TECHNICAL DATA SHEETS FOR AAC/ACSR CONDUCTORS, GS EARTHWIRE AND ALUMINIUM TUBE

1.0 GENERAL

Owner has stardardised the guaranteed technical particulars for the following AAC/ACSR conductors, Galvanised steel earthwire and aluminum tube. The contractor shall supply the conductors as per the standard GTP mentioned below. Any deviation to the following GTP shall be clearly brought out by the bidder in their bid.

1.1 Guaranteed Technical Particulars (GTP) for conductors:

A. GTP of ACSR MOOSE conductor:

Sl.	Description	Unit	ACSR MOOSE
1.0	**Applicable Standard**	IEC-61089	
2.0	**Raw Materials**		
2.1	Aluminium		
a)	Minimum purity of Aluminium	%	99.50
b)	Maximum copper content	%	0.04
2.2	Steel wires/ rods		
a)	Carbon	%	0.50 to 0.85
b)	Manganese	%	0.50 to 1.10
c)	Phosphorous	%	Not more than 0.035
d)	Sulphur	%	Not more than 0.045
e)	Silicon	%	0.10 to 0.35 (Max.)
2.3	Zinc		
a)	Minimum purity of Zinc	%	99.95
3.0	**Aluminium strands after stranding**		
3.1	Diameter		
a)	Nominal	mm	3.53
b)	Maximum	mm	3.55
c)	Minimum	mm	3.51
3.2	Minimum Breaking load of strand		
a)	Before stranding	KN	1.57
b)	After stranding	KN	1.49
c)	*Maximum D.C. resistance of strand at 20 deg. Centigrade*	*Ohm/ KM*	*2.921*
3.3	Maximum resistance of 1 m length of strand at 20 deg. C	Ohm	0.002921
4.0	**Steel strand after stranding**		

ANNEXURE-B

Sl.	Description	Unit	ACSR MOOSE
1.0	**Applicable Standard**	IEC-61089	
2.0	**Raw Materials**		
2.1	Aluminium		
4.1	Diameter		
a)	Nominal	mm	3.53
b)	Maximum	mm	3.60
c)	Minimum	mm	3.46
4.2	Minimum Breaking load of strand		
a)	Before stranding	KN	12.86
b)	After stranding	KN	12.22
4.3	Galvanising		
a)	Minimum weight of zinc coating per sq.m.	gm	260
b)	Minimum number of dips that the galvanised strand can withstand in the standard preece test	Nos.	2 dips of one minute & 1 dip of half minute
c)	Min. No. of twists in guage length equal 100 times the dia. of wire which the strand can withstand in the torsion test (after stranding)	Nos	16 (After stranding) 18 (Before stranding)
5.0	ACSR Conductor		
5.1.a)	Stranding		Al -54/3.53 mm+ Steel-7/3.53 mm
b)	Number of Strands		
i.	Steel centre	Nos.	1
ii.	1st Steel Layer	Nos.	6
iii.	1st Aluminium Layer	Nos.	12
iv.	2nd Aluminium Layer	Nos.	18
v.	3rd Aluminium Layer	Nos.	24
5.2	Sectional Area of aluminium	Sq. mm	528.50
5.3	Total sectional area	Sq. mm	597.00
5.4	Approximate Weight	Kg/m	2.004
5.5	Diameter of the conductor	mm	31.77
5.6	UTS of the conductor	kN	161.20 (Min.)
5.7	Lay ratio of the conductor	mm	Max Min
a)	Outer Steel layer	mm	18 16
b)	8/12 wire Aluminium layer	mm	14 12
c)	14/ 18 wire Aluminium layer	mm	13 11

ANNEXURE-B

Sl.	Description	Unit	ACSR MOOSE
1.0	**Applicable Standard**	IEC-61089	
2.0	**Raw Materials**		
2.1	Aluminium		
d)	20/24 wire Aluminium layer	mm	12 10
5.8	DC resistance of the conductor at 20°C	ohm/ km	0.05552
5.9	Standard length of the conductor	m	1800
5.10	Tolerance on Standard length	%	(+/-) 5
5.11	Direction of lay of outer layer	-	Right Hand
5.12	Linear mass of the conductor		
a)	Standard	kg/ km	2004
b)	Minimum	kg/ km	1965
c)	Maximum	kg/ km	2045
5.13	Modulus of Elasticity (Final State)	Kg/sq.mm	6860
5.14	Co-efficient of Linear Expansion	Per Deg. C	$19.3x10^{-6}$
5.15	Minimum Corona Extinction Voltage	KV (rms)	320
5.16	RIV at 1 Mhz under dry condition	Micro volts	Max. 1000 at 320 kV (rms)
6.0	**Drum Dimensions**		
a)	Flange Diameter	mm	1800
b)	Traverse width	mm	950
c)	Barrel Diameter	mm	650
d)	Flange thickness	mm	50x50

1.2 Guaranteed technical particulars of Galvanised Steel Earthwire

	Description	Unit	Standard Values
1.0	**Raw Materials**		
1.1	**Steel wires / rods**		
a)	Carbon	%	Not more than 0.55
b)	Manganese	%	0.40 to 0.90
c)	Phosphorous	%	Not more than 0.04
d)	Sulphur	%	Not more than 0.04
e)	Silicon	%	0.15 to 0.35
1.2	**Zinc**		
a)	Minimum purity of Zinc	%	99.95

ANNEXURE-B

2.0	**Steel strands**		
2.1	**Diameter**		
a)	Nominal	mm	3.66
b)	Maximum	mm	3.74
c)	Minimum	mm	3.58
2.2.	**Minimum breaking load of strand**		
a)	After stranding	KN	10.58
2.3	**Galvanising**		
a)	Minimum weight of zinc coating per sq.m. after stranding	gms.	275
b)	Minimum number of dips that the galvanized strand can withstand in the standard preece test	Nos.	3 dips of 1 minute and one dip of ½ minute
c)	Minimum number of twists in a gauge length equal to 100 times diameter of wire which the strand can withstand in the torsion test, after stranding	Nos.	18
3.0	**Stranded Earth wire**		
3.1	**UTS of Earth wire**	KN	68.4 (min.)
3.2	**Lay length of outer steel layer**		
a)	Standard	mm	181
b)	Maximum	mm	198
c)	Minimum	mm	165
3.3	**Maximum DC resistance of earth wire at 20^0 C**	Ohm/km	3.375
3.4	**Standard length of earth wire**	M	2000 or actual quantity whichever is less.
3.5	**Tolerance on standard length**	%	±5
3.6	**Direction of lay for outside layer**		Right hand
3.7	**Linear mass**		
a)	Standard	Kg/km	583
b)	Maximum	Kg/km	552
c)	Minimum	Kg/km	600
3.8	**Overall diameter**	mm	10.98

1.3 Guaranteed Technical Parameters of Aluminum Tube

A. <u>GTP for 3" IPS & 4" IPS AL. TUBE</u>

Sl. No.	Description	3" AL. TUBE	4" AL. TUBE

ANNEXURE-B

1.	Size	3" IPS (EH Type)	4" IPS (EH Type)
2.	Material	Aluminium Alloy 6101 T6 confirms to 63401 WP (range 2) of IS 5082 : 1998/Equivqlent BS standard	
3.	Chemical Composition		
i)	Cu	0.05 Max	
ii)	Mg	0.4 to 0.9	
iii)	Si	0.3 to 0.7	
iv)	Fe	0.5 Max	
v)	Mn	0.03 Max	
Vi)	Al	Remainder	
4.	Outer diameter	88.90 mm	114.2 mm
5.	Tolerance on outer diameter	*+2.2 mm, - 0.0 mm*	*+2.2 mm, - 0.0 mm*
6.	Thickness	7.62 mm	8.51 mm
7.	Tolerance on thickness	*+2.2 mm, - 0.0 mm*	*+2.2 mm, - 0.0 mm*
8.	Cross-sectional area	1945.76 sq.mm	2825.61 sq.mm
9.	Weight	5.25 kg/m	7.7 kg/m
10.	Moment of Inertia	*1621589.99 mm^4*	*3972577.97 mm^4*
11.	Section Modulus	*36481.21 mm^3*	*69572.29 mm^3*
12.	Minimum Ultimate Tensile Strength	20.5 Kg/sq.mm	
13.	Temperature co-efficient of resistance	0.00364 per Deg.C	
14.	Minimum Electrical Conductivity at 20 deg.C	55% of IACS	
15.	Linear Temperature Co-efficient of Expansion (20 Deg.C -200 Deg.C)	0.000023	
16.	Modulus of Elasticity	6700 Kg/sq.mm	
17.	Minimum Elongation on 50 mm	10%	
18.	Thermal Conductivity at 100 Deg.C	0.43 Calories/sec/sq.mm/cm/deg.C	
19.	Minimum 0.2% proof stress	17.34 Kg/sq.mm	
20	Minimum Yield point	17.50 Kg/sq.mm	17.50 Kg/sq.mm
21	Minimum Breaking Strength	20.42 Kg/sq.mm	20.42 Kg/sq.mm

ANNEXURE-C

CORONA AND RADIO INTERFERENCE VOLTAGE (RIV) TEST

1. General

Unless otherwise stipulated, all 220kV & 132kV equipment together with its associated connectors, where applicable, shall be tested for external corona both by observing the voltage level for the extinction of visible corona under falling power frequency voltage and by measurement of radio interference voltage (RIV).

2. Test Levels:

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

3. Test Methods for RIV:

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

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

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

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

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

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

4. Test Methods for Visible Corona

The purpose of this test is to determine the corona extinction voltage of apparatus, connectors etc. The test shall be carried out in the same manner as RIV test described above with the exception that RIV measurements are not required during test and a search technique shall be used near the onset and extinction voltage, when the test voltage is raised and lowered to determine their precise values.The test voltage shall be raised to 110% of RIV test voltage and maintained there for five minutes. In case corona inception does not take place at 110%, test shall be stopped, otherwise test shall be continued and the voltage will then be decreased slowly until all visible corona disappears. The procedure shall be repeated at least 4 times with corona inception and extinction voltage

recorded each time. The corona extinction voltage for purposes of determining compliance with the specification shall be the lowest of the four values at which visible corona (negative or positive polarity) disappears. Photographs with laboratory in complete darkeness shall be taken under test conditions, at all voltage steps i.e. 85%, 100%, and 110%. Additional photographs shall be taken at corona inception and extinction voltages. At least two views shall be photographed in each case using Panchromatic film with an ASA daylight rating of 400 with an exposure of two minutes at a lens aperture of f/5.6 or equivalent. The photographic process shall be such that prints are available for inspection and comparison with conditions as determined from direct observation. Photographs shall be taken from above and below the level of connector so as to show corona on bushing, insulators and all parts of energised connectors. The photographs shall be framed such that test object essentially, fills the frame with no cut-off.

In case corona inception does not take place at 110%, voltage shall not be increased further and corona extinction voltage shall be considered adequate.

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

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

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

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

5. Test Records:

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

a) Background noise before and after test.

b) Detailed procedure of application of test voltage.

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

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

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

f) Onset and extinction of visual corona for each of the four tests required

shall be recorded

STRUCTURE

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1.0 GENERAL

The scope of specification covers design, fabrication, trial assembly, supply and erection of galvanized steel structures for towers, girders, lightning masts and equipment support structures. Structures shall be lattice or Pipe type structure fabricated from structural steel conforming to relevant British standard Codes (BS Codes)/ equivalent International Standards.

Line diagrams of Towers, girders, Lightning mast, equipment support structures for 220kV structures enclosed with the tender document are for information only. However, The line diagram of all structures of 220 kV, 132kV and 33 kV for new switch yards shall be prepared by the contractor based on their design during detailed engineering stage. The fabrication drawing/line diagram of structures for extension of existing switch yards shall be furnished by NEA/Consultant to the successful bidder progressively during detailed engineering stage. The bidder shall mention in their bid for the type of proposed structure i.e. Pipe or lattice type structure. The fabrication drawings, proto corrected drawings along with Bill of Material (BOM) for all the structures (Both Gantry and Equipment support structures) shall be prepared by the contractor during detailed engineering for submission to NEA/Consultant for their approval. Support structure for circuit breaker shall also be designed by the Manufacturer/Contractor.

It is the intent of the NEA/Consultant to provide structures which allow interchangeability of equipments at a later stage. Accordingly, Contractor is expected to design the equipment support structures with the provision of stool. Stools shall be provided by the Contractor between the equipment and its support structure to match the bus bar height. The top of stool shall be connected to the equipment and the bottom of the stool shall be connected to the Base support structure.

The scope shall include supply and erection of all types of structures including bolts, nuts, washers, step bolts, inserts in concrete, gusset plates, equipment mounting bolts, structure earthing bolts, foundation bolts, spring washers, fixing plates, ground mounted marshalling boxes (AC/DC Marshalling box & equipment control cabinets), structure mounted marshalling boxes and any other items as required to complete the job.

The connection of all structures to their foundations shall be with base plates and embedded anchor/foundation bolts. All steel structures and anchor/foundation bolts, fasteners (Nuts,bolts,washers) shall be fully galvanized as per relevant British standard Codes (BS Codes) / equivalent International Standards. The weight of the zinc coating shall be at least 610 grammes /sq. m for anchor bolts/foundation bolts and for structural members. One additional nut shall be provided below the base plate which may be used for the purpose of leveling.

Contractor shall provide suitable arrangement on the equipment support structures wherever required to suit fixation of accessories such as marshalling boxes, MOM boxes, Control Cabinets, Junction box, surge counter, etc. in the equipment structure fabrication drawings.

2.0 DESIGN REQUIREMENTS FOR STRUCTURES

2.1 For design of steel structures loads such as dead loads, live loads, wind loads etc. shall be based on relevant British standard Codes (BS Codes) / equivalent International Standards.

2.2 For materials and permissible stresses, relevant British standard Codes (BS Codes) / equivalent International Standards. Shall be followed in general. However, additional requirements given in following paragraphs shall be also considered.

2.3 Minimum thickness of galvanized lattice structure member shall be as follows:

Members	Min Thickness (mm)
Leg members, Ground wire	5
Peak members\/Main members	5
Other members	4
Redundant members	4

2.4 Maximum slenderness ratios for leg members, other stressed members and redundant members for compression force shall be as per relevant British standard Codes (BS Codes) / equivalent International Standards.

2.5 Minimum distance from hole center to edge shall be 1.5 x bolt diameter. Minimum distance between center to center of holes shall be 2.5 x bolt diameter.

2.6 All bolts shall be M16 or higher as per design requirement.

2.7 **Step Bolts**

In order to facilitate inspection and maintenance, the tower structures shall be provided with climbing devices. Each tower shall be provided with M16 step bolts 175mm long spaced not more than 450mm apart, staggered on faces on diagonally opposite legs extending from about 0.5 meters above plinth level to the top of the tower. The step bolt shall conform to relevant British standard Codes (BS Codes) / equivalent International Standards. Ladders along with safety guard shall be provided for the Lightning Mast Tower.

2.8 **Design Criteria**

a) All gantry structures shall be designed for the worst combination of dead loads, live loads, wind loads and Seismic forces as per relevant British standard Codes (BS Codes) / equivalent International Standards. (latest), loads due to deviation of conductor, load due to unbalanced tension in conductor, torsional load due to unbalanced vertical and horizontal forces, erection loads, short circuit forces including "snatch" in the case of bundled conductors etc. Short circuit forces shall be calculated considering a fault level of 40.0 kA for 220kV, 31.5KA for 132kV and 25KA for 33kV or as applicable. Relevant British standard Codes (BS Codes) / equivalent International Standards. May be followed for evaluation of short circuit forces.

b) Switchyard gantry structures shall be designed for the two conditions i.e. normal condition and short circuit condition. In both conditions the design of all structures shall be based on the assumption that stringing is done only on one side i.e. all the three (phase) conductors broken on the other side.

Factor of safety of 2.0 under normal conditions and 1.5 under short circuit condition shall be considered on all external loads for the design of switchyard structures.

c) Vertical load of half the span of conductors/string and the earth wires on either side of the beam shall be taken into account for the purpose of design. Weight of man with tools shall be considered as 150 kgs. for the design of structures.

d) Terminal/line take off gantries shall be designed for a minimum conductor tension of 2 metric tonnes per phase for 220 kv, 1 Metric tonne per phase for 132 kV and 0.50 Metric Tonne for 33 kV or as per requirements whichever is higher. The distance between terminal gantry and dead end tower shall be taken as 200 meters for 220kV, 150m for 132kV and 80 m for 33 kV switch yard. The design of these terminal gantries shall also be checked considering +/- 30 deg deviation of conductor in both vertical and horizontal planes. For other gantries the structural layout requirements shall be adopted in design.

e) The girders / beams shall be connected with lattice/Tower columns by bolted joints.

f). All equipment support structures shall be designed for the worst combination of dead loads, erection load. Wind load/seismic forces, short circuit forces and operating forces acting on the equipment and associated bus bars as per relevant British standard Codes (BS Codes) / equivalent International Standards.

g) If luminaries are proposed to be fixed on gantries/towers, then the proper loading for the same shall be considered while designing. Also holes for fixing the brackets for luminaries should be provided wherever required.

h) Foundation bolts shall be designed for the loads for which the structures are designed.

i) The height of Lightning Mast shall be as per approved structural layout and designed for diagonal wind condition. . The lightning mast shall be provided with platform for mounting of lighting fixtures and a structural steel ladder within its base up to the level of platform. The ladder shall be provided with protection rings The platforms shall also have protection railing. The details of lighting fixtures would be as per approved drawings of electrical fixtures.

3.0 DESIGN, DRAWINGS, BILL OF MATETRIALS AND DOCUMENTS

3.1 The Contractor shall submit design and line diagram of each structure for approval of NEA/Consultant. Fabrication drawing based on approved line diagram shall be prepared by the contractor for approval of NEA/Consultant. The BOM (Bill Of Material) shall be prepared by the contractor based on approved fabrication drawing. The Line diagram should indicate not only profile, but section, numbers and sizes of bolts and details of typical joints. In case NEA/Consultant feels that any design or drawings are to be modified even after its approval, Contractor shall modify the designs & drawings and resubmit the same for approval.

3.2 The fabrication drawings shall indicate complete details of fabrication and erection including all erection splicing details and typical fabrication splicing details, lacing details, weld sizes and lengths. Bolt details and all customary details in accordance with standard structural engineering practice. The fabrication drawing and bill of material based on design/line

diagram shall be submitted to NEA/Consultant for approval. Approved bill of materials prepared on the basis of fabrication drawing shall be the basis for payment.

3.3 Such approvals shall, however, not relieve the contractor of his responsibility for safety and durability of the structure and good connection and any loss occurring due to defective fabrication, design or workmanship shall be borne by the contractor.

3.4 The contractor shall submit editable soft copy of all designs preferably in Staad / excel form and drawings in AutoCAD to NEA/Consultant. The list of British standard codes relevant to steel structures have been given in Chapter-14-Civil section of technical specification This list is illustrative but not exhaustive. The contractor shall submit the copy of relevant portion of BS codes/equivalent International standard referred to NEA/Consultant for reference if necessary during detailed engineering stage.

4.0 FABRICATION AND ERECTION

4.1 The fabrication and erection works shall be carried out generally in accordance with relevant British standard Codes (BS Codes) / equivalent International Standards. All materials shall be completely shop fabricated and finished with proper connection material and erection marks for ready assembly in the field.

4.2 The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged and shall be so prepared that the specified camber, if any, is provided. In order to minimize distortion in member the component parts shall be positioned by using the clamps, clips, dogs, jigs and other suitable means and fasteners (bolts and welds) shall be placed in a balanced pattern. If the individual components are to be bolted, paralleled and tapered drifts shall be used to align the part so that the bolts can be accurately positioned.

4.3 Sample towers, beams and lightning masts and equipment support structures may be trial assembled in the fabrication shop to ensure fitment of various members and to avoid problems during erection.

4.4 For all structures, BOM along with fabrication drawings in hard and editable soft copies shall be submitted to NEA/Consultant as document for information. The responsibility of correctness of such fabrication drawing and BOM shall be fully with the contractor.

4.5 Approval of fabrication drawings and BOM shall, however, not relieve the Contractor of his responsibility for the safety and durability of the structure and good connections and any loss or damage occurring due to defective fabrication, design or workmanship shall be borne by the Contractor.

4.6 The Contractor should arrange on his own all plant and equipment, welding set, tools and tackles, scaffolding, trestles equipments and all other

accessories and ancillaries required for carrying out erection without causing any stresses in the members which may cause deformation and permanent damage. Minor modification if any, required during erection shall be done at site with the approval of NEA/Consultant.

5.0 BOLTING

i) Every bolt shall be provided with a washer under the nut so that no part of the threaded portion of the bolt is within the thickness of the parts bolted together.

ii) In case of fasteners, the galvanizing shall confirm to relevant British standard Codes (BS Codes) / equivalent International Standards. The spring washer shall be electro galvanized as per relevant British standard Codes (BS Codes) / equivalent International Standards.

6.0 WELDING

The work shall be done as per approved fabrication drawings which shall clearly indicate various details of joints to be welded, type of weld, length and size of weld, Symbols for welding on erection and shop drawings shall be according to relevant British standard Codes (BS Codes) / equivalent International Standards. Welding shall be carried out in accordance to relevant British standard Codes (BS Codes) / equivalent International Standards.

7.0 FOUNDATION BOLTS

7.1 Foundation bolts for the towers and equipment supporting structures and elsewhere shall be embedded in first stage concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate.

7.2 The Contractor shall be responsible for the correct alignment and leveling of all steel work on site to ensure that the towers/structures are plumb.

7.3 All foundation bolts for lattice structure, pipe structure are to be supplied by the Contractor.

7.4 All foundation bolts shall be fully galvanised so as to achieve minimum 610 grammes Per Sq.m. of Zinc Coating as per relevant British standard Codes (BS Codes) / equivalent International Standards.

7.5 All foundation bolts and its material shall conform to relevant British standard Codes (BS Codes) / equivalent International Standards. All foundation bolts shall be provided with two number standard nuts, one check nut, one plain washer and MS plate at the bottom of foundation bolt.

8.0 STABILITY OF STRUCTURE

The Supplier shall be responsible for the stability of the structure at all stages of its erection at site and shall take all necessary measures by the additions of temporary

bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations.

9.0 GROUTING

The method of grouting the column bases shall be subject to approval of NEA/Consultant and shall be such as to ensure a complete uniformity of contact over the whole area of the steel base. No additional payment for grouting shall be admissible.

10.0 GALVANISING

10.1 All structural steel works (Gantry structures, Equipment support structures) and foundation bolts shall be galvanized after fabrication. The galvanization shall be done as per requirement relevant British standard Codes (BS Codes) / equivalent International Standards.

10.2 Zinc required for galvanizing shall have to be arranged by the Contractor/manufacturer. Purity of zinc to be used shall be 99.95% as per relevant British standard Codes (BS Codes) / equivalent International Standards.

10.3 The Contractor shall be required to make arrangement for frequent inspection by the owner as well as continuous inspection by a resident representative of the owner, if so desired for fabrication work.

11.0 TOUCH-UP PAINTING

Minor defects in hot dip galvanized members shall be repaired by applying zinc rich primer and two coats of enamel paint to the satisfaction of NEA/Consultant before erection.

12.0 INSPECTION BEFORE DISPATCH

Each part of the fabricated steel work shall be inspected as per approved quality plans and certified by NEA/Consultant or his authorized representative as satisfactory before it is dispatched to the erection site. Such certification shall not relieve the Contractor of his responsibility regarding adequacy and completeness of fabrication.

13.0 TEST CERTIFICATE

Copies of all test certificates relating to material procured by the Contractor for the works shall be submitted to NEA/Consultant.

14.0 MODE OF MEASUREMENT

The measurement of the structure, fasteners (Nuts, Bolts, and Washers) and foundation bolts including its nuts washers and MS Plate at bottom shall be done

as per Bid price schedule (BPS). The weight of all structural members and foundation bolts (Bolt, Nuts, washer and MS steel plates welded at bottom of bolt) shall be measured under one head in Metric Tonne. The weight of fasteners and step bolts (Nuts, bolts and washers) used to erect/complete structures shall be measured under another head in Metric tons.

15.0 SAFETY PRECAUTIONS

The Contractor shall strictly follow all precautions at all stages of fabrication, transportation and erection of steel structures. The stipulations contained in relevant

British standard Codes (BS Codes) / equivalent International Standards. for Safety during erection of structural steel work shall also be adhered to.

16.0 MANUFACTURING QUALITY PLAN

The material specification shall also be as per relevant British standard Codes (BS Codes) / equivalent International Standards.

The Contractor shall prepare the manufacturing quality plan to accept/check the material, galvanization and welding as per relevant international standards/BS codes within 1 month after award of work and submit the same to NEA/ Consultant for approval.

CIVIL WORKS

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1.0 GENERAL

The intent of specification covers the following:

Design, engineering, drawing and construction of all civil works at sub-station. All civil works shall also satisfy the general technical requirements specified in other Sections of Specification and as detailed below. They shall be designed to the required service conditions/loads as specified elsewhere in this Specification or implied as per relevant British standard codes (B S Codes)/ equivalent International Standards.

All civil works shall be carried out as per applicable Standards and Codes. All materials shall be of best quality conforming to relevant International Standards and Codes. In case of any conflict between Standards/ Code and Technical Specification, the provisions of Technical Specification shall prevail.

The Contractor shall furnish all design, drawings, labour, tools, equipment, materials, temporary works, constructional plant and machinery, fuel supply, transportation and all other incidental items not shown or specified but as may be required for complete performance of the Works in accordance with approved drawings, specifications and direction of NEA/Consultant.

The work shall be carried out according to the design/drawings to be developed by the Contractor and approved by the NEA/Consultant. For all buildings, structures, foundations etc. necessary layout and details shall be developed by the Contractor keeping in view the functional requirement of the substation facilities and providing enough space and access for operation, use and maintenance. Certain minimum requirements are indicated in this specification for guidance purposes only. However, the Contractor shall quote according to the complete requirements.

2.0 GEOTECHNICAL INVESTIGATION

2.1 The Contractor shall perform a detailed soil investigation to arrive at sufficiently accurate, general as well as specific information about the soil profile and the necessary soil parameters of the Site in order that the foundation of the various structures can be designed and constructed safely and rationally.
A detailed soil report including field data duly certified by site engineers of NEA/Consultant will be submitted by the Contractor for specific approval of NEA/Consultant**.** The report shall contain all soil parameters along with recommendation of soil consultant for type of foundation i.e. pile or open type, soil treatment if any etc. to be used for the design of civil foundations.

2.2 The Contractor may visit the site to ascertain the soil parameters. Any variation in soil data shall not constitute a valid reason for any

additional cost & shall not affect the terms & conditions of the contract. Field tests must be conducted covering entire substation area including all the critical locations i.e. Control Room and GIS Building, township buildings, Lightning Mast. Towers, transformer/Reactor etc.

2.3 SCOPE OF WORK

This specification covers all the work required for detailed soil investigation and preparation of a detailed report. The work shall include mobilisation of necessary equipment, providing necessary engineering supervision and technical personnel, skilled and unskilled labour etc. as required to carry out field investigation as well as, laboratory investigation, analysis and interpretation of data and results, preparation of detailed 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/Consultant. The soil investigation for substation extension in existing switch yard has not been envisaged. Soil data of existing substation shall be referred for the design of foundations in switch yard extension under present scope of work.

All the work shall be carried out as per latest edition of the corresponding relevant British standard codes (B S Codes)/ equivalent International Standards. The Agency carrying out the soil investigation work must have the experience of carrying out soil investigation successfully in the relevant field. NEA shall assess the capability of the agency for soil investigation work for which technical inputs may be furnished by consultant to NEA.

2.3.1 Bore Holes

Bore holes of Minimum 150 mm diameter in accordance with the provisions of relevant international standards/British standards(BS) at the rate of minimum one number bore hole per hectare up to 25meter depth(Minimum) or to refusal which ever occur earlier shall be drilled for new areas (220 kV Yards and 220/132/33 kV yards wherever applicable). In any case number of boreholes shall not be less than five for new substations. By refusal it shall mean that a standard penetration blow count (N) of 100 is recorded for 30 cm penetration. Number of boreholes may be increased in case soil strata are varying from borehole to borehole in order to have fair idea of soil profile. In case of deep pile foundations soil investigation is to be carried out up to 30 m depth from ground level or refusal whichever is earlier. In case rock is encountered, coring in all the boreholes shall be carried out up to 3 meter in rock.

Performing Standard Penetration Tests at approximately 1.5 m interval

in the borehole starting from 1.5 m below ground level onwards and at every change of stratum. The disturbed samples from the standard penetrometer shall also be collected for necessary tests. Standard Penetration Test shall be performed as per relevant British standard codes (B S Codes)/ equivalent International Standards.

Undisturbed samples shall be collected in accordance with the recommendation of relevant British standard codes (B S Codes)/ equivalent International Standards. Or an alternative recognize method as agreed by NEA/Consultant. Undisturbed samples shall be taken in cohesive material or weak cemented granular material where ever possible at 1.0 m interval or at each change in stratum.

The depth of Water Table, if encountered, shall be recorded in each borehole. In case the soil investigation is carried out in winter/summer, the water table for rainy season shall be collected from reliable sources and recorded in the report.

All samples, both disturbed and undisturbed, shall be identified properly with the borehole number and depth from which they have been taken.

The sample shall be sealed at both ends of the sampling tubes with wax immediately after the sampling and shall be packed properly and transported to the Contractor's laboratory without any damage or loss.

The logging of the boreholes shall be compiled immediately after the boring is completed and a copy of the bore log shall be handed over to the Engineer-in-change.

2.3.2 Trial Pits

The Contractor shall excavate two number trial pits per substation (New) and as directed by NEA/Consultant, of area 2m*2m and not exceeding 4 m depth. Undisturbed samples shall be taken from the trial pits as per the direction of the NEA/Consultant. All Trial Pits shall be re-filled with approved material after the tests are complete and shall be compacted in layers of not more than 500mm.

2.3.3 Electrical Resistivity Test

This test shall be conducted to determine the Electrical resistivity of soil required for designing safety-grounding system for the entire station area. The specifications for the equipments and other accessories required for performing electrical resistivity test, the test procedure, and reporting of field observations shall confirm to relevant British standard codes (B S Codes)/ equivalent International Standards. The test shall be conducted using Wagner's four electrode method as specified in relevant British standard codes (B S Codes)/ equivalent International Standards.. Unless otherwise specified at each test location, the test shall be conducted along two perpendicular lines parallel

to the coordinate axis. On each line a minimum of 8 to 10 readings shall be taken by changing the spacing of the electrodes from an initial small value of 1 m upto a distance of 50.0 m.

2.3.4 Plate load test

Two number of Plate load tests per substation (for new substations) shall be conducted each at the location of control room/ GIS building and township area as applicable only to determine the bearing capacity, modulus of sub grade reaction and load/settlement characteristics of soil at shallow depths by loading a plane and level steel plate kept at the desired depth and measuring the settlement under different loads, until a desired settlement takes place or failure occurs. The specification for the equipment and accessories required for conducting the test, the test procedure, field observations and reporting of results shall conform to relevant BS standard. Plate load test shall be performed at the proposed foundation depth below finished ground level for bearing capacity.

Undisturbed tube samples shall also be collected from the pit at 1.0 m depth and bottom of pit from natural ground level for carrying out laboratory tests.

The size of the pit in plate load test shall not be less than five times the plate size and shall be taken up to the specified depth. All provisions regarding excavation and visual examination of pit shall apply here.

Unless otherwise specified the reaction method of loading shall be adopted. Settlement shall be recorded from dial gauges placed at four diametrically opposite ends of the test plate.

The load shall be increased in stages. Under each loading stage, record of Time vs. Settlement shall be kept as specified in relevant British standard codes (B S Codes)/ equivalent International Standards.
Backfilling of the pit shall be carried out as per the directions of the NEA/Consultant**.** Unless otherwise specified the excavated soil shall be used for this purpose. In cases of gravel-boulder or rocky strata, respective relevant codes shall be followed for tests.

2.3.5 Water Sample

Representative samples of ground water shall be taken when ground water is first encountered before the addition of water to aid drilling of boreholes. The samples shall be of sufficient quantity for chemical analysis to be carried out and shall be stored in air-tight containers.

2.3.6 Back Filling of Bore Holes

On completion of each hole, the Contractor shall backfill all bore holes as directed by the NEA/Consultant. The backfill material can be the excavated material.

2.3.7 Laboratory Test

1. The laboratory tests shall be carried out progressively during the field work after sufficient number of samples has reached the laboratory in order that the test results of the initial bore holes can be made use of in planning the later stages of the field investigation and quantum of laboratory tests.

2. All samples brought from field, whether disturbed or undisturbed shall be extracted/prepared and examined by competent technical personnel, and the test shall be carried out as per the procedures laid out in the relevant British standard codes (B S Codes)/ equivalent International Standards.

   The following laboratory tests shall be carried out
   a) Visual and Engineering Classification

   b) Atterberg limits Tests.

   c) Natural moisture content, bulk density and specific gravity.

   d) Grain size distribution analysis.

   e) Swell pressure and free swell index determination.

   f) California bearing ratio.

   g) Consolidated drained test with pore pressure measurement.

   h) Chemical tests on soil and water to determine the carbonates, sulphates, nitrates, chlorides, Ph value, and organic matter and any other chemical harmful to the concrete foundation.

   i) In case rock is encountered, the soil test required for rock as per relevant British standard codes (B S Codes)/ equivalent International Standards including following tests shall also be conducted.
      (i) UCC test.
      (ii) Point load index test.

2.3.8 Test Results and Reports

The Contractor shall submit the detailed report in two (2) copies wherein information regarding the geological detail of the site, summarised observations and test data, bore logs, and conclusions and recommendations on the type of foundations with supporting calculations for the recommendations. The contractor shall also submit the bearing capacity calculation in editable soft copy to NEA/consultant. Initially the contractor shall submit draft report and

after the draft report is approved, the final report in four (4) copies shall be submitted. The field and laboratory test data shall bear the signatures of the Investigation Agency, Contractor and also site representative of NEA/Consultant.

The report shall include, but not limited to the following:-

a) A plan showing the locations of the exploration work i.e. bore holes, trial pits. Plate load test, electrical resistivity test, CBR sample location etc.

b) Bore Logs: Bore logs of each bore holes clearly identifying the stratification and the type of soil stratum with depth. The values of Standard Penetration Test (SPT) at the depths where the tests were conducted on the samples collected at various depths shall be clearly shown against that particular stratum.

Test results of field and laboratory tests shall be summarised strata wise as well in combined tabular form. All relevant graphs, charts tables, diagrams and photographs, if any, shall be submitted along with report. Sample illustrative reference calculations for settlement, bearing capacity, pile capacity shall be enclosed.

Recommendations: The report should contain specific recommendations for the type of foundation for the various structures envisaged at site. The Contractor shall acquaint himself about the type of structures and their functions from the NEA/Consultant. The observations and recommendations shall include but not limited to the following:

a) Geological formation of the area, past observations or historical data, if available, for the area and for the structures in the nearby area, fluctuations of water table etc.

b) Recommended type of foundations for various structures. If piles are recommended the type, size and capacity of pile and groups of piles shall be given after comparing different types and sizes of piles and pile groups.

c) Allowable bearing pressure on the soil at various depths for different sizes of the foundations based on shear strength and settlement characteristics of soil with supporting calculations. Minimum factor of safety for calculating net safe bearing capacity shall be taken as 3.0 (three). Recommendation of liquefaction characteristics of soil if applicable shall be provided.

d) Recommendations regarding slope of excavations and dewatering schemes, if required.

e) Comments on the Chemical nature of soil and ground water

with due regard to deleterious effects of the same on concrete and steel and recommendations for protective measures.

f) If expansive soil is met with, recommendations on removal or retainment of the same under the structure, road, drains, etc. and thickness of treatment shall be given. In the latter case detailed specification of any special treatment required including specification or materials to be used, construction method, equipments to be deployed etc. shall be furnished. Illustrative diagram of a symbolic foundation showing details shall be furnished.

g) Recommendations for additional investigations beyond the scope of the present work, if considered such investigation as necessary.

f) In case of foundation in rocky strata, type of foundation and recommendation regarding rock anchoring etc. should also be given.

3.0 CONTOUR SURVEY, SITE LEVELLING

3.1 CONTOUR SURVEY & SITE LEVELLING:

The land for construction of substation will be handed over to the successful bidder as on where basis progressively after award of work. The contractor shall carry out survey work by taking spot level at 05 m x05 m grid interval with respect to temporary bench mark transferred from permanent bench mark in the locality if available either on bridge , government buildings of local authorities or any other permanent structure. The contractor shall submit the spot levels (in grid format) in editable soft copy in excel format and contour map with contour interval of 0.5 m in editable auto cad soft drawing.

The contractor will level the area required for construction of substation work either at single level, multi level or gradual slope with the finished ground level as approved by NEA/Consultant during detailed engineering based on highest flood level. The levelling area shall be decided by NEA/Consultant during detailed Engineering stage.

The layout and levels of all structure etc. shall be made by the Contractor at his own cost from the general grids of the plot and benchmarks set by the Contractor and approved by NEA/Consultant. The Contractor shall provide all assistance in instruments, materials and personnel to NEA/Consultant for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

3.2 SCOPE

This clause covers clearance of site, contour survey, site levelling, maintaining finished ground level by cutting/filling in all types of soil and soft/ disintegrated rock, supplying and compaction of fill material

if required. Cutting/felling of trees and their disposal has not been envisaged under the present scope.

3.3 **GENERAL**

Site shall be cleared, surveyed and levelled/sloped by the contractor as per approved general arrangement drawing or levelling area decided during detailed engineering after award of work.

Work covered under this clause comprises the site clearance, survey work/setting out and making profiles (preparation of plot plan, setting up Bench Mark and taking spot levels at 05m x 05 m interval, preparation of contour plan with contour interval of 0.50 m), Earth work in Excavation &filling in specified area with all lifts and leads and earth work in filling with borrowed earth with all leads and lifts (Borrow areas including payment of royalty for borrowed earth shall be arranged by the contractor at his own cost). During detailed engineering stage, the contractor will prepare the levelling proposal for optimum levelling and submit to NEA/Consultant for approval. Contractor shall submit the hard copy and editable soft copy of levelling proposal (levelling quantity calculation in Excel form and levelling drawing in Auto CAD) to NEA/Consultant for approval.

3.4 Filling material shall conform to relevant British standard codes (BS Codes)/ equivalent International Standards. Unsuitable filling material if any shall be removed and replaced by suitable fill material. The filling shall be compacted in layers to achieve 95% of standard Proctor's density at Optimum moisture contents (OMC). Cohesion less material shall be compacted to 70% relative density (minimum). Levelling/Filling shall be carried out as per relevant British standard codes (B S Codes)/ equivalent International Standards.

3.5 All materials involved in excavation shall be classified by NEA/ Consultant in the following groups:

3.5.1 **All kinds of soils and soft/disintegrated rocks (Not requiring blasting):** The material which can be quaried/excavated with pick, shovel, jumpers, scarifiers, crowbars and mechanical implements and will include various types of soils, plain cement concrete, shingle, river/nallah boulders, soling of road/foot path, stone masonary, soft conglomerate and laterite stone, lime stone and hard conglomerate etc.

3.5.2 **Hard Rocks**: All kinds of rocks which can only be excavated by machines and requires blasting, chiselling in edging or in another agreed method and will also include reinforcement cement concrete.

3.6 The quantity of excavation in all types of soils and soft/disintegrated rock shall be worked out by using initial and final level and no void deduction shall be made to calculate net quantity of earth work with 95% compaction.

3.7 The volume of hard rock shall be computed on the basis of stack of excavated rubble after making 50 % deduction for voids.

3.8 The surface of excavation or filling shall be neatly dressed to the required formation level with tolerance of (±) 100 mm.

4.0 SITE PREPERATION, EXCAVATION, BACKFILL & DISPOSAL OF SURPLUS EARTH.

4.1 SITE PREPERATION

The layout and levels of all structure etc. shall be made by the Contractor at his own cost from the general grids of the plot and benchmarks set by the Contractor and approved by the NEA/Consultant. The Contractor shall give all help in instruments, materials and personnel to the NEA/Consultant for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

4.2 SCOPE

This clause covers clearing of the site, maintaining the finished ground level with available surplus excavated suitable back fill material generated from foundation works etc.

4.3 GENERAL

1) The Contractor shall develop the site area to meet the requirement of the intended purpose. The site preparation shall conform to the requirements of relevant sections of this specification or as per stipulations of relevant British standard codes (B S Codes)/ equivalent International Standards.

2) The fill material shall be suitable for the above requirement. The fill shall be with such a material that the site so designed shall not be affected by erosion from wind and water from its final compacted position or the in-situ position of undisturbed soil.

3) Material unsuitable for founding of foundations shall be removed and replaced by suitable fill material to be approved by the NEA/Consultant.

4) Backfill material around foundations or other works shall be suitable for the purpose for which it is used and compacted to the density described under Compaction. Excavated material not suitable or not required for backfill shall be disposed off in areas as directed by purchaser up to a maximum lead of 2 km.

5) Contractor may record the initial level of the site as per present condition and submit the quantity of volume of earthwork required.

6) Contractor may propose any suitable alternative for better optimization of project.

4.4 EXCAVATION AND BACKFILL

SCOPE

This clause covers excavation for foundation works of Towers, Equipment support structures, Transformer/Reactor foundations, External Lighting poles, Cable trenches, Buildings, Car parking shed, Fire Wall, DG set, Water tanks, etc, backfilling of Foundations Works.

1. Excavation and backfill for foundations shall be in accordance with the relevant British standard codes (B S Codes)/ equivalent International Standards.

2. Whenever water table is met during the excavation, it shall be dewatered and water table shall be maintained below the bottom of the excavation level during excavation, concreting and backfilling.

3. When embankments are to be constructed on slopes of 15% or greater, benches or steps with horizontal and vertical faces shall be cut in the original slope prior to placement of embankment material. Vertical faces shall measure not more than 1 m in height.

4. Embankments adjacent to abutments, culverts, retaining walls and similar structures shall be constructed by compacting the material in successive uniform horizontal layers not exceeding 15 cm in thickness. (Of loose material before compaction). Each layer shall be compacted as required by means of mechanical tampers approved by the Purchaser. Rocks larger than 10 cm in any direction shall not be placed in embankment adjacent to structures.

5. Earth embankments of roadways and site areas adjacent to buildings shall be placed in successive uniform horizontal layers not exceeding 20 cm in thickness in loose stage measurement and compacted to the full width specified. The upper surface of the embankment shall be shaped so as to provide complete drainage of surface water at all times.

4.5 COMPACTION

1. The density to which fill materials shall be compacted shall be as per relevant BS and as per direction of NEA/Consultant. All compacted sand filling shall be confined as far as practicable. Backfilled earth shall be compacted to minimum 95% of the Standard Proctor's density at OMC. The sub grade for the roads and embankment filling shall be compacted to minimum 95% of the Standard Proctor's density at OMC. Cohesion less material sub grade shall be compacted to 70% relative density

(minimum).

2. At all times unfinished construction shall have adequate drainage upon completion of the road's surface course, adjacent shoulders shall be given a final shaping, true alignment and grade.

3. Each layer of earth embankment when compacted shall be as close to optimum moisture content as practicable. Embankment material which does not contain sufficient moisture to obtain proper compaction shall be wetted. If the material contains any excess moisture, then it shall be allowed to dry before rolling. The rolling shall begin at the edges overlapping half the width of the roller each time and progress to the centre of the road or towards the building as applicable. Rolling will also be required on rock fills. No compaction shall be carried out in rainy weather.

4.6 REQUIREMENT FOR FILL MATERIAL UNDER FOUNDATION

The thickness of fill material under the foundations shall be such that the maximum pressure from the footing, transferred through the fill material and distributed onto the original undisturbed soil will not exceed the allowable soil bearing pressure of the original undisturbed soil. For expansive soils, the fill materials and other protections etc. to be used under the foundation is to be got approved by the NEA/Consultant.

4.7 DISPOSAL OF SURPLUS EARTH

The surplus earth generated from foundation work shall be disposed away from levelling area boundary at low lying areas within 2Km lead. The surplus earth if disposed within substation main boundary, the same shall be spread in uniform layers and compacted with suitable compacting equipment to achieve 95% compaction at O.M.C.

5.0 ANTIWEED TREATMENT & STONE SPREADING

5.1 SCOPE OF WORK

The Contractor shall furnish all labour, equipment and materials required for complete performance of the work in accordance with the drawings, specification.

Stone spreading along with cement concrete layer shall be done in the areas of the switchyard under present scope of work within fenced area. However the stone spreading along with cement concrete layer in future areas within fenced area shall also be provided in case step potential without stone layer is not well within safe limits.

5.2 GENERAL REQUIREMENT

The material required for site surfacing/stone filling shall be free from all types of organic materials and shall be of standard quality, and as approved by the Purchaser.

The material to be used for stone filling/site surfacing shall be uncrushed/crushed/broken stone of 40mm nominal size (ungraded single size) conforming to relevant BS. Hardness, flakiness shall be as required for wearing courses shall be as are per relevant BS.

(a) Hardness
Abrasion value as per relevant BS.
Impact value as per relevant BS.

(b) Flakiness Index
One test shall be conducted as per relevant British standard codes (B S Codes)/ equivalent International Standards.

After all the structures/equipments are erected, anti weed treatment shall be applied in the switchyard where ever stone spreading along with cement concrete is to be done and the area shall be thoroughly de-weeded including removal of roots. The recommendation of local agriculture or horticulture department may be sought where ever feasible while choosing the type of chemical to be used. The anti weed chemical shall be procured from reputed manufacturers. The doses and application of chemical shall be strictly done as per manufacturer's recommendation. Nevertheless the effectiveness of the chemical shall be demonstrated by the contractor in a test area of 10MX10M (appx.) and shall be sprinkled with water at least once in the afternoon every day after forty eight hours of application of chemical. The treated area shall be monitored over a period of two to three weeks for any growth of weeds by the NEA/Consultant. The final approval shall be given by NEA/Consultant based on the results.

NEA/Consultant shall decide final formation level so as to ensure that the site appears uniform devoid of undulations. The final formation level shall however be very close to the formation level indicated in the approved drawing.

After anti weed treatment is complete, the surface of the switchyard area shall be maintained, rolled/compacted to the lines and grades as decided by NEA/Consultant. The sub grade shall be consolidated by using half ton roller with suitable water sprinkling arrangement to form a smooth and compact surface. The roller shall run over the sub grade till the soil is evenly and densely consolidated and behaves as an elastic mass.

In areas that are considered by the NEA/Consultant to be too congested with foundations and structures for proper rolling of the site surfacing material by normal rolling equipments, the material shall be compacted

by hand, if necessary. Due care shall be exercised so as not to damage any foundation structures or equipment during rolling compaction.

The sub grade shall be in moist condition at the time the cement concrete is placed. If necessary, it should be saturated with water for not less than 6 hours but not exceeding 20 hours before placing of cement concrete. If it becomes dry prior to the actual placing of cement concrete, it shall be sprinkled with water and it shall be ensured that no pools of water or soft patches are formed on the surface.

Over the prepared sub grade, 75mm thick base layer of cement concrete in 1:5:10 (1 cement :5 sand : 10 Stone aggregates) shall be provided in the area excluding roads, drains, cable trenches as per detailed engineering drawing. For easy drainage of water, the slope of 1:1000 is to be provided from the ridge to the nearest drain. The ridge shall be suitably located at the centre of the area between the nearest drains. The above slope shall be provided at the top of base layer of cement concrete in 1:5:10. A layer of cement slurry of mix 1:6 (1 cement: 6 sand) shall be laid uniformly over cement concrete layer. The cement consumption for cement slurry shall not be less than 150 kg. Per 100 sq.m.

A final layer of 100mm thickness of uncrushed/crushed/broken stone of 40mm nominal size (ungraded size) shall be spread uniformly over cement concrete layer after curing is complete.

6.0 SITE DRAINAGE

Preparation of overall drainage layout, design, drawing and providing rain water drainage system within the substation boundary under the present scope including connection at one or more points to the outfall point located outside the substation boundary wall is in the scope of contractor. Invert level of drainage system at outfall point shall be decided in such a way that the water can easily be discharged outside the substation boundary wall. In case outfall point is more than 100 m away from boundary wall, only 100 metre drain outside the boundary wall is in the scope of contractor. Outfall point shall be got approved from NEA/Consultant before commencement of construction. While designing the drainage system following points shall taken care of:

(a) The surface of the switchyard shall be sloped to prevent accumulation of water.
(b) Drain shall be constructed at suitable locations in such a way that substation is not flooded and roads are not affected with ponding of surface water. In the switchyard maximum spacing between two drains shall not be more than 100 meter. It will be ensured that no area is left undrained.
(c) Open surface drains having 300mm bottom width and 300mm depth at starting point of drain shall be provided. The depth of drain shall be measured with respect to finished ground level of switch yard i.e. from bottom of switch yard stone filling.

(d) Longitudinal slope shall not be less than 1 in 1000.

(e) Open surface drains shall be constructed with brick masonry or concrete blocks. As per design of contractor. PCC (1:2:4) shall be laid over 40mm thick layer of PCC 1:4:8 (1 cement: 4coarse sand: 8 stone aggregate 20mm nominal size.)

(f) The side wall of the drains shall be 25 mm above the gravel level to prevent falling of gravel into drain. Groove of 125 mm width shall be provided at 2000 mm spacing with suitable mild steel grating..

(g) The maximum velocity for pipe drains and open drains shall be limited to 2.4m/sec and 1.8m/sec respectively. However, minimum non-silting velocity of 0.6m/sec shall be ensured.

(h) Pipe drains shall be provided in areas of switchyard where movement of crane will be necessary in operating phase of the substation.

(i) For pipe drains, concrete pipe of class NP2 shall be used. However, for road crossings etc. higher strength pipe of class NP3 shall be provided. For rail crossings, RCC pipes of class NP4 shall be provided. For design of RCC pipes for drains and culverts, relevant British standard codes (B S Codes)/ equivalent International Standards. Shall be followed.

(j) Two Nos. of portable pumps of 5 hp capacity for drainage of water shall be provided by the Contractor.

(k) Pipe drains shall be connected through manholes at an interval of max. 30m.

(l) If the invert level of outfall point is above the last drain point in the substation boundary, sump of suitable size has to be constructed with in the substation boundary.

(m) The drainage scheme and associated drawings shall be got approved from NEA/Consultant before commencement of construction.

6.1 RAINWATER HARVESTING:

In addition to drainage of rainwater in accordance with above clause 6.0, the contractor shall design, prepare drawings and provide rainwater harvesting system also. Rainwater harvesting shall not be done if the depth of underground water table is within 8.0m from finished ground level or as per provision of relevant British standard codes (B S Codes)/ equivalent International Standards. While designing the rain water harvesting system, following points may be taken care of:

Rainwater harvesting shall be done by providing two numbers recharge structures with bore wells. The recharge structures shall be suitably located within the sub-station. Branch drains from the main drain carrying rainwater from entire switchyard, constructed in accordance with clause 5.0, shall be connected to the recharge structures.

The internal diameter of recharge shafts shall be 4.5 meter with 230mm thick lining of brick work up to a depth of 2.0 meter from ground level and 345mm thick brickwork below 2.0 meter depth. The brick/concrete block work shall be constructed with cement mortar 1:6 (1 cement: 6 coarse sand). The overall depth of shaft shall be 5.0 meter below invert level of drain. The shaft shall be covered with RCC slab for a live load of 300 kg. Per sq. m. Two openings of size 0.7 x 0.7 meter shall be provided in the RCC cover slab as shown in the drawing. An iron cover made of 5mm thick chequered plate with hinges shall be provided on the openings. Galvanized M.S. rungs of 20mm diameter at spacing of 300 mm shall be provided in the wall of shaft below the opening in the RCC slab to facilitate cleaning of shaft.

A 300 mm diameter bore well shall be drilled in the centre of the shaft. The depth of bore well shall be 5.0 meter more than the depth of sub soil water.

A 100 mm dia medium duty MS pipe conforming to relevant BS shall be lowered in the bore well keeping bail plug towards bottom of bore well. The pipe shall have 1.58mm holes for 4.0 meter length starting from 1.0 meter from bottom of bore well. Holes of 3.0mm dia. shall be provided for a length of 2.0 meter starting from the bottom level of coarse sand and down wards. The overall length of pipe shall be equal to total depth of bore well plus depth of shaft.

Gravel of size 3mm to 6mm shall be filled around 100 dia. MS pipe in the bore well. The shaft shall be filled with 500 mm thick layers each from the bottom of shaft with boulders of size 50mm to 150mm, gravel of size 5mm to 10mm, coarse sand having particle size 1.5mm to 2.0mm and boulders of size not less than 200mm respectively.

7.0 ROADS

a). All the roads as shown in the General Arrangement drawing for the substation issued along with the tender documents are in the present scope. Adequate turning space for vehicles shall be provided and bend radii shall be set accordingly. Road to the Transformer /Reactor shall be as short and straight as possible.

b) All concrete roads within substation boundary wall shall be with 3.75 m RCC concrete pavement of suitable thickness and 1.3 m wide earthen shoulder on either side of the road. Below RCC concrete pavement, water bound macadam of adequate thickness as per design (WBM) shall be laid.

d) Strengthening of existing roads as shall be carried out with 2.5 cm thick premix carpet and 100 mm thick compacted layer of WBM (Water Bound Macadum) after filling the pot holes of existing roads with WBM material.

e) All roads shall be designed as per relevant British standard codes (B S Codes)/ equivalent International Standards. All drawings of road and culverts shall be prepared by the contractor.

f) All the culverts and allied structures (required for road/rail, drain, trench crossings etc.) shall be designed as per relevant British standard codes (B S Codes)/ equivalent International Standards.

7.1 Road Outside NEA boundary (Access Road)

The construction site will be accessible by vehicle during fair weather. The scope of works in this section comprises construction of access road and repair and maintenance of the same during the construction period so that it shall be left in well and good condition at the end of the project construction.

Asphalt Pavement

General
This specification covers all construction works for 4 -6 meter wide driveway road within Employer's premises.

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.
The compaction of the sub-base course shall be carried out by at least 8 ton capacity steel roller with proper watering. The required density for the applied sub-base course is at least 90%.

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 (min. 40mm compacted).

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 100mm.

Payment

The unit price bid in the Price Schedule shall include the cost of design, all labor, all material, civil construction works, etc.

Payment for the Contract item "Asphalt Road" will be made at the unit price per sq. m. of finish surface bid, 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.

8.0 TRANSFORMERS/REACTOR FOUNDATION, RAIL TRACK/ RAIL CUM ROAD TRACK

The Contractor shall design, prepare drawing and provide a RCC Rail cum road system integrated with the Transformer/Reactor foundation to enable installation and the replacement of any failed unit. The transfer track system

shall be suitable to permit the movement of any failed unit fully assembled (including OLTC, bushings) with oil. This system shall enable the removal of any failed unit from its foundation to the nearest road. If trench/drain crossings are required then suitable R.C.C. culverts shall be provided in accordance with relevant BS.

The Contractor shall provide a pylon support system for supporting the fire fighting system.

Each Transformer /Reactor including oil conservator tank and cooler banks etc. shall be placed in a self-sufficient pit surrounded by retaining walls (Pit walls). The clear distance of the retaining wall of the pit from the Transformer/Reactor shall be 20% of the Transformer /Reactor height or 0.8m whichever is more. The oil collection pit thus formed shall have a void volume equal to 200% volume for 220 kV & above and 130% for 132 kV& below of total oil in the Transformer /Reactor. The minimum height of the retaining walls shall be 15 cm above the finished level of the ground to avoid outside water pouring inside the pit. The bottom of the pit shall have an uniform slope towards the sump pit. While designing the oil collection pit, the movement of the Transformer must be taken into account.

The grating shall be made of MS flat of size 40mmx 5mm placed at 30mm center to center and 25mmx5mm MS flat at spacing of 150mm at right angle to each other. Maximum length of grating shall be 2000mm and width shall not be more than 500mm. The gratings, supported on ISMB 150mm, shall be placed at the formation level and will be covered with 100mm thick layer of broken/crushed/non-crushed stone having size 40mm to 60mm which acts as an extinguisher for flaming oil. All steel works used for grating and support in transformer foundation shall be painted with Zinc phosphate primer (two packs) conforming to relevant British standard codes (B S Codes)/ equivalent International Standards.

Each oil collection pit shall be drained towards a sump pit within the collection pit whose role is to drain water and oil due to leakage within the collection pit so that collection pit remains dry.

8.1 MATERIALS

Complete foundation shall be made of reinforced cement concrete and shall be designed as per guidelines for design of foundations given in clause 10.0 in the specification.

8.2 DRAINAGE

One 0.5 H.P pump for each pit shall be supplied and installed by the Contractor to evacuate the fire fighting& rain water from the sump pit in to the nearest drain.

9.0 FIRE PROTECTION WALLS

9.1 GENERAL

Fire protection walls shall be provided, if required, in accordance with Local Advisory Committee (LAC) recommendations. The scope of works covers design, preparation of drawing and construction of RCC fire protection walls. While designing the wall, following points may be taken care of:

9.1.1 FIRE RESISTANCE

The firewall shall have a minimum fire resistance of 3 hours. The partitions, which are made to reduce the noise level, shall have the same fire resistance. The walls of the building, which are used as firewalls, shall also have a minimum fire resistance of 3 hours.

The firewall shall be designed to protect against the effect of radiant heat and flying debris from an adjacent fire.

9.1.2 DIMENSIONS

The firewall shall extend 600 mm on each side of the Transformer /Reactors and 600 mm above the conservator tank or safety vent.

These dimensions might be reduced in special cases, as per the approval of owner where there is lack of space. A minimum of 2.0meter clearance shall be provided between the equipments e.g. Transformer /Reactors and firewalls.

The building walls, which act as firewalls, shall extend at least 1 m above the roof in order to protect it.

9.1.3 MATERIALS

The firewall will be made of reinforced cement concrete as per the relevant British standard codes (B S Codes)/ equivalent International Standards.

10.0 CABLE TRENCHES AND CABLE TRENCH CROSSINGS

The work covered under this clause comprises of design, drawing and construction of cable trenches and cable trench crossings. While designing, following points may be taken care of:

a). The cable trenches and pre-cast removable RCC cover (with lifting arrangement) shall be constructed using RCC of M25 (Minimum) grade as per relevant British standard codes (B S Codes)/ equivalent International Standards.

b). The cable trench walls shall be designed for the following loads.

(i) Dead load of 155 kg/m length of cable support + 75 Kg on one tier at the outer edge of tier.

(ii) Earth pressure + uniform surcharge pressure of 2T/m2.

c). Cable trench covers shall be designed for self-weight of top slab + concentrated load of 150 kg at centre of span on each panel.

d). Necessary sumps shall be provided and each sump shall be provided with pumps of 5 HP capacity shall be supplied for pumping out water collected in cable trench. Cable trenches shall not be used as storm water drains.

e). The top of trenches shall be kept at least 100 mm above the finished ground level. The top of cable trench shall be such that the surface rainwater do not enter the trench.

f). All metal parts inside the trench shall be connected to the earthing system.

g). Trench wall shall not foul with the foundation. Suitable clear gap shall be provided.

h). The trench bed shall have a slope of 1/500 along the run & 1/250 perpendicular to the run.

i). Cable trenches shall be blocked at the ends if required with brick masonry in cement sand mortar 1:6 and plaster with 12mm thick 1:6 cement sand mortar.

J) Cable trench crossings shall be designed for critical load likely to be passed over the crossing. The cable trench crossing may be of either RCC box culvert type or RCC hume pipes embedded in plain concrete as per design of contractor.

11.0 FOUNDATION / RCC CONSTRUCTION

11.1 GENERAL

1. Work covered under this Clause of the Specification comprises the design ,drawing and construction of foundations and other RCC constructions for switchyard tower structures, bus supports, equipment supports, cable trenches, Transformer /Reactors, jacking pad, pulling blocks, fire protection walls, control cubicles, marshalling kiosks, auxiliary equipments, Control Room Cum Administrative building, GIS hall, Fire fighting Pump house, fire fighting water tanks, Auxiliary Building, Panel room, ,township buildings, Parking shed ,RCC retaining wall, or for any other equipment or service and any other foundation required to complete the work. This clause is as well applicable to the other RCC constructions.

2. Concrete shall conform to the requirements mentioned in relevant British standard codes (B S Codes)/ equivalent International Standards. And all the tests shall be conducted as per relevant British standard codes (B S Codes)/ equivalent International Standards. However, a minimum grade of M25 (design Mix) concrete shall be used for all foundations and structural/load bearing members as per relevant

British standard codes (B S Codes)/ equivalent International Standards.

3. If the site is sloppy, the foundation height will be adjusted to maintain the exact level of the top of structures to compensate such slopes.

4. The switchyard foundation's plinths and building plinths shall be minimum 300mm and 500 mm above finished ground level respectively.

5. Minimum 75mm thick lean concrete (1:4:8) shall be provided below all underground structures, foundations, trenches etc. to provide a base for construction.

6. Concrete made with Portland slag cement shall be carefully cured and special importance shall be given during the placing of concrete and removal of shuttering.

7. The design and detailing of foundations shall be done based on the approved soil data and sub-soil conditions as well as for all possible critical loads and the combinations thereof. The Spread footings foundation or pile foundation as may be required based on soil/sub-soil conditions and superimposed loads shall be provided.

8. If pile foundations are adopted, the same shall be cast-in-situ driven/bored or pre-cast or under reamed type as per relevant parts of relevant British standard codes (B S Codes)/ equivalent International Standards. Only RCC piles shall be provided. Suitability of the adopted pile foundations shall be justified by way of full design calculations. Detailed design calculations shall be submitted by the contractor showing complete details of piles/pile groups proposed to be used. Necessary initial load test shall also be carried out by the bidder at their cost to establish the piles design capacity. Only after the design capacity of piles has been established, the Contractor shall take up the job of piling. Routine tests for the piles shall also be conducted. All the work (design & testing) shall be planned in such a way that these shall not cause any delay in project completion.

11.2 DESIGN

While designing foundations, following may be taken care of:

11.2.1. All foundations except for external lighting poles shall be of reinforced cement concrete. The external lighting pole shall be embedded in plain cement concrete (1:2:4) foundation. The design and construction of RCC structures shall be carried out as per relevant BS and minimum grade of concrete shall be M-25 (design Mix). Higher grade of concrete than specified above may be used at the discretion of Contractor without any additional financial implication to the NEA/Consultant.

11.2.2. Limit state method or any other method as per relevant British standard codes (B S Codes)/ equivalent International Standards of design shall

be adopted unless specified otherwise in the specification.

11.2.3. For detailing of reinforcement relevant BS followed. Cold twisted deformed bars conforming to relevant British standard codes (B S Codes)/ equivalent International Standards. Two layers of reinforcement (on inner and outer face) shall be provided for wall & slab sections having thickness of 150 mm and above. Clear cover to reinforcement shall be as per relevant British standard codes (B S Codes)/ equivalent International Standards.

11.2.4. RCC water retaining structures like storage tanks, etc. shall be designed as uncracked section in accordance with relevant British standard codes (B S Codes)/ equivalent International Standards. However, water channels shall be designed as cracked section with limited steel stresses as per relevant BS.

11.2.5. The procedure used for the design of the foundations shall be the most critical loading combination of the steel structure and or equipment and/or superstructure and other conditions which produces the maximum stresses in the foundation or the foundation component and as per the relevant British standard codes (B S Codes)/ equivalent International Standards of foundation design. Detailed design calculations shall be submitted by the bidder showing complete details of piles/pile groups proposed to be used.

11.2.6. Design shall consider any sub-soil water pressure that may be encountered following relevant standard strictly.

11.2.7. Necessary protection to the foundation work, if required shall be provided to take care of any special requirements for aggressive alkaline soil, black cotton soil or any other type of soil which is detrimental/harmful to the concrete foundations.

11.2.8. RCC columns shall be provided with rigid connection at the base.

11.2.9. All sub-structures shall be checked for sliding and overturning stability during both construction and operating conditions for various combinations of loads. Factors of safety for these cases shall be taken as mentioned in relevant British standard codes (B S Codes)/ equivalent International Standards or as stipulated elsewhere in the Specifications. For checking against overturning, weight of soil vertically above footing shall be taken and inverted frustum of pyramid of earth on the foundation should not be considered.

11.2.10. Earth pressure for all underground structures shall be calculated using co-efficient of earth pressure at rest, co-efficient of active or passive earth pressure (whichever is applicable). However, for the design of substructures of any underground enclosures, earth pressure at rest shall be considered.

11.2.11. In addition to earth pressure and ground water pressure etc., a

surcharge load of 2T/Sq. m shall also be considered for the design of all underground structures including channels, sumps, tanks, trenches, substructure of any underground hollow enclosure etc., for the vehicular traffic in the vicinity of the structure.

11.2.12. Following conditions shall be considered for the design of water tank in pumps house, channels, sumps, trenches and other underground structures:

a) Full water pressure from inside and no earth pressure & ground water pressure & surcharge pressure from outside (application only to structures which are liable to be filled up with water or any other liquid).

b) Full earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.

c) Design shall also be checked against buoyancy due to the ground water during construction and maintenance stages. Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the superimposed loadings.

11.2.13. Base slab of any underground enclosure shall also be designed for empty condition during construction and maintenance stages with maximum ground water table (GWT). Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the super-imposed loadings.

11.2.14. Base slab of any underground enclosure like water storage tank shall also be designed for the condition of different combination of pump sumps being empty during maintenance stages with maximum GWT. Intermediate dividing piers of such enclosures shall be designed considering water in one pump sump only and the other pumps sump being empty for maintenance.

11.2.15. The foundations shall be proportioned so that the estimated total and differential movements of the foundations are not greater than the movements that the structure or equipment is designed to accommodate.

11.2.16. The foundations of transformer/reactor and circuit breaker shall be of lock type foundation. Minimum reinforcement shall be governed by relevant British standard codes (B S Codes)/ equivalent International Standards.

11.2.17. The tower and equipment foundations shall be checked for a factor of safety as per relevant British standard codes (B S Codes)/ equivalent International Standards for two conditions i.e. Normal condition and short circuit condition against sliding, overturning and pullout. The same factors shall be used as partial safety factor over loads in limit state design also.

11.3 ADMIXTURES & ADDITIVES

11.3.1. Only approved admixtures shall be used in the concrete for the Works. When more than one admixture is to be used, each admixture shall be batched in its own batch and added to the mixing water separately before discharging into the mixer. Admixtures shall be delivered in suitably labelled containers to enable identification.

11.3.2. Admixtures in concrete shall conform to relevant British standard codes (B S Codes)/ equivalent International Standards. The water proofing cement additives shall conform to relevant BS. Concrete Admixtures/ Additives shall be approved by NEA/Consultant.

11.3.3. The Contractor may propose and the NEA/Consultant may approve the use of a water-reducing set-retarding admixture in some of the concrete. The use of such an admixture will not be approved to overcome problems associated with inadequate concrete plant capacity or improperly planned placing operations and shall only be approved as an aid to overcoming unusual circumstances and placing conditions.

11.3.4. The water-reducing setting-retarding admixture shall be an approved brand as per relevant British standard codes (B S Codes)/ equivalent International Standards.

11.3.5 The water proofing cement additives shall be used as required/advised by NEA/Consultant.

12.0 CHAINLINK FENCING AND GATE

12.1 General

Work covered under this clause comprises of design, drawing, supply, fabrication, erection, painting or galvanisation as specified etc of switch yard Fencing and gate, construction of foundation of steel posts and toe wall .While providing switch yard fencing and gate, Following points may be taken care of :

12.2 Areas requiring Fencing

12.2.1 Fencing shall be provided for complete switchyard as per drawing. Separate gate shall be provided for men and equipment.

12.2.2 Internal fence surrounding the various equipments (if) mounted on ground or a height lower than 2.5m. Necessary gates shall be provided for each area so surrounded.

12.3 Product materials

The minimum requirements are as follows:

Chain link fence fabric (galvanization) in accordance to relevant British standard codes (B S Codes)/ equivalent International Standards.

12.4 Posts

The posts shall be of medium M.S. tubes of 50mm diameter conforming to grade as per relevant international /BS standard. The tubes shall also conform relevant British standard codes (B S Codes)/ equivalent International Standards. The length of tubular post shall be 2600 mm.

An M.S. base plate of size 160 X 160 X 6mm thick shall be welded with the tubular post. The post shall be provided on the top with M S plate.

The tubular post shall be welded with 8 number of M S flat of size 50 x 6mm – 75mm long at suitable locations. Two number of 13.5 mm diameter holes on each cleats shall be provided to bolt the fence fabric panel. The cleats shall be welded at equal spacing in such a way that 4 numbers of cleats are on one side and remaining 4 cleats are on the opposite side of the post. The cleats on the corner posts shall be welded in such a way that it suits the site requirement.

The whole assembly of tubular post shall be hot dip galvanized. The zinc coating shall be minimum 610 gram per sq. meter. The purity of zinc shall be 99.95% as per relevant BS.

12.5 Fence Fabric & Fence Panel

Chain link fencing shall be made of 3.15 mm diameter wire with 75 X 75 mm mesh size. Fence fabric shall be galvanised. Chain link fencing shall be fabricated in the form of panel 1300 X 2928 mm. An M.S. flat of at least 50x6 mm size shall be welded all-round fence fabric to form a panel. Four pairs of 13.5mm diameter holes on the vertical M S flat matching the spacing of holes in cleats fixed with pipe shall be provided to fix the fence panel with the tubular posts. A washer shall also be provided below each nut. The contractor, for fixing the panels, shall supply the 12mm diameter bolts including nuts and washers. All nuts, bolts and washers shall be hot dip galvanized.

The fence panel shall be provided with two or more coats of approved standard Zinc paint over approved standard steel primer.

12.6 Installation

1. Fence shall be installed along the switchyard line as shown in the approved drawings.
2. Post holes shall be excavated by approved method.
3. All posts shall be 3.0m apart measured parallel to ground surface.
4. Posts shall be set in 1:2:4 Plain Cement Concrete block of minimum 0.40x0.40x1.2m depth. 75mm thick plain cement concrete 1:4:8 shall be provided below concrete blocks. Posts shall be braced and held in plumb position and true alignment and elevation until concrete has set.
5. Fence fabric shall not be installed until concrete has cured a minimum

of 7 days.

6. Fence fabric panel shall be fixed to the post at 4 nos. MS flat each of 50x6, 75 long through 2 nos. of bolts (12mm diameter) on each flat.

12.7 Gate

1. The gate shall be made of medium duty M.S. pipe conforming to relevant I.S. with welded joints. The main frame (outer frame) of the gate shall be made of 40mm dia pipe and vertical pipes of 15mm dia @ 125mm spacing (maximum) shall be welded with the main frame. Two number of 1.25 mm thick and 125 mm wide MS plates (Horizontal) @ 500 mm centre to centre distance shall be welded on each gate leaf. Gate leaves shall be fixed with a vertical post of 2700 mm long two steel channels-150 welded together. A 8 mm thick 200X 200 mm size MS plate shall be welded at the bottom of channel frame.
2. The gates shall be fabricated with welded joints to achieve rigid connections. The gate frames shall be painted with one coat of approved steel primer and two coats of synthetic enamel paint.
3. The gates shall be provided with suitable locking arrangement welded on 4 mm thick MS plate on the gate leaf.
4. The main gate shall be 5.0m wide and shall be of double leaf type (as shown in the drawing). Next to the main gate, a men gate (1.25m wide single leaf) shall also be provided.
5. Steel roller shall be provided with the gate.
6. Gate shall be installed in location as shown in approved G.A. drawing.
7. The vertical post of gate shall be embedded in PCC foundation of 500 X500X1250 mm deep size.

13.0 BUILDINGS

13.1 GENERAL

The scope includes the design, drawing, engineering and construction including anti-termite treatment, plinth protection, DPC of Building including sanitary, water supply, electrification, false ceiling etc as applicable ,complete of control room building, fire fighting building, Auxiliary building and panel room. Electrification and air conditioning of building shall be provided as detailed in other sections of electrical portion.

13.2 CONTROL ROOM CUM ADMINISTRATIVE BUILDING (SEPERATE 11kV ROOM, GIS BUILDING, CONTROL ROOM IF ALTERNATIVE LAYOUT IS FOLLOWED)

GENERAL

The scope includes design, engineering and construction, including anti-termite treatment, plinth protection, DPC, peripheral drains, water supply, plumbing, sanitation, fire-fighting, electrification etc. of Control Room Building.

The Control Room Building and other building shall be of size as per the quantity available in BOQ approximately. It will be a single / double storeyed RCC Framed structure if constructed separately away from GIS hall. It shall be so designed that most of the area of switchyard is visible from the Control Room.

The building auxiliary services like air conditioning systems, fire protection and detection systems and all other miscellaneous services shall be designed in accordance with the requirements as specified in relevant section or elsewhere in this Specification. The building shall be constructed as per the design and drawings to be developed by the contractor. Tentative carpet area requirement for different rooms of control room cum administrative building is given as below for guidance to the contractor:

TENTATIVEAREA REQUIREMENTS (Will be decided during detail engineering)

• Control Room	As required
• ACDB & DCDB Room	As per requirement.
• Battery Room	As per requirement.
• Electrical Lab	
• Conference Room with attached Toilet	
• Telecom Room	As per requirement
• S/S-In-charge office with attached Toilet	
• Room for executives	
• Room for non-executives	
• Lobby -Reception	
• Corridor width	Minimum width of corridor shall be 1800 mm.
• Portico	
• Common Toilet-Men	
• Toilet for Women	
• Janitor Room	
• Pantry	
• Provision of shaft for electrical, sanitary, water supply facilities shall also be kept.	

Minimum Height to be maintained in case alternative layout is followed.

132kV GIS Building	9m
11kV Room	5m
Control Room Building	4.5m

If the layout with combined alternative is followed during DDE considering the pile Foundation, payment for Transformer hall will be made as per the rate of 132kV GIS Hall.

13.3 DESIGN CRITERIA

The Building shall be designed:

1. To the requirements of the International standards/British Standards.

2. for the specified climatic and loading conditions.

3. To adequately suit the requirements of the equipments and apparatus contained in the buildings and in all respects to be compatible with the intended use and occupancy.

4. with a functional and economical space arrangement.

5. To be aesthetically pleasing. Different buildings shall show a uniformity and consistency in architectural design, as far as possible.

6. To allow for easy access to the equipments as well as maintenance of the equipments.

7. Wherever access to the roof is required, RCC stair case shall be provided.

8. Fire retarding materials for walls, ceilings doors etc., which would prevent supporting or spreading of fire and wherever required, shall be decided by the bidder.

9. Suitable Expansion joints, wherever required, shall be provided as per Codal Provisions.

10. All the members of the buildings frame shall be designed for the worst combination of loads as per relevant British standard codes (B S Codes)/ equivalent International Standards.

11. Permissible stresses for different load combinations shall be taken as per relevant British standard codes (B S Codes)/ equivalent International Standards.

12. Seismic coefficient Method or Response spectrum method shall be used for seismic analysis of the building for Earthquake forces, as per relevant British standard codes (B S Codes)/ equivalent International Standards.

13. The architecture design of the buildings shall be as per the Nepalese Architecture & Style. Refer attached conceptual drawing. Drawing shall be developed as per requirement with complete details

13.4 DESIGN LOADS

1. Building structure shall be designed for the most critical combinations of dead loads, super-imposed loads, equipment loads, erection loads, wind loads, seismic loads etc. Any other incidental load, if anticipated, shall be duly accounted for in the design, and shall be clearly mentioned by the bidder.

2. Dead loads shall include the weight of structures complete with finishes, fixtures and partitions, and shall be taken as per relevant British standard codes (B S Codes)/ equivalent International Standards.

3. Super-imposed loads in different areas shall include live loads, minor equipment loads, cable trays, small pipe racks/hangers and erection, operation

and maintenance loads, wherever these loads are expected. Equipment loads shall constitute, if applicable, all load of equipments to be supported on the building frame.

AREA	Load
1. For Offices.	5.0 kN/m2
If higher than 5.0 kN/m2.	As per actual Requirement.
2. For Equipment Floors.	10.0 kN/m2
If higher than 10 kN/m2 (Based on Equipment weight and layout plans).	As per actual Requirement.
3. Staircases & Balconies.	5.0 kN/m2
4. Toilets.	2.0 kN/m2
5. Chequered Plate.	4.0 kN/m2
6. Cooridoors/Walkways.	3.0 kN/m2
7. Accessible Roofs.	1.5 kN/m2
8. Non-accessible Roofs.	0.75 kN/m2

4. Wind loads shall be calculated as per relevant British standard codes (B S Codes)/ equivalent International Standards. The Factors affecting the wind speed shall be taken based on the site conditions.

5. Earthquake loads shall be calculated as per relevant British standard codes (B S Codes)/ equivalent International Standards.

6. Wind forces and Seismic forces shall not be considered to act simultaneously.

7. All the load combinations to create worst combinations of loads shall be as per relevant International standards/British Standards.

8. Floors/ Slabs shall be designed to carry loads imposed by equipments, cables, piping, movement of maintenance trucks (if required) and any other load associated with the building. In general, floors shall be designed for live loads as per relevant British standard codes (B S Codes)/ equivalent International Standards. Cable and piping loads shall also be considered in addition to the live loads for floors where these loads are expected.

13.5 FLOORS, WALLS & ROOFS

1. All walls shall be non-load bearing in filled panel walls, in brickwork as per the specification. Minimum thickness of external walls shall be 230 mm (one brick) with 1:6 cement sand mortar. Ornamental Brick (Dachi Appa) shall be addedto the external walls as per design/ drawings. Partition walls if any shall be of 115 mm thick brick masonary in cement sand mortar (1:4).
2. All Floor/Roof slabs shall be regular beam slab construction. However, sunken RCC slab shall be provided in toilet areas as per the requirement.

3. False ceiling as per requirement shall be provided as detailed in Table-1 (Detailed Finish Schedule).
4. Minimum height of skirting above finished floor level shall be 150 mm. The skirting material shall match with the floor finish.
5. Minimum height of the parapet walls shall be 750 mm.
6. Ground floor finish shall be laid over 20 mm thick cement sand mortar,100 mm thick plain cement concrete (PCC) 1:4:8 (1 cement: 4 sand : 8 stone aggregates),100 mm thick local sand filling. The earth below ground floor shall be well rammed before laying sand filling.
7. First floor details shall comprise of finish as per schedule, 20 mm cement sand mortar and 50 mm thick PCC(1:4:8) over RCC slab.

13.6 DETAILS OF ROOF

Roof of the Building shall consist of Cast-in-situ RCC slab treated with a water proofing system which shall be an integral cement based treatment conforming to relevant British standard codes (B S Codes)/ equivalent International Standards. The water proofing treatment shall be of following operations:

(a) Applying and grouting a slurry coat of neat cement using 2.75 kg/m2 of cement admixed with proprietary water proofing compounds conforming to relevant British standard codes (B S Codes)/ equivalent International Standards. Over the RCC slab including cleaning the surface before treatment.

(b) Laying cement concrete using broken stone of size from 25mm to 100mm size with 50% of cement mortar 1:5 (1 cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to relevant British standard codes (B S Codes)/ equivalent International Standards over 20mm thick layer of cement mortar of min 1:5 (Cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to relevant British standard codes (B S Codes)/ equivalent International Standards to required slope and treating similarly the adjoining walls up to 300mm height including rounding of junctions of walls and slabs.

(c) After two days of proper curing applying a second coat of cement slurry admixed with proprietary water proofing compound conforming relevant British standard codes (B S Codes)/ equivalent International Standards.

(d) Finishing the surface with 20mm thick joint less cement mortar of mix 1:4 (1 cement: 4 course sand) admixed with proprietary water proofing compound conforming to relevant British standard codes (B S Codes)/ equivalent International Standards and finally finishing the surface with trowel with neat cement slurry and making of 300 x 300 mm square.

(e) The whole terrace so finished shall be flooded with water for a minimum period of two weeks for curing and for final test. All above operations to be done in order and as directed and specified by the Engineer-in-charge.

(f) Average thickness of water proofing shall be 120 mm and minimum thickness at khurra shall be 65 mm.

13.7 PARTITIONS

Partitions wherever provided, shall be made of powder coated aluminum frame provided with 5.5 mm thick clear glass or pre-laminated board depending upon the location of partition.

13.8 PLASTERING

External surfaces of buildings shall have 18 mm thick plaster in two layers, with the under layer 12mm thick 1:5 cement sand plaster and the top layer 6 mm thick 1:6 cement sand plaster. Inside wall surfaces shall have 12/15 mm thick 1:6 cement sand plaster. Rough surfaces shall have 15mm and smooth surface shall have 12 mm thick cement sand plaster.

All RCC ceilings shall be provided with 6 mm thick cement sand (fine) plaster (1:3) except for areas with false ceiling.

13.9 EXTERNAL PAINTING

External surfaces of the Control Room Building shall be painted with acrylic exterior flat paint as per manufacturer's specification and approval of NEA/Consultant.

13.10 DOORS, WINDOWS AND VENTILATORS

The schedule of doors, windows and ventilators of the Control Room Building shall be as per the detailed finish schedule given in Table-1 (Detailed Finish Schedule), and shall conform to the relevant British standard codes (B S Codes)/ equivalent International Standards. Rolling Steel shutters shall be provided as per the layout and requirements of the building. Main entrance door to control room building shall be made of powder coated aluminium frame with 5.5 mm thick glazing.

13.11 CABLE TRENCH INSIDE CONTROL ROOM BUILDING

All cable trenches inside the Control Room Building shall be covered with minimum 6mm thick steel chequered plate with suitable stiffeners.

13.12 PLINTH PROTECTION

750 mm wide and 50 mm thick plain cement concrete 1:2:4 (1 cement:2 sand:4 graded 20 mm nominal size stone aggregate) shall be laid over 75 mm thick dry stone aggregates well rammed and consolidated with interstices filled with local sand including smooth finishing top.

13.13 PLUMBING & SANITATION

1. All plumbing and sanitation works shall be executed to comply with the requirements of the appropriate bye-laws, rules and regulations of the Local Authority having jurisdiction over such matters. The Contractor shall arrange for all necessary formalities to be met with regards to the inspection, testing, obtaining approval and giving notices etc.

2. 'SINTEX' or an equivalent make PVC Roof water tank(s) of adequate capacity depending on the number of users for 24 hours storage shall be provided. However, a minimum of 2 nos. 1500 liter capacity shall be provided.

3. Chlorinated Polyvinyl chloride (CPVC) pipes having thermal stability for hot and cold water supply including all CPVC plain and brass threading conforming to relevant British standard codes (B S Codes)/ equivalent International Standards shall be used for internal piping works for water supply.

4. UPVC pipes conforming to relevant British standard codes (B S Codes)/ equivalent International Standards shall be used for sanitary works above ground level and RCC pipes shall be used for sanitary works below ground.

5. Each toilet shall have the following minimum fittings:

(i) WC (Western type) 390 mm high along with toilet paper roll holder and all other fittings, in toilets attached to conference room and S/S In-charge office; and WC (Indian Type) Orissa Pattern (580 x 440 mm) with all fittings shall be provided in common toilets.

(ii) Urinal (430 x 260 x 350 mm size) with all fittings and built-in-sensor for automatic flush after use.

(iii) Wash basin (550 x 400 mm) with all fittings.

(iv) Bathroom mirror (600 x 450 x 6 mm thick) with hard board backing.

(v) CP brass towel rail (600 x 20 mm) with CP brass brackets.

(vi) Soap holder and liquid soap dispenser.

(vii) Automatic Hand Dryer.

6. Water cooler for drinking water with adequate water storage facility shall be provided which shall preferably be located near pantry and away from the toilet block.

7. One no. stainless steel kitchen sink with Drain board (510 x 1040 x 178 mm bowl depth) for pantry shall be provided.

8. All fittings, fasteners, gratings shall be chromium plated.

9. All sanitary fixtures and fittings shall be of approved quality and type, manufactured by reputed manufacturers. All items brought to site must bear identification marks of the Manufacturer.

10. Contractor shall provide necessary nos. of septic tank and soak pit of adequate capacity to treat the sewage/sullage from the buildings.

11. Contractor shall undertake all other activities required to complete and commission the building.

13.14 BUILDING STORM WATER DRAINAGE

1. The building design shall provide for the collection of storm water from the roof. This water shall be drained to the main drainage system of the Sub-station.

2. PVC Rainwater down comer pipes conforming to relevant International standards/British Standards with water tight lead joints conforms to relevant British standard codes (B S Codes)/ equivalent International Standards shall be provided to drain off the rain water from the roofs. These pipes shall be suitably concealed with masonry work or cement concrete or cladding material. The number and size of down comer pipes shall be governed by relevant British standard codes (B S Codes)/ equivalent International Standards.

3. All drains inside the buildings shall have minimum 40 mm thick grating covers; and in areas where heavy equipment loads are envisaged, Pre-Cast RCC covers shall be provided in place of steel grating.

4. Suitable arrangements for draining out water collected from equipment blow

downs, leakages, floor washings, fire fighting etc. shall be provided for each floor.

13.15 DETAILED FINISH SCHEDULE

The detailed finish schedule for Control Room Building Cum Administrative building is given below:

Table- 1: DETAILED FINISH SCHEDULE

Sl. No.	LOCATION	FLOORING & SKIRTING 150 MM HIGH	WALL(INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
1.	Control Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of 10mm thick toughened glass by using suitable patch fittings/spider fittings. The glass shall extend horizontally from column to column and vertically from sill level of 0.75 m to bottom of lintel/roof beam. All doors shall be glazed powder coated aluminium doors with 5.5.mm Thk. Glazing.
2.	Conference Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing
3.	S/S In-charge Room.	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
4	Office Rooms	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
5.	Electrical/Electronics Test Lab./Telecom Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
6.	ACDB & DCDB Room	62mm thick cement concrete flooring with metallic hardener topping . Skirting shall be of cement sand plaster.	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool. Windows/ventilator shall be of powder coated aluminium with 4mm glazing.

Sl. No.	LOCATION	FLOORING & SKIRTING 150 MM HIGH	WALL(INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
7.	Battery Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool. Windows/ventilator shall be of powder coated aluminium with 4mm glazing.
8.	Reception/Lobby	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
9.	Corridor	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminum doors with 5.5.mm thk. Glazing.
10.	Portico	Cast-in-situ 52mm thk. Cement concrete with metallic hardener .	Granite cladding	Oil bound washable distemper on smooth surface applied with plaster of paris putty	All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
11.	Toilet	Ceramic tiles	DADO glazed tile 2100mm high, oil bound washable distemper above DADO	Oil bound washable distemper	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters made of pre-laminated particle board with powder coated aluminium frame.
12.	Janitor room	Ceramic tiles with white cement	Vitrified tiles 8mm thick size 600 x 600mm	Oil bound washable distemper	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters made of pre-laminated particle board with powder coated aluminium frame.

*Providing and fixing 15mm thick approximately 600 X 600mm Mineral fiber board panel false ceiling and making cut-outs for electrical fixtures, AC diffusers, openable access etc complete with silhouette profile system with 15mm wide flange incorporating 6mm central recess white / black main runners at 1200mm centre-centre and not greater than 600mm from the adjacent wall. The cross tees shall be provided to make a module of approximately 600mm X 600mm by fitting 600 mm long cross tees centrally placed between 1200 mm long cross tees .Cross tees also have 15mm wide flange incorporating 6mm central recess white/black. The module formed

above shall be anchored to the slab with channels or angles, suspenders as per manufacturer's specifications.

13.16 SUBMISSIONS

The following information/documents/drawings shall be submitted for review and approval:

1. Structural design calculations, Structural drawings (including construction/ fabrication), both in hard and soft copies, for all reinforced concrete and structural steel structures.

2. Fully dimensioned and detailed floor plans, cross-sections, longitudinal sections and elevations identifying the major building components.

3. Product information of building components and materials, including walls, partitions, flooring, ceilings, roofing, doors, wall paneling and windows and building finishes along with BOQ.

5. A detailed schedule of building finishes including colours schemes along with item description.

6. A door & window schedule showing door & window types and locations, lock sets and latch sets and other door hardware along with item details.

Approval of the above information shall be obtained before ordering materials or starting construction/fabrication, as applicable.

13.17 FALSE CEILING

Providing and fixing seamless ceiling with Gypsum board of 12mm thick fixed to the underside of GI frame work. The GI is fixed to the roof Slab with metal expansion fastener. The joint shall be finished with joint paper tape by using jointing Compound recommended by manufacturer with the approval of NEA/Consultant. The rate includes for all necessary cutting of ceiling for the fixing of complete fixtures.

13.18 Under deck Insulation

The method of fixing shall consist of slotted M.S. angles of appropriate size (minimum 65x50x2mm) fixed to soffit of RCC roof slab at 600mm centres in both directions by Rawl plugs of adequate strength. The slots shall have 14g G.I. tie wire drawn through them.
50mm thick insulation mat Fibreglass Crown - 100 or equivalent shall, be made out of fibre-glass or approved equivalent conforming to IS: 8183, backed with 34g aluminium foil and 22g x 12mm mesh wire netting. The net shall be stretched tightly across the slotted angles or slotted plates holding it in place by means of wires. The joints of the wire netting shall be butted and tightly laced down with 14g G.I. wire. The system shall be got approved from NEA/Consultant.

13.19 ELECTRIFICATION

All electrification shall be executed as per details specified elsewhere in the technical specification. All details shall be as per relevant British standard

codes (B S Codes)/ equivalent International Standards.

14.0 FIRE FIGHTING PUMP HOUSE BUILDING

GENERAL

The scope includes design, engineering and construction, including anti-termite treatment, plinth protection, DPC, peripheral drains, fire-fighting, electrification etc. of fire fighting pump house building.

The fire fighting pump house building shall be essentially single storied reinforced cement concrete (RCC) framed Building. The building auxiliary services like internal electrification, fire protection systems shall be designed in accordance with the requirements as specified in relevant section of technical Specification. The design and layout of foundation of various pumps and cable trenches inside building shall be prepared by the contractor as per requirement of proposed fire fighting system.

AREA REQUIREMENTS

Dimensions of the Building shall be decided by the bidder depending upon the requirement. The approximate size of building shall be as per attached drawing. The height of building shall be measured from finished floor level to top of roof slab.

DESIGN CRITERIA

The Building shall be designed:

1. To the requirements of the relevant/British standards/ equivalent International standards quoted therein, and as specified in this specification.

2. for the specified climatic and loading conditions.

3. To adequately suit the requirements of the pumps and fire fighting system contained in the buildings and in all respects to be compatible with the intended use and occupancy.

4. with a functional and economical space arrangement.

5. To be aesthetically pleasing. Different buildings shall show a uniformity and consistency in architectural design, as far as possible.

6. To allow for easy access to the equipments as well as maintenance of the equipments.

7Spiral staircase with 1.5 m diameter shall be provided for access to the roof.

8. With, wherever required, fire retarding materials for walls, ceilings doors etc., which would prevent supporting or spreading of fire and shall be decided by the bidder.

9. Suitable Expansion joints, wherever required, shall be provided as per Codal Provisions.

10. All the members of the buildings frame shall be designed for the worst combination of Loads as per relevant International standards/British Standards.

11. Permissible stresses for different load combinations shall be taken as per

relevant International standards/British Standards.

12. Seismic analysis of the building for Earthquake forces shall be carried out as per relevant International standards/British Standards.

DESIGN LOADS

1. Building structure shall be designed for the most critical combinations of dead loads, super-imposed loads, equipment loads, wind loads, seismic loads etc. Any other incidental load, if anticipated, shall be duly accounted for in the design, and shall be clearly mentioned by the bidder.

2. Dead loads shall include the weight of structures complete with finishes, fixtures and partitions, and shall be taken as per relevant International standards/British Standards.

3. Super-imposed loads in different areas shall include live loads, cable trays, and small pipe racks/hangers, piping system and erection, operation and maintenance loads wherever these loads are expected.

1) Non-accessible Roof – 0.75 kN/m2.

2) Accessible Roof – 1.5 kN/m2

4. Wind loads shall be calculated as per relevant International standards/British Standards. The Factors affecting the wind speed shall be taken based on the site conditions.

5. Earthquake loads shall be calculated as per relevant International standards/British Standards.

6. Wind forces and Seismic forces shall not be considered to act simultaneously.

7. All the load combinations to create worst combinations of loads shall be as per relevant International standards/British Standards.

7. Floors shall be designed to carry loads imposed by Pumps, cables, piping, movement of maintenance trucks (if required) and any other load associated with the building. In general, floors shall be designed for live loads as per relevant International standards/British Standards. Cable and piping loads shall also be considered in addition to the live loads for floors where these loads are expected.

FLOORS, WALLS & ROOFS

The floor shall be constructed with 52 mm thick cement concrete finished with metallic hardener topping. 150 mm thick base plain cement concrete layer,100 mm thick compacted local sand filling and 200 mm thick hard core of stone ballast with interstices filled with local sand shall be laid below cement concrete flooring top. The earth filling below floor shall be well rammed.

PLASTERING

External surfaces of building shall have 18 mm thick plaster in two layers, with the under layer 12mm thick 1:5 cement sand (coarse) plaster and the top layer 6 mm thick 1:6 cement sand (coarse) plaster. Inside wall surfaces shall have 12/15 mm thick 1:6 cement sand (coarse) plaster. Rough surfaces shall have 15mm and smooth surface shall have 12 mm thick cement sand plaster. Ceiling shall be plastered with 6 mm thick cement sand plaster (1 Cement: 3

Sand).

EXTERNAL PAINTING

External surfaces of the Building shall be painted with acrylic exterior flat paint as per manufacturer's specification and approval of NEA/Consultant.

DOORS, WINDOWS AND VENTILATORS

The schedule of doors, roller shutter, windows and ventilators of the Building shall be of steel as per relevant International standards/British Standards. Rolling Steel shutters shall be provided as per the layout and requirements of the building. Main entrance door to the Building shall be MS door frame with M.S. sheet double shutter. Windows and ventilators shall be of steel made of hot rolled sections windows and ventilators shall be provided with 5.5 mm thick glazing.

CABLE TRENCH INSIDE FIRE FIGHTING PUMP HOUSE BUILDING

All cable trenches inside the building shall be covered with minimum 6 mm thick steel chequered plate with suitable stiffeners. The structural steel used for cable tray support, earthing cleat, chequerred plates for internal cable trenches of fire fighting pump house building shall be measured and paid under miscellaneous steel item of BPS

PLINTH PROTECTION

750 mm wide plinth protection all-around the building shall be provided. Plinth protection shall comprise of 50 mm thick PCC (1:2:4) laid over 75 mm thick well compacted stone aggregates with interstices filled with local sand including smooth finishing top.

PARAPET

230 mm thick and 750 mm high brick parapet shall be provided. The parapet shall be plastered with cement sand plaster (1:6).

BUILDING STORM WATER DRAINAGE

1. The building design shall provide for the collection of storm water from the roof. This water shall be drained to the main drainage system of the Sub-station.
2. PVC down comer pipes conforming to relevant International standards/British Standards with water tight lead joints or medium class galvanized mild steel pipes conforms to relevant International standards/British Standards shall be provided to drain off the rain water from the roofs. These pipes shall be suitably concealed with masonry work or cement concrete or cladding material.
3. Suitable arrangements for draining out water collected from equipment blow downs, leakages, floor washings, fire fighting etc. shall be provided, if found necessary.

DETAILS OF ROOF

Roof of the Building shall consist of Cast-in-situ RCC slab treated with a water proofing system which shall be an integral cement based treatment conforming to relevant International standards/British Standards. The water proofing treatment shall be of following operations:

(a) Applying and grouting a slurry coat of neat cement using 2.75 kg/m2 of cement admixed with proprietary water proofing compounds conforming to relevant International standards/British Standards over the RCC slab including cleaning the surface before treatment.
(b) Laying cement concrete using broken stones 25mm to 100mm size with 50% of cement mortar 1:5 (1 cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to relevant International standards/British Standards over 20mm thick layer of cement mortar of min 1:5 (Cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to relevant International standards/British Standards to required slope and treating similarly the adjoining walls up to 300mm height including rounding of junctions of walls and slabs.
(c) After two days of proper curing applying a second coat of cement slurry admixed with proprietary water proofing compound conforming to relevant British standard codes (B S Codes)/ equivalent International Standards. (d) Finishing the surface with 20mm thick joint less cement mortar of mix 1:4 (1 cement: 4 course sand) admixed with proprietary water proofing compound conforming to relevant International standards/British Standards and finally finishing the surface with trowel with neat cement slurry and making of 300 x 300 mm square.
(e) The whole terrace so finished shall be flooded with water for a minimum period of two weeks for curing and for final test. All above operations to be done in order and as directed and specified by the Engineer-in-charge.

(f) Average thickness of water proofing shall be 120 mm and minimum thickness at khurra shall be 65 mm.

DETAILED FINISH SCHEDULE

The detailed finish schedule for Fire Fighting Pump House Building is given below:

Table- 2 : DETAILED FINISH SCHEDULE

S.N	LOCATION	FLOORING & SKIRTING 150 MM HIGH	WALL(INTERNAL)	CEILING	LLER SHUTTER,DOOR, WINDOWS & VENTILATOR
1.	Fire Fighting Pump House	62mm thick cement concrete flooring with metallic hardener topping .skirting shall be of cement sand plaster.	Oil bound washable distemper on masonry portion.	As per Manufacturer details.	Windows/ ventilator shall be hot rolled steel section with 5.5mm thick glazing. Entry door shall be of M.S. Sheet double shtter and rolling shutter shall be of steel.

ELECTRIFICATION

All electrification shall be executed as per details specified elsewhere in the technical specification. All details shall be as per relevant British standard codes (B S Codes)/ equivalent International Standards.

15.0 AUXILLIARY BUILDING

Auxiliary building shall be single storeyed reinforced cement concrete framed structure building. The size of building shall be about 15 m X 20 m approximately. However, bidder may suggest suitable size as per his requirement. The building shall house 11 kV indoor switchgear.

The details like floor details, door, windows, ventilator, internal finish details etc shall match with respective room of RCC control room building. External finish shall also match with control room building.

1. Contractor shall develop the layout in such a way that its aesthetic look is pleasant. The design of Auxiliary building shall be carried out as per relevant International standard/British Standards.
2. The internal cable trenches, panel etc shall be designed by the contractor as per requirement. Layout of these cable trenches, panel layout shall also be prepared by the contractor as per requirement.

CABLE TRENCH INSIDE AUXILLIARY BUILDING

All cable trenches inside the building shall be covered with minimum 6 mm thick steel chequered plate with suitable stiffeners. The structural steel used for cable tray support, earthing cleat, chequerred plates for internal cable trenches shall be measured and paid under miscellaneous steel item of BPS.

ELECTRIFICATION

All electrification shall be executed as per details specified elsewhere in the technical specification. All details shall be as per relevant British standard codes (B S Codes)/ equivalent International Standards.

16.0 FIRE FIGHTING WATER TANK

1. Reinforced cement concrete water tank with two compartments each of size 9.31 m X 9.31 m and capacity of 317 Cubic Meter shall be constructed. A sump of size 2.5 m X 2.5 m x 0.5 m deep shall be provided at one corner in each compartment. Finished floor level of water tank shall be about 200 mm above finished ground level of switch yard. Base slab of water tank shall rest on 75 mm thick plain cement concrete (1:3:6) laid over 800 mm thick well compacted stone packing (Stone Size from 25 mm to 150 mm) with interstices filled with local sand.
2. The roof of Water tank shall be of Coloured. The sheet shall be supported on suitable steel purlins etc. Suitable gutter shall be provided to drain off rain water.
3. A steel door of size 900 mm X 1850 mm with single shutter made of hot rolled steel section and MS steel door frame shall be provided at about (+) 4.5 m level for access inside water tank.
4. Suitable MS rungs of 20 mm diameter rod @ 300 mm centre to centre staggered on both faces (External and internal) of wall at suitable location shall be provided to act as ladder.
5. Integral water proofing compound of reputed brand shall be added to the concrete and plaster of water tank. Quantity of compound shall be as per manufacturer's recommendation.
6. All inserts, nozzles, pipe sleeves etc shall be provided during concreting at suitable locations as per fire fighting system. The size is to be decided by the contractor to meet the requirement.

7. Inside surfaces of water tank shall be plastered with cement sand plaster (1 Cement:6 sand).
8. The outer surface of water tank shall be painted with the paint matching with Fire fighting pump house building.
9. P.V.C. water stopper shall be provided at all construction joints of water tank.
10. The design of water tank shall be carried out as per relevant British standard codes (B S Codes)/ equivalent International Standards.

17.0 SWITCH YARD PANEL ROOM

RCC switchyard panel room with the size as mentioned in bid price schedule shall be constructed. RCC sloped roof shall be provided. The sloped roof shall be covered with suitable tiles to enhance aesthetic look. The floor details (sand, PCC, cement mortar)shall match with that of other buildings. The floor finish shall be provided with vitrified tiles. Plinth protection as per other buildings. The finish details like painting, plaster shall match with other buildings. Doors shall be aluminium glazed .
All walls, floor and roof shall be provided with suitable chicken wire mesh which shall be connected with earthing system through 75 x 12 mm MS flat. Air conditioning and internal electrification of panel room shall be done as mentioned in respective technical specification and BPS in Electrical portion. The size and layout of internal cable trenches of panel room shall be decided by the contractor as per requirement. All cable trenches inside the panel room shall be covered with minimum 6 mm thick steel chequered plate with suitable stiffeners. The structural steel used for cable tray support, earthing cleat, chequerred plates for internal cable trenches shall be measured and paid under miscellaneous steel item of BPS
The design shall conform to relevant British standard codes (B S Codes)/ equivalent International Standards.

18.0 CAR PARKING SHED

Aesthetically pleasant RCC car parking shed as per design and drawings as developed by the contractor and suitable to park 10/5 cars as per BoQ shall be constructed at suitable location to be decided during detailed engineering stage

19.0 WATER SUPPLY

(i) Water shall be made available by NEA/consultant at any feasible point within substation boundary at single point to the contractor. Contractor shall state the total water requirement both in terms of quantity and head to NEA/Consultant.

(ii) The contractor shall carry out all the plumbing/erection works required for supply of water in control room cum administrative building beyond the single point as at (i) above.

(iii) The contractor shall carry out all the plumbing/erection works required for supply of water to Fire Fighting pump house beyond the single point as at (i) above.

(iv) The details of tanks, pipes, fittings, fixtures etc for water supply are given elsewhere in the specification under respective sections.

(v) A scheme shall be prepared by the contractor indicating the layout and details of water supply which shall be got approved by NEA/Consultant before actual start of work including all other incidental items not shown or specified but as may be required for complete performance of the works. All drawings shall be prepared by the contractor for approval of NEA/Consultant.

(vi) Bore wells and pumps for water supply is not in the scope of contractor.

20.0 SEWERAGE SYSTEM

(i) Sewerage system shall be provided for all buildings wherever applicable.

(ii) The Contractor shall construct septic tank and soak pit suitable for 50 and 10 users each for control room building, transit camp and town ship buildings is constructed .If septic and soak pit system is not acceptable by local Nepal Authority, contractor will have to install suitable sewerage system as per local statutory requirement.

(iii) The system shall be designed as per relevant British standard codes (B S Codes)/ equivalent International Standards. All drawings shall be prepared by the contractor for approval of NEA/Consultant.

21.0 GIS HALL CUM CONTROL ROOM BUILDING

21.1 Control Room and GIS Hall

The GIS building shall be of pre-engineered steel structure. Control room building, if attached to GIS hall, shall be of pre-engineered steel structure similar to GIS hall and shall be RCC framed structure, if it is not connected with GIS hall. In case of steel control room building all walls shall be of brick masonry and roof of ground floor shall be of RCC. Internal access to the GIS hall from control room building shall be provided.

Material specification and other details for construction of Pre-engineered steel building shall be as described in subsequent paragraphs. The base plate of steel columns shall be mounted on the RCC foundation by means of hot dip galvanised foundation bolts (Galvanisation of 610 gms/Sq. M). In order to facilitate inspection and maintenance, the structures shall be provided with climbing devices. Separate fire escape doors shall also be provided in the GIS Building.

Panels shall be kept in an air-conditioned enclosure. A glazed partition made of aluminium frame and 5.5mm thick glass shall be provided between GIS hall and panel room. The glazing shall be kept at a sill level of 0.9 m above floor level. The height of glazing shall be

minimum 2.1 m above sill level.

Walkway of width of 1.0m shall be provided at gantry girder level on the two longer side of GIS hall along with climbing arrangement to facilitate maintenance of crane.

All the material required for Pre-engineered (steel) building shall be procured from reputed manufacturer for which prior approval shall be obtained. Manufacturing of various parts of the building shall start only after approval of "Manufacturing Quality Plan to be prepared by the bidder during detailed engineering stage". Complete material shall be offered for inspection by QA&I department of Consultant/NEA before dispatch. Inspection shall be carried out based on assembly (fabrication) drawings approved by consultant/NEA and "BILL OF MATERIAL" & Shop drawing prepared by the Manufacturer and certified by the Contractor for its correctness. Approval of BOM and shop drawing from employer is not required.

21.2 **Material Specification**

21.2.1 Primary members fabricated from plate sand sections with minimum yield strength of 345 Mpa or to suit design by continuous swelding.

21.2.2 Secondary members for Purlins and Grits shall conform to the physical specification of ASTMA570(Grade50)or equivalent BS/equivalent international standard shaving a minimum yield strength of 345 MPa. The minimum thick ness of secondary members shall be 2.5 mm.

21.2.3 Rod / ANGLE/pipe bracing shall conform to the physical specification of relevant BS/equivalent international standards of minimum 245MpaYieldStrength

21.2.4 All hot rolled sections shall conform the physical specifications of BS/equivalent international standards. All other miscellaneous secondary members shall have minimum yield strength of 250 MPa.

21.3 **DESCRIPTION**

21.3.1 **PRIMARY MEMBERS:**

Primary structural framing shall include the transverse rigid frames, columns, corner columns, end wall wind column sand crane gantry girder sand Frames at Door openings.

21.3.2 **SECONDARY MEMBERS:**

Secondary structural framing shall include the purlins, girts, eaves truts, wind bracing, flange bracing, base angles, clips, flashing sand other miscellaneous structural parts. Suitable wind bracings sag rods to be reckoned while designing the structure.

21.3.3 **PURLINS, GIRTS,CLIPS:**

Purlins, girts and clips should be of Pre Galvanised steel of 345Mpa havinga coating thickness of 275 gms/sq. M inclusive of both sides.

21.3.4 ROOF SHEETING

Factory assembled 50mm thick puff (density 40kg/cu.m. +2 Kg/cu m as per BS/equivalent International Standards) sandwiched panels shall be provided. These panels shall be made of puff insulation sandwiched between two high tensile steel sheets each of 0.5 mm thickness. The material of sheets shall confirm to ASTM 792 M Grade 345B with minimum yield strength of 345 Mpa .The steel sheets shall be provided with hot dip coating of Zinc aluminium alloy (approximately 55% Al , 43.5% Zn and 1.5 % silicon) .Total mass of zinc aluminium alloy coating shall be minimum 200 gm/Sq. m inclusive of both sides. The tolerance of base metal thickness (BMT) of steel sheet shall be as per BS/equivalent International Standards . After hot dip coating of Zinc aluminium alloy ,the sheet shall be provided with steel primer and silicon modified polyester (SMP) paint. The total thickness of primer and paint shall be 40 microns inclusive of both sides (TCT) comprising of 20 microns of SMP paint on top surface and 10 microns of backer coat (polyester coat) on back surface over 5 microns thick primer each on both surfaces with inorganic pigments coated free from heavy metals. Painting shall conform to BS/equivalent International Standards . In case SMP paint is not available, Super Durable Polyester paint (SDP) can also be used by the bidder without cost implication to NEA.

21.3.5 **Wall Panels**

Wall panel material specifications shall be same as roof panels.

21.3.6 **SHEETING FASTENERS:**

Standard fasteners shall be selft aping zinc plated metal screws with EPDM bonded zinc plated washers. All screws shall be colour coated to match roof and wall sheeting.

21.3.7 **SEALER**:

This is to be applied at all side lap sand end laps of roof panel sand around self lashing windows. Sealer shall be pressure sensitive elastomeric Butyl tapes. The sealer shall be non-asphaltic, non-shrinking and non toxic and shall be superior adhesive metals, plastics and painted at temperatures from 51°C to +104°C.

21.3.8 **CLOSURES**:

Solid or closed cell closures matching the profiles of the panel shall be installed along the eaves, rake and other locations specified on drawings.

21.3.9 **FLASHING AND TRIM:**

Flashing and/or trim shall be furnished at the rake, corners, eaves, and framed opening sand wherever necessary to provide weather tightness sand finished appearance. Colour shall be matching with the colour of wall. Material shall be 26 gauge thick conforming to the physical specifications of sheeting.

21.3.10 **WALL LIGHTS:**

For day lighting purpose of GIS hall, minimum 2mm thick approved translucent polycarbonate sheet shall be provided for wall lighting in addition to windows for at least 10% of wall area on upper portion of both long walls. The polycarbonate sheet shall be fixed with necessary EPDM, rubber gasket, Silicon Sealant, cold forged fastener, aluminium profile etc. including MS supporting structural steel (conforming to relevant BS/equivalent International Standards) frame to ensure water tight arrangement.

21.3.11 **GUTTERS AND DOWN SPOUTS:**

Gutters and down spouts shall be adequately designed to ensure proper roof drainage system. Material shall be same as that of sheeting with matching colour.

21.3.12 PAINTING OF BUILT UP STEEL FRAMES, CRANE GANTRY GIRDERS, FRAMES AT DOOR OPENINGS, WALK WAY STEEL AND LADDER:

The built up frame ,Crane gantry girders, frames for door openings and steel for walk way shall be applied with a priming coat of standard steel primmer followed by one coat coating of epoxy paint and final coating of PU (Minimum 100 Micron) . The steel work for aforesaid members shall be provided with suitable treatment of shot blasting before application of steel primer. The steel material of ladder shall be galvanized.

21.3.13 COLOUR SCHEME:

Colour Scheme matching with local aesthetic and best industry practices shall be submitted by vendors for approval of NEA. Three alternatives of coloured isometric views with colour codes shall be submitted for approval. The monotony of external colour of sheet shall be avoided by providing vertical bands of different coloured sheet. The colour of roof sheet shall be light coloured to minimize heat absorption. External and internal masonry walls shall be painted with suitable colour matching with colour of steel sheet.

21.4 **CONNECTIONS:**

21.4.1 **SITECONNECTIONS**

a) All primary bolted connections shall be provided with galvanized high strength bolts, washers, nuts conforming to

specifications of relevant standard.

b) All secondary bolted connections shall be furnished with bolts, nuts, washers conforming to the specifications of grade 4.6 of relevant standard or ASTM-A307.

21.4.2 **SHOPCONNECTIONS**

All shop connections shall be welded with appropriate arc welding process and welding shall be in accordance with relevant standard, AWSD 1.1. as appropriate. The Webs should be welded on to the flanges at both the faces at top and bottom for columns, beams and crane girders. Weld material should have strength more than the parent metal.

21.4.3 **ROOF & WALLBRACINGS**

Roof and wall bracings shall have minimum yield strength of 250Mpa and shall conform to the specifications of relevant standard.

21.5 INTERNAL FINISH SCHEDULE

The finishing schedule is given in subsequent clauses and table-1. Areas not specified in finish schedule shall be provided with vitrified tile flooring, and Premium Acrylic emulsion paint oil bound washable distemper over two mm thick putty. Paints used in the work shall be of best quality specified in relevant standard.

21.5.1 FLOORING

Flooring in various rooms of control room building and GIS hall shall be as per detailed schedule given in Table -1.

21.5.2 WALLS

All walls of control room building shall be non-load bearing walls. Min. thickness of walls shall be 230 mm (one brick) with 1:6 cement sand mortar. Partition walls (115mm thick) in toilets and pantry can be half brick walls with 1:4 cement sand mortar and two nos. 6mm dia MS bars at every third course.

In GIS building and the attached relay room 230mm thick brick wall shall be provided up to roof level of relay room attached to GIS hall. 50mm thick puff sandwiched panels as described above shall be provided above brick wall.

21.5.3 ROOF

(A) GIS Building and Control Room (if steel structure)

Roofing Panel: 50mm thick puff (density 40kg/cu.m.) sandwiched panels shall be provided as described in previous clauses.

21.6 CABLE TRENCH IN GIS HALL

All cable trenches in GIS hall shall be covered with minimum 6mm thick steel chequered plate with suitable stiffeners. Chequered plate shall be painted with two or more coats of Epoxy paint as per relevant standards.

21.7 EXTERNAL PLASTER AND PAINTING

External plaster 18mm thick shall be of 1:6 cement sand plaster in two layers. External surface of the control room building and GIS building (brick wall portion) shall be painted with Premium acrylic smooth exterior paint with silicon additives over and including priming coat of exterior primer as per relevant standards.

21.8 INTERNAL FINISH SCHEDULE

Internal finish Schedule for control room building and GIS hall is given in Table - 1 below:

Table -1

S.No.	LOCATION	FLOORING & SKIRTING 150MM HIGH	WALL (INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
1.	Control Room	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of 10mm thick toughened glass by using suitable patch fittings/spider fittings. The glass shall extend horizontally from column to column and vertically from sill level of 0.75 m to bottom of lintel/roof beam. All doors shall be glazed powder coated aluminium doors with 5.5.mm Thk. Glazing.
2.	Conference	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
3.	In-charge Room	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
4	Other Office Rooms	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
5.	Electronics Test Lab.	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed

S.No.	LOCATION	FLOORING & SKIRTING 150MM HIGH	WALL (INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
			surface applied with plaster of paris (2 mm thick)		powder coated aluminium doors with 5.5.mm thk. Glazing.
6.	ACDB & DCDB Room	62mm thick cement concrete flooring with metallic hardener topping	Oil bound washable distemper on smooth surface applied with plaster of paris putty as perrelevant standards	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool. Windows/ventilator shall be of powder coated aluminium with 4mm glazing.
7.	Battery room	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool. Windows/ventilator shall be of powder coated aluminium with 4mm glazing.
8.	Lobby	18mm thick granite flooring	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
9.	Corridor	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
10.	Portico	18mm thick granite flooring	Granite cladding	Acrylic emulsion paint over a coat of cement primer on smooth surface applied with readymade putty 1 mm thick as perrelevant standards	All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
11.	Toilet	Ceramic tiles	DADO glazed tile 2100mm high, oil bound washable distemper above DADO	Acrylic emulsion paint over a coat of cement primer on smooth surface applied with readymade putty 1 mm thick as per relevant standards	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters made of pre-laminated particle board (with powder coated aluminium frame.

S.No.	LOCATION	FLOORING & SKIRTING 150MM HIGH	WALL (INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
12.	Janitor room	Ceramic tiles	DADO glazed tile 2100mm high, oil bound washable distemper above DADO	Acrylic emulsion paint over a coat of cement primer on smooth surface applied with readymade putty 1 mm thick as per relevant standards	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters made of pre-laminated particle board with powder coated aluminium frame.
13.	GIS Hall	62mm thick cement concrete flooring with metallic hardener topping (DSR item code 11.5). Two coats of PU coating over the metallic hardener shall be provided. The final coat of PU shall be applied after Installation of equipments. Total thickness of PU coats shall be minimum 300 microns.	Premium Acrylic emulsion paint having Volatile Organic Compound (VOC) content less than 50 gms per liter of approved brand and manufacturer on smooth surface applied with plaster of paris (2 mm thick) over approved primer coat .	In case of RCC roof, ceiling shall be finished with Premium Acrylic emulsion paint having Volatile Organic Compound (VOC) content less than 50 gms per liter of approved brand and manufacturer over approved primer coat	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters with powder coated aluminium frame.
14.	Panel/Relay Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
15.	AHU Room	62mm thick cement concrete flooring with metallic hardener topping	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	Acrylic emulsion paint over a coat of cement primer on smooth surface applied with readymade putty 1 mm thick as per relevant standards	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters with powder coated aluminium frame.

21.9 Staircase shall be provided with stainless steel railing and 18mm thick granite slab in risers and treads.

21.10 DOORS AND WINDOWS

The details of doors and windows of the control room building shall be as per finish schedule Table-1 conforming to relevant BS/equivalent International Standards. Rolling steel shutters shall be provided as per layout and requirement of buildings. Main entrance door to control room building shall be made of powder coated aluminium frame with 5.5 mm thick glazing.

21.11 PARTITION

Partitions, if required, shall be made of powder coated aluminium frame provided with 5.5 mm thick clear glass or pre- laminated board depending upon the location of partition.

21.12 FALSE CEILING

Fifteen millimeter thick densified regular edged eco friendly light weight calcium silicate false ceiling as per relevant standards shall be provided in the areas specified in Finish Schedule.

21.13 PLUMBING & SANITATION

(i) All plumbing and sanitation shall be executed to comply with the requirements of the appropriate bye-laws, rules and regulations of the Local Authority having jurisdiction over such matters. The Contractor shall arrange for all necessary formalities to be met in regard to inspection, testing, obtaining approval and giving notices etc.

(ii) PVC "SYNTEX" or equivalent make Roof water tank of adequate capacity depending on the number of users for 24 hours storage shall be provided. Minimum 2 Nos 1500 liter capacity shall be provided.

(iii) Chlorinated Polyvinyl chloride (CPVC) pipes having thermal stability for hot and cold water supply including all CPVC plain and brass threading conforming to relevant standards shall be used for internal & external piping work for potable water supply.

(iv) UPVC pipes conforming to relevant standards shall be used for sanitary works above ground level and RCC pipe shall be used for works below ground.

(v) Each toilet shall have the following minimum fittings.

(a) WC (Western type) 390 mm high with toilet paper roll holder and all fittings in toilets attached to conference and sub-station in charge office.

and

WC (Indian Type) Orissa Pattern (580 x 440 mm) with all fittings shall be provided in common toilets.

(b) Urinal (430 x 260 x 350 mm size) with all fittings.

(c) Wash basin (550 x 400 mm) with all fittings.

(d) Bathroom mirror (600 x 450 x 6 mm thick) hard board backing

(e) CP brass towel rail (600 x 20 mm) with C.P. brass brackets

(f) CP Soap holder and CP liquid soap dispenser.

(g) All urinals and washbasins shall be provided with built in sensors.

(vi) Water cooler for drinking water with adequate water storage

facility shall be provided and located near control room and not near toilet block.

(viii) 1 no. stainless steel kitchen sink with Drain board (510 x 1040 x 178 mm bowl depth) for pantry shall be provided.

(ix) All fittings, fastener, grating shall be chromium plated.

(x) All sanitary fixtures and fittings shall be of approved quality and type manufactured by well known manufacturers. All items brought to site must bear identification marks of the type of the Manufacturer.

(xi) Stoneware pipes may be used for soil, waste and drain pipes in the areas not subjected to heavy loads otherwise Heavy duty cast iron pipes may be used.

(xii) Contractor shall provide septic tank and soak pit of adequate capacity to treat the sewage / sullage from the building.

(xiii) Contractor shall implement all other jobs required to complete and commission the building.

22.0 Residential and Non Residential Buildings

All buildings shall be constructed as RCC Framed buildings. The architectural features shall match with local architecture. For preparation of architectural drawings of these buildings, the contractor shall depute local Architect of repute who must be well aware of local bye laws and statutory clearances required for residential and guest house/field hostel/Transit camp building from Nepal Authority. The buildings shall be designed for loads as applicable in accordance to relevant standards. The plumbing and sanitary works including over head water tanks placed on terrace and for each building shall also be deemed to be included in the civil works of building. Construction of man holes/chambers, connection of internal plumbing and sanitary system with external sewerage and water supply system shall be considered as a part of civil works of buildings. These works will not be measured and paid separately.

The details and approximate size of various buildings are as below:

(a) D-Type Quarter: One Number with size 15 m x 14 m-Single Storeyed.
(b) C-Type Quarters: Four Numbers: One Block of four quarters having two quarters on ground floor and two quarters on first floor. Block will have an area of about 12 m X 25 m on each floor.
(c) B-Type Quarters: Four Numbers : One Block of four quarters having two quarters on ground floor and two quarters on first floor. Block will have an area of about 10 m X 25 m on each floor.

The area for above buildings has been indicated as tentative. The Contractor shall adopt the suitable size to accommodate various rooms and services for each type of building. The size of various rooms shall be in accordance to local laws.

The finish schedule has been tabulated as below:

Schedule of Finishes for Quarters					
Floor	**Room Name**	**Flooring**	**Walls**	**Ceiling**	**Remarks**
Typical Flat	Living	Polished Vitrified Tiles	Plastered & Painted OBD Over 2mm POP Finish	Plastered & Painted with Wash Over 2MM POP	
	Living Balcony	Antiskid Vitrified Tiles	Plastered & Painted with Exterior Paint	DO	For Qrts. As applicable
	Kitchen	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M IS 15622	Plastered & Painted OBD Over 2mm POP Finish	DO	Ceramic Tiles UP to 0.6M Above Kitchen Platform
	Toilet	Do	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Above 2.1M Plaster & Painted OBD over 2MM POP Finish
	Bed Room	Vitrified Tiles	Plastered & Painted OBD Over 2mm POP Finish	DO	
	Bed Room Balcony	Antiskid Vitrified Tiles	Plastered & Painted with Exterior Paint	DO	
	Attached Toilet/ Bed Room Toilet	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M IS 15622	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Above 2.1M Plaster & Painted OBD over 2MM POP Finish
	Passage	Vitrified Tiles With Light Shade	Plastered & Painted OBD Over 2mm POP Finish	DO	
	Cupboard	1:2:4 Concrete with neat cement finish	Plastered & Painted OBD	DO	
	Staircase	Marble Stone Treads & Landings	Plastered & Painted OBD Over 2mm POP Finish	DO	Enamel Paint for M.S. Railing
	Car Parking	80mm Flexi Paver Blocks	Plastered & Painted with Exterior Paint	Plastered & Painted OBD over 2mm POP Finish	For D Type Qtrs. Only
Schedule of Finishes for Transit Camp					
Floor	Room Name	Flooring	Walls	Ceiling	Remarks
	Porch	60mm thk. Flexi Paver Blocks	Plastered & Painted with Exterior Paint	Plastered & Painted with OBD Over 2mm POP Finish	

	Drawing & Dining	Polished Vitrified Tiles 0.6x0.6M	Plastered & Painted Plastic Emulsion Paint over 2mm POP Finish	Minera Fbre False Ceiling POP Cornice & Moulding Painted with Plastic Emulsion Paint	Vitrified Tiles Skirting of 150mm high to be Provided
	Lobby	DO	DO	Plastered & Painted OBD Over 2mm POP Finish	DO
	Kitchen	DO	DO	DO	Ceramic Tiles from Floor Level to 0.6M Above Kitchen Platform
	VIP Room & Lounge	DO	DO	DO	POP Cornice &Moulding shall be Provided for Ceiling
	Attached Toilet of VIP Room	Vitrified Tiles (Antiskid) 0.6x0.6M	Ceramic Tiles 0.3x0.45M (Minimum size)up to Ceiling	DO	
	Dormitory	22mm Thk. Terrazzo Tiles Light shade	Plastered & Painted OBD Over 2mm POP Finish	DO	
	Dormitory Toilet/Bath	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Area Above 2.1M Plaster & Painted OBD over 2MM POP Finish
	Staircase	18mm Thk. Udaipur Green Marble Stone	Plastered & Painted OBD Over 2mm POP Finish	DO	SS Hand Railing as per Drawing
	Bed Rooms	Polished Vitrified Tiles 0.6mx0.6m	Plastered & Painted with Plastic Emulsion Paint Over 2mm POP Finish	DO	
	Attached Toilets	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Area Above 2.1M Plaster & Painted OBD over 2MM Thk. POP Finish
	Care Taker Room	Vitrified Tiles With Light Shade	Plastered & Painted OBD Over 2mm POP Finish	DO	
	Common Toilet	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Area Above 2.1M Plaster & Painted OBD over 2MM Thk. POP Finish
	Store	Vitrified Tiles With Light Shade	Plastered & Painted OBD	DO	

	Balconies	Antiskid Vitrified Tiles Light Shade	Plastered & Painted with Exterior Paint	DO	
	Terrace	Brick Bat Coba Water Proofing	Plastered & Painted with Exterior Paint		

23.0 Boundary wall, Main Gate, Security Room and septic tank and soak pit

23.1 Boundary Wall :

RCC framed with brick masonry/concrete block/stone masonry in fill between columns shall be provided along periphery of substation. The brief description of boundary wall is given below:

(a) Height of boundary wall (Masonary portion) above ground = 2.5 m
(b) 0.5 m Heigh of Y shaped angle supports (50x50x6 mm) above each column with about 0.5 m deep grouted in column shall be provided as grill on the boundary wall
(c) C/c distance of RCC Column (230 X 230 mm size) = 2.5 m
(d) 8 rows of galvanised barbed wire with concertina coil a top of boundary wall shall be provided. 4 rows of barbed wire on each arm of Y-shaped angle is to be provided.
(e) Grade of Concrete for RCC works = M25
(f) Mix of masonry works = 1 Cement: 6 Sand
(g) 12 mm thick Cement sand plaster (1 cement: 6 Sand) over exposed portion of boundary wallalong with 50mm thick PCC(1:2:4) coping on the top of wall.
(h) Two coats of oil bound distemper with one coat of cement primer of approved make shall be applied over exposed portion of boundary wall.
(i) A RCC plinth beam (230 X 300 mm deep) shall be provided at ground level. A lintel beam of 230 X 230 mm shall be provided over gratings.
(j) Suitable steel grating made of 20 mm square bars shall be provided at suitable locations preferably @ 100 m to allow the flow of surface water.
(k) Suitable foundation of about 1.5 depth shall be provided for each RCC column. 75 mm thick PCC (1:4:8) layer shall be provided below all RCC works.
(l) All steel works shall be provided with two coats of synthetic enamel paint over a coat of steel primer of approved make.
(m) Twin columns with 25 mm expansion gap at every 45 meter length shall be provided.
(n) Suitable design of boundary wall shall be developed by the contractor.

The boundary wall shall be measured and paid on running meter length basis.

23.2 Main Gate

A steel gate of 2.1 m high and 6 m wide along with 1.5 m wide man gate shall be provided at entry location of substation. The gate shall be supported on steel columns. The steel support columns shall be encased with suitable RCC foundations. Suitable wheel mounting arrangement shall be provided at the

bottom of gate for smooth opening of gate. All steel works shall be provided with two coats of synthetic enamel paint over a coat of steel primer of approved make.

The item shall be measured and paid on Lump sum basis.

23.3 Security Room:

A RCC framed room of size 3 m X 3m and 3 m high with 1.5 m wide veranda shall be provided near gate.An attached toilet of 1.5 m x 1.5 m size shall be provided. Suitable septic tank and soak pit for 10 users with cleaning interval of 3 years shall also be provided. A RCC platform (600 mm wide) at window sill level along with wardrobe shall be provided. All sanitary works and a PVC water tank of 1000litre capacity shall also be provided. All finish details shall match with other buildings mentioned elsewhere in the technical specification.

The item shall be measured and paid on square meter area basis.

24.0 MODE OF MEASUREMENT

24.1 Geotechnical investigation

This shall include carrying out field tests, laboratory tests, compilation of results and preparation of soil report with recommendations for type of foundations shallow or pile type, suitability of soil for construction of substation etc. The geotechnical investigation work shall be measured on lump sum basis.

24.2 Contour survey and site leveling.

The Contour survey work shall not be measured and paid separately and shall be deemed to be included in the item of site leveling work.
Measurement of Earth work in all kind of soil including soft/disintegrated rock in the item of cutting and filling and item of earth work in the filling with borrowed earth shall be made in Cubic meters. No void deduction for 95% compaction.

24.3 Earthwork

This shall include excavation in all kinds of soil including rock, all leads and lifts including back filling with suitable earth, compacting, dewatering (if required) and disposal of surplus earth or rock to a suitable location within a lead up to 2 km. The surplus earth if disposed within substation boundary shall be spread in uniform layers each compacted with two passes of suitable compacting equipment. The quantity of excavation for foundations of towers, equipment support structures, all transformers/Reactors, DG Set, firewall, cable trenches, fire fighting water tank, buildings and underground water tanks, covered car parking, External lighting poles, control cubicles, marshalling box shall only be measured. The quantity of excavation for roads, rail cum road, drains, culverts, rainwater harvesting, septic tank, soak pit, external water supply system, site surfacing, chain link fencing (including gate) shall not be measured separately and shall be deemed to be included in the composite rates quoted by the bidder for the respective works. All other excavation required for the completion of the work including plinth protection,

flooring, sewerage system, manholes, pipes, earth mat etc. shall also not be paid for. The measurement of excavation of all concrete works shall be made considering dimension of the pit leaving 150mm gap around the base pad (lean concrete) or actually excavated pit, whichever is less. The quantity shall be measured in cubic metres.

24.4 PCC

Providing and laying Plain Cement Concrete of all types and at all locations including all leads and lifts. The quantity shall be measured in cubic meters as per lines and levels indicated in the drawings.

24.4.1 PCC 1:2:4 (1 cement : 2 sand : 4 coarse aggregate 20 mm nominal size) shall be measured in flooring of buildings, plinth protection, fencing, transformer/reactor foundation, rail track, drain, culverts, septic tank, chain link fencing, fencing gate ,external lighting poles etc. as indicated in the approved drawings.

24.4.2 PCC 1:4:8 (1 cement : 4 coarse sand : 8 stone aggregate, 40mm nominal size) shall be measured below all foundations of towers, equipment support structures, buildings, fire fighting water tanks, covered car parking, cable trench, roads, under flooring, rail-cum-road, transformer foundation, reactor foundation, drain, cable trench crossings, culverts, fence, gate etc. as indicated in the approved drawings.

24.4.3 PCC 1:5:10 (1 Cement: 5 sand: 10 Stone aggregate, 40mm nominal size) shall be provided for site surfacing in switchyard, roof water proofing etc.

All other PCC required for the completion of the work including hold fasts of doors/windows/rolling shutters, fixing of plumbing pipes, bedding concrete for sewer lines, embedment of electrical conduits etc. shall not be measured and deemed included in the composite rates quoted by the bidder for respective works. Water proofing compound wherever specified shall be added without any extra cost.

24.5 RCC

Measurement of reinforced cement concrete at all locations shall be made and shall include all leads, lifts, formwork, grouting of pockets and underpinning, (but shall exclude reinforcement & miscellaneous structural steel like inserts etc.), of M25 design mix (Minimum). This shall also include pre-cast RCC work and addition of water proofing compound wherever required for which no additional payment shall be made. The quantity shall be measured in cubic meters as per lines and levels indicated in the drawings. No deduction shall be made for volume occupied by reinforcement/inserts/sleeves and for openings having cross-sectional area up to 0.1 Sq.M.

24.6 Steel Reinforcement

Reinforcement steel shall be measured in length (actual or theoretical as per drawing whichever is less) including hooks, if any, separately for different diameters as actually used in RCC work, excluding overlaps. From the length so measured, the weight of reinforcement shall be calculated in metric tonnes on the basis of sectional weights as adopted by British Standards/equivalent International standards. Wastage, overlaps, couplings, welded joints, spacer bars, chairs, stays, hangers and annealed steel wire or other methods for binding and placing shall not be measured and cost of these items shall be deemed to be included in the rates for reinforcement.

24.7 Stone filling over grating in Transformer/Reactor foundation

Measurement of stone (40mm nominal size) filling over gratings of transformer/reactor foundations shall be made as per theoretical volume of the space to be filled in the transformer foundation as per approved drawings. This shall be measured in Cu.M.

24.8 Miscellaneous structural steel

Measurement for Supply, fabrication, transportation and erection of all miscellaneous structural steel work for rails along with rail fixing details and gratings with supports for transformers/reactors, Cable trenches with covers (Chequered plate covers, cable supports, earthing cleats and edge protection angles etc), all other steel fittings and fixtures, inserts and embedment in concrete of transformer/reactor foundation and cable trenches shall be made as per approved drawings. The unit rate for this item shall be inclusive of cutting, grinding, drilling, bolting, welding, pre- heating of the welded joints, applying a priming coat of steel primer and anti-corrosive bitumastic paint/ synthetic enamel paint in general but with Zinc Phosphate Primer (Two packs) for grating and support for grating in Transformer foundation. (Wherever specified), setting of all types of embedment in concrete, etc. Steel required for foundation bolts, nuts and bolt, doors, windows, ventilators, louvers, rolling shutters, chain link fencing, gratings in drains, soil pipes, plumbing pipes, floor traps, embedment's required for rainwater harvesting, septic tank, soak pit, roof truss and purlins required for fire water tank, etc. shall not be considered for payment and measurements. Quantity shall be measured in metric tonnes.

24.9 Roads

A). The measurement for the concrete road shall be made on the basis of area in square meter (M2) of top concrete completed surface of the road and shall be deemed to include all items such as excavation, compaction, rolling, watering, WBM, shoulder, etc complete as per approved drawing but excluding concreting and reinforcement which shall be paid separately under respective items of BPS.

B) The measurement of bituminous road shall be made on the basis of area in square meter (M2), of the top bituminous completed surface of the road and shall include all items such as excavation, compaction,

rolling, watering, sub base course, WBM, shoulder, premix carpet etc complete as per approved drawing.

C) The measurement of strengthening of existing road (bituminous road) shall be made on the basis of area in square meter (M2), of the top bituminous completed surface of the road including premix carpet etc but excluding item of granular sub base course which shall be paid separately under respective item of BPS.

24.10 Anti-weed Treatment and Stone Spreading

The measurement shall be done for the actual area in square metres of stone spreading provided in the switchyard .It includes providing and spreading of 100mm thickness of uncrushed/crushed/broken stone of 40mm nominal size as per relevant BS codes/equivalent International standards for the specified area. Application of anti weed treatment including material shall not be measured separately and item would be deemed to be included in the quoted rate of stone spreading in switchyard.

24.11 Chain Link Fencing and gate

The measurement shall be made in running metres of the fence provided as per approved drawing. The rate shall be including the post, fencing, MS Flat, painting, brick work and plaster of toe wall etc. complete but excluding the concrete. The switch yard gate shall be measured in numbers.

24.12 **Cable Trenches and Cable trench Crossings**

Earthwork, PCC, RCC, reinforcement steel, RCC hume pipes and miscellaneous steel required for construction of Cable Trenches and cable trench crossings shall be measured under respective items of Bid price schedule (BPS) as described in clauses of aforesaid paras. No additional payment for brick work, plaster and PVC pipes used for cable trench crossings and sealing of trench mouth shall be admissible.

24.13 **Drains & Culverts**

PCC (1:2:4 and 1:4:8) for drains and culverts shall be measured under respective items of Bid price schedule (BPS) as described in clauses of aforesaid paras . All other items like excavation, brick work, plaster and stone pitching except RCC hume pipes required for completion of drains and culverts shall be deemed to be included in the quoted rate of drain. The quantity for each type of drain section shall be measured in running meters. However, RCC hume pipes used in culverts shall be measured under under respective item of Bid price schedule (BPS) as described in clause of hume pipes.

24.14 External Finishing of RCC Framed Buildings/structures:

The item shall be measured per square meter area basis. Contractor has to assess the quantity as per requirement of Control room cum administrative

building, Fire Fighting Pump House, fire fighting water tank, switchyard panel room, residential and non residential buildings, covered car parking and quote for the same separately. This shall include following items.

1) External plastering/cement wash : 18mm Cement plaster in two coats under layer 12 mm thick cement plaster 1:5 (1 cement: 5 coarse Sand) finished with a top layer of 6 mm thick cement plaster 1:6 (1 cement: 6 fine Sand) for all buildings and fire fighting water tank .
2) Providing and applying two or more coats of Acrylic smooth exterior paint over an under coat of suitable primer on new cement plaster surfaces of the control room building, auxiliary building, fire fighting pump house building, fire fighting water tank, panel room , residential and non residential buildings and covered car parking. It shall be inclusive of required tools, scaffolding, materials and other painting accessories etc. as per recommendations of manufacturer.

24.15 Hume Pipe

Hume pipe shall be measured diameter-wise and laid as per approved drawings and shall be measured in running meters. The item shall be inclusive of excavation, laying, back filling, jointing etc. but excluding concrete and reinforcement (if any).

24.16 Building

The measurement of all items except excavation, concrete, reinforcement steel of each type of buildings shall be made on area in Square Meter basis. However, the quantity of excavation, concrete, reinforcement shall be measured in respective items of BPS and described in above paras. The structural steel used for cable tray support, earthing cleat, chequered plates for internal cable trenches of building and panel room wherever applicable shall be measured and paid under miscellaneous steel item of BPS and described above paras. The structural steel and foundation bolts for fixing equipments with foundations/raft within buildings shall not be measured separately which shall be deemed to be included in the quoted rates per square meter of buildings. External Finishing shall be measured and paid in respective items of BPS and described in above paras. The rest of the entire work required to complete the building in all respect as per drawings prepared by contractor and approved by NEA/Consultant shall be deemed to be included in this item rate per square meter area basis.

24.17 Rain Water Harvesting

This is a lump sum item. The contractor shall be required to complete the work in all respect as per drawings prepared by contractor and approved by NEA/Consultant. All the items including excavation, miscellaneous steel, brick work, fillings of boulders, gravel, sand, pipes etc. shall be deemed to be included in this lump sum rate. However, the concrete (all types) and the reinforcement shall be measured and paid under respective item of BPS and described in above paras.

24.18 Rail cum Road

The measurement for the rail cum road shall be made in square metres of top concrete completed surface of the rail cum road and shall include all items such as excavation, compaction, rolling, watering, WBM etc. complete as per approved drawing but excluding concrete, reinforcement, structural steel and rails with rail fixing details which shall be measured separately under respective item of BPS and described in above paras.

24.19 Septic Tank and Soak Pit

This is a lump sum item. The contractor shall be required to complete the work in all respect as per drawings furnished by the contractor and approved by NEA/Consultant. All the items including excavation, masonry work, all types of fillings, all types of pipes including plumbing and vent pipes, all type of fittings etc. shall be deemed to be included in this lump sum rate. However, the concrete (all types) and the reinforcement shall be measured and paid under the respective item mentioned above.

24.20 Fire Water Tank

This is a lump sum item. The contractor shall be required to complete the work in all respect as per approved drawings. The items including brick work if any, and miscellaneous steel including steel embedment Rungs, roof truss, corrugated AC Sheet roofing, door, pipe sleeves, internal finish, etc. shall be deemed to be included in this lump sum cost. However, the items like excavation, concrete (all types), reinforcement steel, external finish shall be measured and paid under the respective item of BPS and described in above paras.

24.21 External water supply from Bore-well/ other source of water supply arrangement to Fire water tank, Control Room building, Residential and non residential buildings

The external water supply from Bore-well shall be measured diameter-wise in running meters. It shall include all the items such as excavation, piping, pipe fittings, painting, brickwork, sand filling, concrete, valves, chambers cutting chases in walls, openings in RCC and repairs, etc. required to complete the job.

24.22 External Sewage System of Control Room Building and other Buildings of Township.

It shall be measured diameter wise in running meters. It shall include all the items such as excavation, piping, pipe fittings, manholes, gali trap, gali chamber casing in concrete and repairs etc required to complete the job. Any modification in the existing sewage system, if required, shall be done by the Contractor without any extra cost implicated to NEA/Consultant.

25.0 MISCELLANEOUS GENERAL REQUIREMENTS

25.1 Dense concrete with controlled water cement ratio as per BS-code shall be used for all underground concrete structures such as pump-house, tanks, water retaining structures, cable and pipe trenches etc. for achieving water-tightness.

25.2 All joints including construction and expansion joints for the water retaining structures shall be made water tight by using PVC ribbed water stops with central bulb. However, kicker type (externally placed) PVC water stops shall be used for the base slab and in other areas where it is required to facilitate concreting. The minimum thickness of PVC water stops shall be 5 mm and minimum width shall be 230 mm.

25.3 All steel sections and fabricated structures which are required to be transported on sea shall be provided with anti corrosive paint to take care of sea worthiness.

25.4 All mild steel parts used in the water retaining structures shall be hot-double dip galvanised. The minimum coating of the zinc shall be 750 gm/sq. m. for galvanised structures and shall comply with relevant BS. Galvanizing shall be checked and tested in accordance with relevant BS. The galvanizing shall be followed by the application of an etching primer and dipping in black bitumen in accordance with BS: 3416.

25.5 A screed concrete layer not less than 100 mm thick and of grade not weaker than M10 conforming to relevant BS shall be provided below all water retaining structures. A sliding layer of bitumen paper or craft paper shall be provided over the screed layer to destroy the bond between the screed and the base slab concrete of the water retaining structures.

25.6 Bricks having minimum 75 kg/cm2 compressive strength can only be used for masonry work. Contractor shall ascertain himself at site regarding the availability of bricks of minimum 75 kg/cm2 compressive strength before submitting his offer. The contractor may use concrete blocks of equivalent compressive strength in place of brick work.

25.7 Doors and windows on external walls of the buildings (other than areas provided, with insulated metal claddings) shall be provided with RCC sun-shade over the openings with 300 mm projection on either side of the openings. Projection of sunshade from the wall shall be minimum 450 mm over window openings and 750 mm over door openings.

25.8 All stairs shall have maximum riser height of 150 mm and a minimum tread width of 300 mm. Minimum width of stairs shall be 1500 mm. Service ladder shall be provided for access to all roofs. RCC fire escape staircase if required as per local bye laws, shall be provided in control buildings.

25.9 Angles 50x50x6 mm (minimum) with lugs shall be provided for edge protection all round cut outs/openings in floor slab, edges of drains

supporting grating covers, edges of RCC cable/pipe trenches supporting covers, edges of manholes supporting covers, supporting edges of manhole precast cover and any other place where breakage of corners of concrete is expected.

25.10 Anti termite chemical treatment for buildings shall be given to all column pits, wall trenches, foundations, filling below the floors etc. as per relevant International/BS .

25.11 Hand-railing minimum 900mm high shall be provided around all floor/roof openings, projections/balconies, walk ways, platforms, steel stairs etc. All handrails and ladder pipes shall be 32 mm nominal bore MS pipes (medium class) and shall be galvanised (medium-class as per relevant BS). All rungs for ladder shall also be galvanised as per relevant BS.

For RCC stairs, hand railing with 20 mm square MS bars, balustrades with suitable MS flats & aluminium handrails shall be provided.

25.12 For all civil works covered under this specification, design Mix of Minimum M25 grade as per relevant International /BS shall be used. Reinforcement steel shall be of minimum Fe 500 grade.

The material specification, workmanship and acceptance criteria shall be as per relevant clauses of applicable International/BS standard.

25.13 Items/components of buildings not explicitly covered in the specification and BPS but required for completion of the project shall be deemed to be included in the scope.

25.14 Requirement of sulphate resistant cement (SRC) for sub structural works shall be decided in accordance with the International/BS Standards based on the findings of the detailed soil investigation to be carried out by the Bidder.

25.15 Foundation system adopted by Bidder shall ensure that relative settlement and other criteria shall be as per provision in relevant BS and other International Standards.

25.16 All water retaining structures designed as uncracked section shall also be tested for water tightness at full water level in accordance with relevant international/ BS standards.

25.17 Construction joints shall be as per International/BS standard..

25.18 All underground concrete structures like basements, pumps houses, water retaining structures etc. shall have plasticizer cum water proofing cement additive conforming to relevant BS. The concrete surface of these structures in contact with earth shall also be provided with two coat of bituminous painting for water/damp proofing.

In case of water leakage in the above structures, The Method shall be applied as per relevant international standard/BS standard for repairing the leakage.

25.19 All building/construction materials shall conform to the best quality specified in relevant International /BS standard.

26.0 INTERFACING

The proper coordination & execution of all interfacing civil works activities like fixing of conduits in roofs/walls/floors, fixing of foundation bolts, fixing of lighting fixtures, fixing of supports/embedment's, provision of cut outs etc. shall be the sole responsibility of the Contractor. He shall plan all such activities in advance and execute in such a manner that interfacing activities do not become bottlenecks and dismantling, breakage etc. is reduced to minimum.

27.0 STATUTORY RULES

27.1 Contractor shall comply with all the applicable statutory rules pertaining to factories act (as applicable for the State). Fire Safety Rules of Tariff Advisory- Committee and Water and sewerage Act for pollution control etc.

27.2 Provisions for fire proof doors, no. of staircases, fire escape stairs ,fire separation wall, plastering on structural members (in fire prone areas) etc. shall be made according to the recommendations of Local Advisory Committee.

27.3 Statutory clearance and norms of Local Pollution Control Board shall be followed as per Water Act for effluent quality from plant.

28.0 FIELD QUALITY PLAN

All tests as required in accordance to BS codes or equivalent International standards have to be carried out. The contractor shall prepare field quality plan for civil works as per relevant /BS codes/equivalent International Standards during detailed engineering stage and submit to NEA/Consultant for approval within ONE month after award of work.

29.0 BRITISH STANDARD CODES

Major British standard Codes for civil work have been given in the following list. This list is illustrative but not exhaustive. However, for design and engineering relevant BS codes or equivalent International standards shall be referred by the contractor. Relevant portion of BS codes or equivalent international standards referred by the contractor for the design shall be made available to NEA/Consultant if necessary during detailed engineering stage.

Sr. No.	Standard No.	Title	Year
1	BS 41	Structural steel sections. Specification for hot-	2005

		rolled sections	
2	BS 13771	Methods of test for soils for civil engineering purposes. General requirements and sample preparation	1990
3	BS 4449	Steel for the reinforcement of concrete. Weldable reinf orcing steel. Bar, coil and decoiled product. Specificati on (with A2:2009)	2005
4	BS 4482	Steel fabric for the reinforcement of concrete. Specifica tion	2005
5	BS 4483	Steel fabric for the reinforcement of concrete. Specifica tion	2005
6	BS EN 1021 02	Hot finished structural hollow sections of non-alloy and fine grain steels. Tolerances, dimensions and sectional properties	2006
7	BS EN 1005 61	Specification for structural steel equal and unequal angles. Dimensions	1999
8	BS EN ISO 8 00001	Quantities and units. General	2013
9	BS 5930	Code of practice for site investigations (with A2:2010)	1999
10	BS EN 1993-11	Eurocode 3. Design of steel structures. General rules an d rules for buildings	2005
11	NA to BS E N 199311	UK National Annex to Eurocode 3. Design of steel stru ctures. General rules and rules for buildings	2008
12	BS EN 1993-15	Eurocode 3. Design of steel structures. Plated structural elements	2006
13	NA to BS E N 199315	UK National Annex to Eurocode 3. Design of steel stru ctures. Plated structural elements	2008
14	BS EN 1993-18	Eurocode 3. Design of steel structures. Design of joints	2005
15	NA to BS E N 199318	UK National Annex to Eurocode 3. Design of steel stru ctures. Design of joints	2008
16	BS 60732	Precast concrete masonry units. Guide for specifying pr ecast concrete masonry units	2008
17	BS 7668	Weldable structural steels. Hot finished structural hollo w sections in weather resistant steels. Specification	2004
18	BS EN 1997-1	Eurocode 7. Geotechnical design. General rules	2004
19	NA to BS E N 19971	UK National Annex to Eurocode 7. Geotechnical desig n. General rules	2007
20	BS EN 1992-3	Eurocode 2. Design of concrete structures. Liquid retai ning and containing structures	2006
21	BS EN 1992-11	Eurocode 2. Design of concrete structures. General rule s and rules for buildings	2004
22	NA to BS E N 199211	UK National Annex to Eurocode 2. Design of concrete structures. General rules and rules for buildings	2005
23	BS 75334	Pavements constructed with clay, natural stone or concr ete pavers. Code of practice for the construction of pav ements of precast concrete flags or natural stone slabs	2006
24	BS EN 1971	Cement. Composition, specifications and conformity cr iteria for common cements	2011
25	BS 743	Specification for materials for damp proof courses	1970
26	BS 8122	Testing aggregates. Methods for determination of densi ty	1995
27	BS 952-1	Glass for glazing. Classification	1995
28	BS 952-2	Glass for glazing. Terminology for work on glass	1980

29	BS EN 12620	Aggregates for concrete	2013
30	BS 1125	Specification for WC flushing cisterns (including dual flush cisterns and flush pipes)	1987
31	BS 1188	Specification for ceramic wash basins and pedestals	1974
32	BS 1199 and 1200	Specifications for building sands from natural sources	1976
33	BS EN 13310	Kitchen sinks. Functional requirements and test methods	2003
34	BS 1245	Pedestrian doorsets and door frames made from steel sheet. Specification	2012
35	BS 1254	Specification for WC seats (plastics)	1981
36	BS 1370	Specification for low heat Portland cement	1979
37	BS EN 1008	Mixing water for concrete. Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete	2002
38	BS 3505	Specification for unplasticized polyvinyl chloride (PVCU) pressure pipes for cold potable water	1986
39	BS EN 15743	Supersulfated cement. Composition, specifications and conformity criteria	2010
40	BS EN ISO 3766	Construction drawings. Simplified representation of concrete reinforcement	2003
41	BS 8666	Scheduling, dimensioning, bending and cutting of steel reinforcement for concrete. Specification	2005
42	BS 4514	Unplasticized PVC soil and ventilating pipes of 82.4 mm minimum mean outside diameter, and fittings and accessories of 82.4 mm and of other sizes. Specification	2001
43	BS 4551	Mortar. Methods of test for mortar and screed. Chemical analysis and physical testing (with A2:2013)	2005
44	BS EN 122001	Plastics rainwater piping systems for above ground external use. Unplasticized poly (vinyl chloride) (PVC-U). Specifications for pipes, fittings and the system	2000
45	BS EN 1462	Brackets for eaves gutters. Requirements and testing	2004
46	BS EN 607	Eaves gutters and fittings made of PVC-U. Definitions, requirements and testing	2004
47	BS 6262	Code of practice for glazing for buildings	1982
48	BS EN 14411	Ceramic tiles. Definitions, classification, characteristics, evalua tion of conformity and marking	2012
49	BS 6510	Steel framed windows and glazed doors. Specification	2010
50	BS EN 636	Plywood. Specifications	2012
51	NA to BS EN 19923	UK National Annex to Eurocode 2. Design of concrete structures. Liquid retaining and containment structures	2007
52	BS EN 1339	Concrete paving flags. Requirements and test methods	2003
53	BS EN 1340	Concrete kerb units. Requirements and test methods	2003

Annexure B1

Ornamental Brick Works

Dachi Bricks

The Brick shall be machine pressed chimney made traditional bricks of first class quality approved by the Engineer and free from grit and other impurities such as lime, iron and other deleterious salts, conforming to NS 12035. These shall be well burnt, sound, and hard with sharp edges and shall emit ringing sound when struck with a mallet. These shall be of uniform size. The size of the bricks shall be 21.8cm x 10.0cm x 5.6cm (dachiappasano) unless otherwise specified, with a tolerance of ± 2mm in each direction. The compressive strength should be more than 3.5N/mm².

Samples

Samples of each type of brick taken at random from the load shall be deposited with the Engineer for his approval before being used in the work. All subsequent deliveries shall be up to the standard of the sample approved.

Mix Proportion

For dachiappa brickwork of 108mm thick, the mortar mix shall be in a proportion of 1:4 i.e. consisting of one part cement and 4 parts sand and finished with surkhi pointing.

Laying Brickwork

All brick shall be built in Stretcher bond. Each brick shall be set with bed and vertical joints filled thoroughly with mortar finished in Surkhi pointing. Selected bricks shall be used for the exposed brickwork. The walls shall be taken up truly plumb. All courses shall be laid truly horizontal and vertical joints shall be truly vertical. Vertical joints in alternate course shall come directly over the other. The thickness of brick courses shall be kept uniform and for this purpose wooden straight edge with graduation giving thickness of each brick course including blade joint (thin joints) shall be used. Necessary tools comprising of wooden straight edge, masons sprit level, square, foot rule, plumb, line and pins etc. shall be frequently and fully used by the masons to ensure that the walls are taken up true to plumb, line and levels. Both the faces of walls of thickness greater than 23cm shall be keptin proper plane. All the connected brickwork shall be carried up nearly at one level and no partition of work shall be raised more than one meter above the rest of the work. Any dislodged brick shall be removed and reset in fresh mortar. Before commencing any brickwork, the Contractor shall confer with other trades to ensure that all pipes, reinforcement bars, conduits, drains, sleeves, bolts, hangers, or any other materials necessary tobe installed in the brickwork at the time it is built, have been fixed or provided for.

Surkhi Pointing

Bricks shall be laid such that all joints are filled properly with surkhi pointing. The gap in the joints shall be not more than 1mm and properly pointed during the progress of the work. The face of brickwork shall be kept cleaned and mortar dropping removed.

Putlog Holes

The putlog holes (if inevitable for scaffolding), which provide resting space for horizontal members shall not be left in masonry under one metre in width or immediately near the skewbacks of arches. The holes left in the masonry work for supporting the scaffolding shall be filled with bricks filled with mortar to fit the size of opening with proper beds and joints.

Clay Tile

Roofing tiles are to be clay tile from reputed Factory locally made tile. The clay tile single lap inter locking at head and side and with ridge tiles etc. to match. They are to be uniform in size, shape and colour and free from twist and other defects, in every respect equal to samples to be deposited with and approved by the Engineer In-charge. Each tile are hooked by 16g GI strap to eaves board (fascia) and in verges too. Before laying tile the gutter should be fixed. Replaced cracked or damaged tiles and clean down and leave roofs water tight on completion.

Door and Windows (Wooden frames)

The contractor is to clear out and destroy or remove all cut and shavings and other wood waste from all parts of the building and the site generally, as the work progress and at the conclusion of the work.

Carpentry:

All carpentry shall be executed with workmanship of the best quality. Scantling and boarding shall be accurately sawn and shall be of uniform width and thickness throughout. All carpenter's work shall be left with sawn surface except where particularly specified to be wrought All carpenter's work shall be accurately set out in strict accordance with the drawings and shall be framed together and securely fixed in best possible manner with properly made joints. All necessary brads, sheet metal screws, etc. shall be provided as directed and approved.

Joinery: All joints shall be accurately set out on boards to full size for the information and guidance of the artisans before commencing the respective works, with all joints, iron work and other works connected there with fully delineated. Such setting out must be submitted to the Engineer In-charge and approved before such respective works are commenced.

All jointer's work shall be cut out and framed together as soon after the commencement of the building as is practicable, but is not to be wedged up or glued until the building is ready for fixing same. Any portions that warp, wind or develop shakes or other defects within six months after completion of the works shall be removed and new fixed in their place on contractor's own expense. All work shall be properly mortises, tenons, house, shouldered, dovetailed, notched, wedged, pinned, braided, etc., as directed and to the satisfaction of the consultants and all properly glued up with the best quality approved glue. Joints in joinery must be as specified or detailed, and so designed and secured as to resist or compensate for any stresses to which they may be subjected. All nails, springs, etc. are to be punched and

puttied. Loose joints are to be made where provision must be made for shrinkage, glued joints where shrinkage need not be considered and where sealed joints are required. Glue for load-bearing joints or where conditions may be damp must be damp must be of the resin type. For non-load-bearing joints or conditions may be guaranteed casein or organic glues may be used. All exposed surfaces of joinery work shall be wrought and all arise "eased-off" by plaining and sandpapering to an approved finish suitable to the specified treatment.

Dimensions:

Joinery shall hold up to the specified sizes and as measure.

Fixing Joinery:

All beads, fillets and small members shall be fixed with round or oval brads on nails well punched in and stopped. All large members shall be fixed with brass screws, the heads let in and palette to match the grain. Unless otherwise specified, plugs of external work shall be of hardwood; plugs for internal work may be of softwood. Holes for plugging must be made with a proper drilling tool and the holes completely filled with the plugging material. Unless otherwise specified all skirting, window, grounds and backings for same, fillets etc., shall be plugged at intervals not exceeding600mm.

Bedding Joinery:

All door and window frames, sills, wooden bars etc., which are fixed to brickwork, concrete by means of grounds, lugs, etc., shall be bedded solid in mortar as previously described and pointed with a recessed joint 6mm deep to the approval of the Engineer In-charge. Plywood, Block boards, Chipboards and MDF board, shall be bonded with synthetic resin of "interior" type and sheet metal screws unless otherwise stated for the doors. Where stated to be "exterior" type, they shall be weather proof. All exposed edges of block board and chipboard shall be lipped with hardwood as described below. Samples of all such materials and their source of manufacture must be approved by the Engineer In-charge before used in the works.

Inspection and Testing

The Engineer In-charge shall be given facilities for inspection of all works in progress whether in workshop or on site. All timber as it arrives on the site and not approved by them must be removed forthwith, failing which the Employer, with the advise of the Engineer In-charge, may arrange for the removal of the rejects and impose of them as they may consider advisable at the contractor's expenses. Notwithstanding approval having been given as above, any timber incorporated in the works found to be in any way defective before the expiry of the maintenance period shall be removed and renewed at the contractor's expense. The contractor is to allow for testing or prototypes of special construction units and the Engineer In-charge shall be at liberty to select any samples they may require for the purpose of testing i.e. for moisture content, or identification of species, strength, etc. Where timbers need to be extended into a wall, they shall be thoroughly "Brush Treated" with a wood preservative approved by the Engineer In-charge, and as much clear air space maintained around the timber where it adjoins the wall as possible.

Carved wooden door and windows

For shutter, the thickness of 38mm salwood panel shall be used for carving and decorative works, unless otherwise mentioned. The section size of door frame for decorative door shall be 75mm x125mm section or 100mmx100mm or equivalent to this section or as approved by the engineer

Construction Procedure

The carving of the doors and windows should be refined aesthetically with reflection carving craftsmanship as approved by Engineer. For the main decorative carved door shutter, the shutter shall be fitted1 nos. of 300mm brass al drop, 2 nos. 200mm brass door handle, 4nos. of 250mm tower bolt, 6 nos. 25x25x125mm brass hinges, nails, screws, with at least three coats of chapra polish, or as per drawing and instruction of engineer, all complete.

SECTION-14.2
PILE FOUNDATION

CONTENTS

SECTION-14.2
GENERAL INFORMATION & SCOPE

CONTENTS

SECTION-14.2 (Part-I)
GENERAL INFORMATION & SCOPE

1 GENERAL

This section covers the specification for pile foundation work envisaged substation Pile foundations are envisaged for locations such as Control Room Building, GIS hall etc. or where ever required

2 SCOPE

2.1 The work to e performed under this specification consists of boring in all kinds of soil including weathered rock, fissured rock, hard rock, shale etc., providing and installation of cast-in-situ RCC vertical bored piles of diameter as per provision in BoQ, providing all labour, materials, supervision, dewatering, scaffolding, platforms, boring and construction equipment & machineries, tools, tackles and plants, supplies, power, fuel, transportation on land and water, all incidental items not shown or specified but reasonably implied or necessary for successful and timely completion of work including Contractor's supervision in strict accordance with IS Codes, drawings and specifications. The nature of work shall generally involve construction/installation of cast-in-situ RCC vertical bored piles of specified diameter, pile caps, pedestals, tie beam (if required) etc. as per the Purchaser’s construction drawings and also co-ordination with the structures built above the foundation.

2.2 The bidder shall furnish in their bid complete data regarding the method of installation of the pile foundations, complete list of equipment, tools and tackles, rigs, men, materials to be deployed for the work etc.

2.3 The Bidder's offer should be based on the mobilization of at least one no. piling rig for each tower location together with all associated working gangs, tool & tackles etc. (including at least one no. of Rotary Hydraulic drilling rig capable of boring piles up-to 40m depth below existing Ground Level with necessary tools/accessories for boring) However, if extra rigs are required to be deployed by the Contractor to match with the project construction schedule, the same shall be deployed without any additional cost to the Purchaser. The contractor has to execute the complete job as per soil strata actually encountered at the time of construction.

2.4 The Contractor shall be responsible for the soundness of the above pile foundations installed / constructed by them.

2.5 After completion of installation / construction of piles, pile integrity test shall be conducted for each pile by the contractor, in presence of Purchaser’s representative, to establish its soundness. The procedure for conducting of pile integrity test is given briefly at Part – IV of this Specification. The tentative quantity of tests to be

carried out are given in BPS. Bidder has to quote the price accordingly. Initial load test and routine test shall be carried out as per relevant British standard codes/ equivalent international standards.

2.6 The setting of stub/fixing of foundation anchor bolts (as indicated in the drawing) shall be the responsibility of the Contractor.

2.7 The Bidder shall quote based on the provisional Bill Of Quantities (BOQ) furnished in the Bid Proposal Sheet (B.P.S). No deviation in this respect will be acceptable and any bid quoted based on different Bill of Quantities shall be liable for rejection. However, the payment will be made as per actual quantity executed as per Purchaser/Purchaser's design & drawing based on the unit rates for items quoted.

3 SUB-SOIL DATA

3.1 The detailed soil investigation for the locations where pile foundations are envisaged shall be carried out by the Contractor. The contractor has to execute the complete job as per the soil strata actually encountered at the time of construction which may have some variations of reasonable nature from the soil investigation report. Any extra claim whatsoever on account of such variations shall not be entertained.

4 DESIGN AND DRAWINGS

4.1 Purchaser shall develop the pile foundation design based on the soil investigation report. The construction drawings required for execution of pile foundations shall be given to the contractor as per site requirement during execution stage.

5 TABLE OF COMPLIANCE

Bidder shall use one copy of "Technical Specifications" to indicate compliance status. Within the right hand margin, Bidder shall indicate compliance status to each paragraph along with a cross-reference to its proposal and an index key for any explanation or comment.
In addition, The Bidder shall annotate the Table of contents of the above stated volume to provide a high level summary of compliance status, In both cases, the following symbols, and no others, shall be used:

C- Bid complies with all requirements in the adjacent paragraph

A-Bid is not compliant with the requirements in the adjacent paragraph, but a functional alternative is proposed.
X- Bid takes exception to the requirements of the adjacent paragraph and no functional alternative is proposed.
Only one symbol shall be assigned to a paragraph and shall indicate the worst case level of compliance for that paragraph. The annotation may be hand written.

Bidder shall underline, on the compliance copy, all requirements to which exceptions have been taken (X) or to which alternatives have been proposed (A).

Each alternative shall be clearly and explicitly described. Such descriptions shall use the same paragraph numbering as the bid document sections addressed by the alternatives. All alternative descriptions shall be in one contiguous section of the Bidder's proposal, preferably in the same volume, and titled "Alternatives". A separate section titled "Exceptions" should be provided containing any discussion or explanation Bidder chooses to provide concerning exceptions taken.

Alternatives which do not substantially comply with the intent of the bid documents will be considered exceptions.

The Purchaser will assess the merits of each alternative and exception and will be the sole judge as to their acceptance.

SECTION –14.2 (Part-II)
BORED CAST-IN-SITU PILE FOUNDATION

CONTENTS

SECTION –14.2 (Part-II)
BORED CAST-IN-SITU PILE FOUNDATION

1 CONSTRUCTION OF BOARD CAST IN-SITU-PILE FOUNDATION

1.1 General Requirement

1.1.1 The specification covers the technical requirements for piling work, general description of work, quality and workmanship. In every case, work shall be carried out to the satisfaction of the Employer in accordance with the Technical Specifications and conform to location, lines, grades and cross sections shown on the construction drawing or as directed by the Employer. The specifications are not, however, intended to cover all the minute details and the work shall be executed according to the relevant British Standard Codes or equivalent International standard. In absence of the Codes, work shall be executed according to the best prevailing local Public Works Department practice or to the recommendations of the relevant International Standards or to the instructions of the Employer. This specification shall have precedence in case anything contrary to this is stated anywhere in this Bid Document. In case of conflict between the Specification and Codes, the former shall prevail.

1.1.2 The work shall include mobilization of all necessary equipments, providing necessary engineering supervision through qualified and technical personnel, skilled and unskilled labour, etc. as required to carry out the complete piling work. The minimum capacity of some key equipments are listed below. However, bidder has to furnish information regarding the equipments they intend to deploy for the project as per proforma stipulated in the relevant schedules of the BPS.

Sl.No.	Description	Capacity
1.	Tripod height	6m. to 10m. (clear drop)
2.	Rig (winch) capacity	3 T to 5T
3.	Weight of chisel	2T to 3T
4.	Mud pump capacity	15 HP to 25 HP
5.	Dia. of outlet pipe	2.5 inch for bentonite
6.	Rotary drilling rig all accessories	Minimum torque 12T (Hydraulic) alongwith

Note: Bidder may have to provide higher capacity equipments than mentioned above, as per the actual requirement for the execution of the job, without any additional financial implication to EMPLOYER.

2 Layout and Levels

2.1 Layout and levels of structures etc. shall be made by the Contractor, at his own cost, from the general grid of the plot and the bench marks given by the Employer. The Contractor shall make his own arrangements, at his own cost, for locating the co-ordinates and position of piles as per approved drawings and for determining the Reduced Level (R.L.) of the locations with respect to the single bench mark indicated by the Employer. Two established reference lines in mutually perpendicular direction shall be indicated to the Contractor. The Contractor shall provide at site all the required survey instruments, materials and men to Employer for verification of the detailed layout and correctness of the layout and levels to the satisfaction of the Employer so that the work can be carried out accurately according to specifications and approved drawings. The contractor shall be solely responsible for the correctness of layout and levels.

3 Site Preparation

This section of the specification covers site preparation of the areas as indicated in the drawings.
The area shall be stripped to remove roots of grass, rubbish and slush, shrubs or other organic materials. Spoiled materials shall be burnt or removed to approved disposal areas on or near the job site as directed by the Employer.

4 Properties of Construction Materials

This clause specifies the properties of common building materials unless otherwise mentioned in the drawings or schedule of items.

All materials viz., cement, steel, aggregates, water etc. which are to be used for pile construction are detailed below. However, aggregates more than 20mm shall not be used, except for lean concrete.

4.1 Coarse aggregates/Stone

4.1.1 All coarse aggregates shall be as per IS:383 consisting of hard, strong, compact grained and durable pieces of crushed stone having uniform in texture and colour and free from decay, flaws, veins, cracks and sand holes. Coarse aggregates should be of angular shape & rectangular surface and shall be free from organic or clay coatings and other impurities like disintegrated stones, soft flaky particles, adherent coatings, clinkers, slag, mica and any other materials liable to affect the strength, durability or appearance of concrete. The surface of a freshly broken stone shall be bright, clean, and free from any dull, chalky or earthy appearance. Coarse aggregates with round surface shall not be used. ~~A~~ coarse aggregates shall not absorb more than 5% of its weight of water after 24 hours immersion. Samples shall be submitted by the Contractor and approved samples shall be retained by the Employer for comparison of bulk supply.

4.1.2 Sieving and washing of aggregates by approved method shall be carried out wherever required.

4.1.3 Grading of coarse aggregate shall generally conform to IS:383 and shall be such as to produce a dense concrete of the specified proportions and strength and of consistency that will work readily into position without segregation.

4.1.4 The maximum size of aggregate shall be as follows unless specified otherwise:

i) Reinforced concrete with very narrow space - 10mm.
ii) Reinforced concrete & Plain Concrete - 20mm.
iii) Lean Concrete 1:3:6 or 1:4:8-40mm.

4.2 Cement

Cement used shall generally be ordinary Portland Cement conforming to the latest Indian Standard Code IS:8112 or IS:12269. Alternatively, other varieties of cement other than ordinary Portland Cement such as Portland Pozzolana Cement conforming to IS;1489 or Portland Slag Cement conforming to IS:455 can also be used. The Contractor shall submit the manufacturer's certificate, for each consignment of cement procured, to the Employer. However Employer reserves the right to direct the Contractor to conduct tests for each batch/lot of cement used by the Contractor and Contractor will conduct those tests free of cost at the laboratory so directed by the Employer. The Contractor shall also have no claim towards suspension of work due to time taken in conducting tests in the laboratory. Changing of brand or type of cement within the same structure shall not be permitted without the prior approval of the Employer. Sulphate Resistant Cement shall be used if Sulphate content is more than the limits specified in IS:456, as per Geotechnical investigation report and as mentioned in the construction drawing. No additional payment shall be made for using Sulphate Resistant Cement.

4.3 Sand

Sand shall be hard, durable, clean and free from any adherent coatings or organic matter and shall not contain clay balls or pellets. The sand shall be free from impurities such as iron pyrites, alkalis, salts, coal, mica, shale or other laminated materials, in such forms or quantities as to affect adversely the hardening, strength, durability or appearance of concrete or to cause corrosions to any metal in contact with such concrete. In no case the cumulative percentage of impurities in sand shall be more than 5% by weight. All sand shall be properly graded. Unless otherwise directed by the Employer all sand shall pass through IS Sieve no. 2.36mm. Sand for concrete shall conform to IS:383 .

4.4 Water

Water shall be clean, fresh and free from organic matters, acids or soluble salts and other deleterious substances which may cause corrosion, discoloration, efflorescence etc. Potable water is generally considered fit for use. Water to be used shall comply with the requirements of IS:456 . Average 28 days compressive

strength of at least three 15 cm. cubes of concrete prepared with proposed water shall not be less than 90% of average strength of three similar cubes prepared with distilled water. PH of water shall generally be not less than 6.

4.5 Reinforcement

Reinforcement steel shall be clean and free from loose mill scales, dust, loose rust, oil and grease or other coatings which may impair proper bond. Reinforcement shall conform to IS:1786 for deform and cold twisted bars (Fe 500). If mentioned in the BPS, epoxy coated reinforcement shall conform to IS:13620. Thermo Mechanically Treated (TMT) bars (equivalent grade) in place of cold twisted bars are also accepted. Hard drawn steel wire shall conform to IS:432. Hard drawn steel wire fabric shall conform to IS:1566. All steel bars including and above 6mm diameter shall be of tested for quality. Substitution of reinforcement, other than those mentioned above, shall not be permitted without the prior approval of the Employer. Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated or as required to carry out the intent of approved foundation drawings and Specifications. Spacers, chairs, stays, hangers and annealed steel wire for bending etc. as may be necessary, should be used for proper completion of foundation job. Spacers or chairs should be placed at a maximum spacing of 1 m and closer spacing shall be provided wherever necessary.
In area near nala or where subsoil strata is attacking in nature Epoxy coated reinforcement and ready mix concrete shall be used. Such area may involve continuous dewatering also for casting of foundation. Portland Pozzolona cement or Slag cement shall be used for such locations. For concreting under water , Slump of concrete shall be 100 -150 mm recorded by suitable method

5 Storage & Handling of construction Materials

All materials shall be stored by the Contractor in a manner aiding convenient access for identification and inspection at all times. The storage arrangements shall be subject to the approval of the Employer. Storage of materials shall be as described in IS:4082 .

All materials shall be so stored as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged or is otherwise considered defective by the Employer shall not be used for concrete, and shall be removed from site immediately, failing which, the Employer will get the materials removed and the cost thereof shall be recovered from contract price. The Contractor shall maintain up to date accounts of receipt, issue and balance (stock wise) of all materials.

5.1 Cement

The cement shall be stored in dry enclosed shed, well away from the walls and insulated from the floor to avoid contact with moisture. The cement shall be stacked in easily countable stacks to facilitate removal of first in first out basis.

The cement bags shall be gently kept on the floor to avoid leakage of cement from the bags. Sub-standard or partially set cement shall be immediately removed from the site as soon as it is detected. Cement stored for period beyond 90 days shall be tested before use.

5.2 Coarse Aggregates and Sand

All coarse aggregates & sand shall be stored on brick soling or an equivalent platform so that they do not come in contact with dirt, clay, grass or any other injurious substance at any stage. Aggregate of different sizes shall be kept in separate and easily measurable stacks. If so desired by the Employer, aggregates from different sources shall be stacked separately with proper care to prevent intermixing.

5.3 Reinforcement

Reinforcement steel shall be stored consignment wise and size wise, off the ground and under cover. It shall be protected from rusting, oil grease and distortions. If directed by the Employer, the reinforcement steel may have to be coated with cement wash before stacking, to prevent scale and rust at no extra cost to the Employer. The stacks shall be easily measurable. Only steel needed for immediate use shall be removed from storage. Fabricated reinforcement shall be carefully stored to prevent damage, distortion, corrosion & deterioration.

6 Cement Concrete

6.1 General

6.1.1 This section of the specification deals with cement concrete, plain or reinforced, and covers the requirement for concrete mix design, strength and quality, pouring at all levels, forming, protection, curing finishing, admixtures, inserts and other miscellaneous works.

6.1.2 The provisions of IS:456 shall be complied with, unless permitted otherwise. Any other Indian Standard Code shall form the part of the specification to the extent it has been referred to or applicable within this specification.

6.1.3 The Contractor shall furnish all labour, material and equipment to form, place and finish all structural concrete, concrete works and miscellaneous items complete, as described herein.

6.2 Admixtures

6.2.1 The admixtures in concrete for promoting workability, improving strength or for any other purpose, shall be used only after the written permission from the Employer. The Admixtures shall conform to IS:9103.

6.2.2 Admixtures should not impair durability of concrete nor combined with the constituent to form harmful compounds nor increase the risk of corrosion of reinforcement.

6.2.3 6.2.3 Addition of admixtures should not reduce the specified strength of concrete in any case. The workability, compressive strength and the slump loss of concrete with and without the use of admixtures shall be established during the trial mixes before use of admixtures.

6.2.4 The chloride content of admixtures shall be independently tested for each batch before acceptance.

6.2.5 If two or more admixtures are used simultaneously in the same concrete mix, data shall be provided to asses their interaction and to ensure their compatibility.

6.2.6 In case admixtures are used in the concrete for any structure, fresh mix design be done considering the admixture with the specific approval from Employer. No extra payment shall be made to the Contractor on this account.

6.3 Grades of Concrete

6.3.1 The minimum grade of concrete to be used for piling shall be M-25 with minimum cement content 400 kg/m^3 and maximum water cement ratio of 0.5. Concrete shall conform to the controlled design mix as specified in IS:456 . In addition, nominal mixes of 1:3:6 and 1:4:8 (with aggregates of nominal size 40mm maximum, by weight converted to equivalent volume shall also be used as per field quality plan. The concrete in aggressive surroundings due to presence of Sulphate, etc., shall confirm to IS:456. The slump of concrete shall be maintained between 150 to 200 mm.

6.3.2 The Contractor shall carry out concrete mix design in accordance with IS:10262 and submit mix design calculations and get them approved from the Employer well in advance of installation of pile foundations. The Contractor shall carry out adequate number of tests in accordance with IS:456 to ensure concrete of the minimum specified strength at requisite workability(i.e. slump).

6.4 Workmanship

All workmanship shall be according to the current Industry standard and best practices.

Before starting a pour the Contractor shall obtain the approval of the Employer in a "Pour Card" maintained for this purpose. He shall obtain complete instructions about the material and proportions to be used, Slump / workability, Quantity of

water per unit weight of cement, number of test cubes to be taken, type of finishing to be done, any admixture to be added, any limitation on size of pour and stopping of concrete in case of premature stopping of pours.

6.5 Mixing of Concrete

6.5.1 All design mix concrete shall be mixed in mechanically operated mixer of an approved size and type capable of ensuring a uniform distribution on the materials through the mass. However, contractor can also use central batching plant situated within the area allocated for the Contractor's particular use.

6.5.2 The proportions of sand, coarse aggregate, cement and water shall be as determined by the mix design. However, in case of nominal mix concrete (for lean concrete only) the proportions of ~~fine~~ sand, ~~and~~ coarse aggregate, cement and water shall be fixed. The proportions, as determined for design mix concrete and shall always be approved by the Employer. The quantities of the cement, sand and coarse aggregates shall be determined by weight. However, for a faster progress at site, quantities of the cement, sand and coarse aggregates can be converted to equivalent volume. The water shall be measured accurately after giving proper allowance for surface water present in the aggregate for which regular check shall be made by the Contractor.

6.5.3 The water shall not be added to the mix until all the cement and aggregates consisting the batch are already in the drum and dry mixed for at least one minute. Mixing of each batch shall be continued until there is a uniformity in colour and consistency but in no case shall mixing be done for less than two (2) minutes and at least forty (40) revolutions after all the materials and water are in the drum. When absorbent aggregates are used or when the mix is very dry, the mixing time shall be extended as may be directed by the Employer. Mixers shall not be loaded above their rated capacity as it prevents thorough mixing. If there is segregation after unloading from the mixer the concrete should be remixed.

6.5.4 The entire contents of the drum shall be discharged before the ingredients for the next batch are fed into the drum. No partly set or remixed or excessively wet concrete shall be used and it shall be immediately removed from site. Each time the work stops, the mixer shall be thoroughly cleaned and when the next mixing commences, the first batch shall have 10% additional cement at no extra cost to the Employer to allow for loss in the drum.

6.6 Conveying Concrete

Concrete shall be handled and conveyed from the place of mixing to the place of final laying as rapidly as practicable, by approved means, before the initial setting of the cement starts. Concrete should be conveyed in such a way as will prevent segregation of Concrete which may occur during transportation of concrete. In case of any such segregation during transport, the concrete shall be re-mixed. During very hot or cold weather, if directed by the Employer, concrete shall be transported

in deep containers, having mortar leak proof, which will reduce the rate of water loss by evaporation and loss of heat. Conveying equipment for concrete shall be well maintained and thoroughly cleaned before commencement of concrete mixing. Such equipment shall be kept free from set concrete.

6.7 Placing of Concrete

a) Formwork and placement of reinforcement shall be approved in writing by the Employer before concrete is placed. The forms shall be well wetted and oil shavings, dirt and water that may have collected at the bottom shall be removed before concrete is placed. Concrete shall be deposited in its final position without segregation, re-handling or flowing. The interval between adding the water to the dry materials in the mixer and the completion of the final placing inclusive of compaction of the concrete shall be well within the initial setting time for the particular cement in use or as directed by the Employer. As far as possible, concrete shall be placed in the formwork by means approved by the Employer and shall not be dropped from a height or handled in a manner which may cause segregation. Any drop over 1800 mm shall have to be approved by the Employer. Once the concrete is deposited in its final position, it shall not be disturbed. Care should be taken to avoid displacement of reinforcement or movement of formwork.

b) The placing of concrete shall be a continuous operation with no interruption in excess of 30 minutes between the placing of continuous portions of concrete.

c) After the concrete has been placed it shall be spread and thoroughly compacted by approved mechanical vibration to a maximum subsidence without segregation and thoroughly worked around reinforcement or other embedded fixtures into the correct form and shape. Vibrators shall not be used for pushing and shoveling concrete into adjoining areas. Vibrators must be operated by experienced men and over-vibration shall not be permitted. Head tamping in some case may be allowed subject to the approval of the Employer. Care must be taken to ensure that the inserts, fixtures, reinforcement and form work are not displaced or disturbed during placing of concrete. No concrete shall be placed in open while it rains. If there has been any sign of washing of cement and sand, the concrete shall be entirely removed immediately. Suitable precautions shall be taken in advance to guard against rains before leaving the fresh concrete unattended. No accumulation of water shall be permitted on or around freshly laid concrete. Tie beams, pile caps, footings shall be poured in one operation normally, in special circumstances with the approval of the

Employer these can be poured in horizontal layers not exceeding 500 mm in depth. When poured in layers, it must be ensured that the under layer, is not already hardened. Blending of under layer if any, shall be effectively removed.

d) Wherever vibration has to be applied externally the design of formwork and the disposition of vibrators shall receive special consideration to ensure efficient compaction and to avoid surface blemishes.

6.8 Inserts

All anchors, anchor bolts, insert, stubs, etc. and any other items those are required to be embedded in the concrete shall be placed in correct position before pouring. Extra care shall be taken during pouring operation to maintain their position as indicated in the drawings. These inserts shall be welded to the nearest reinforcement to keep them in position and all such welding shall be deemed to be included in the unit rate quoted and no extra payment shall be made on this account.

6.9 Blockouts

Blockouts in concrete as indicated in the drawing or as directed by the Employer shall be provided wherever required. No extra payment shall be made to the Contractor on this account.

6.10 Repairs and Finishes of Concrete

All concrete surfaces shall have even and clean finish, free from honeycombs, air bubbles, fins or other blemishes. The formwork joints marks for concrete work exposed to view shall be rubbed with carborandum stone and defects patched up with a paste of 1 part sand and 1 part cement and cured. The finish shall be made to the satisfaction of the Employer.

The unit rate of concrete work shall be inclusive of the cost of cleaning and finishing exposed surface as mentioned above.

7 Reinforcement Steel

This section of the specification shall cover providing reinforcement steel and its cleaning, bending, binding, placing with arrangements for chairs, supports and suitable covers for all reinforced concrete works, below and above ground level as per drawings and specifications.

7.1 General Requirements

7.1.1 Reinforcement steel of same type & grade shall be used for structural reinforcement work as detailed in the drawing released by the Employer. No work shall be

commenced without proper verification with the bar-bending schedule provided in the drawing .

7.1.2 Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated on the drawings and as per specifications. The reinforcement shall be either plain or deformed steel bars or welded wire fabric conforming to relevant IS specifications.

7.1.3 Any adjustment in reinforcement to suit field conditions and construction joints other than shown on drawings shall be subjected to the approval of Employer.

7.2 Bending

7.2.1 Unless otherwise specified, reinforcement steel shall be bent in accordance with procedure specified in IS:2502. Bends and shapes shall comply strictly with the dimensions in the approved Bar Bending Schedule. Contractor shall be entirely responsible for its correctness. Bars correctly bend shall only be used.

7.2.2 No reinforcement shall be bent when in position in the work without approval of the Employer, whether or not it is partially embedded in concrete. Bars shall not be straightened in a manner that will injure the material. Rebending can be done only if approved by the Employer. Reinforcement bars shall be bent by machine or other approved means producing a gradual and even motion. All the bars shall be cold bent unless otherwise approved.

7.3 Placing in position

7.3.1 All reinforcement shall be accurately fixed and maintained in position as shown on the drawings by ~~such~~ approved means as mild steel chairs, and/or concrete spacer blocks. Bars intended to be in contact, at crossing points, shall be securely bond together at all such points by two number No.20G annealed soft-iron wire.

Binders shall tightly embrace the bars with which they are intended to be in contact and shall be securely held. The vertical distance between successive layers of bars shall be maintained by provision of mild steel spacer bars. They should be so spaced that the main bars do not sag preceptibly between adjacent spacers.

7.3.2 The placing of reinforcements shall be completed well in advance of concrete pouring. Immediately before pouring, the reinforcement shall be checked by the Employer for accuracy of placement and cleanliness and necessary correction as directed by him shall be carried out. The cover for concrete over the reinforcements shall be as shown on the approved drawings unless otherwise directed by the Employer. Care should be taken to ensure that projecting ends of ties and other embedded metal do not encroach into the concrete cover. Where concrete blocks are used for ensuring the cover and positioning reinforcement, they shall be made of mortar 1:2 (one part cement: two parts sand) by volume and cured for at least (7)

days. The sizes and locations of the concrete blocks shall be approved by the Employer.

7.3.3 Longitudinal reinforcement in pile shall be high yield strength cold twisted deformed steel bars conforming to IS:1786. Thermo mechanically Treated (TMT) bars (equivalent grade) in place of Cold twisted deformed steel bars are also accepted. Lateral reinforcement in pile shall be of tor steel conforming to IS:432 Part-I.

7.3.4 The longitudinal reinforcement shall project 52 times its diameter above cut-off level unless otherwise indicated in the drawing.

7.3.5 The minimum diameter of the links or spirals bar shall be 8mm and the spacing of the links or spiral shall not be less than 150mm and in no case more than 250mm. The laterals shall be tied to the longitudinal reinforcement to maintain its shape and spacing.

7.3.6 Reinforcement cage shall be sufficiently rigid to withstand handling and installation without any deformation and damage. As far as possible number of joints (laps) in longitudinal reinforcement shall be minimum. In case the reinforcement cage is made up of more than one segment, these shall preferably be assembled before lowering into casing tube/pile bore by providing necessary laps as per IS:456.

7.3.7 The minimum clear distance between the two adjacent main reinforcement bars shall normally be 100mm for the full depth of cage, unless otherwise specified.

7.3.8 The laps in the reinforcement shall be such that the full strength of the bar is effective across the joint and the reinforcement cage is of sound construction. Laps and anchorage lengths of reinforcing bars shall be in accordance with IS:456, unless otherwise specified. If the bars in a lap are not of the same diameter, the smaller will guide the lap length.

7.3.9 Laps shall be staggered as far as practicable and as directed by the Employer. Not more than 50% bars shall be lapped at a particular section. Lap joints shall be staggered by at least 1.3 times the lapped length (Center to Center).

7.3.10 Proper cover and central placement of the reinforcement cage in the pile bore shall be ensured by use of suitable concrete spacers or rollers, as required, without any additional cost to the Employer.

7.3.11 Minimum clear cover to the reinforcement shall be 75mm unless otherwise mentioned.

7.3.12 Unless otherwise specified by the Employer reinforcement shall be placed within the following tolerance as specified in IS:456:2000.

a) For effective depth 200mm or less +10mm.

b) For effective depth more than 200mm +15mm.

The cover shall in no case be reduced by more than one-third of specified cover or 5mm whichever is less.

7.3.13 Welding of reinforcement bars shall be avoided. However, welding may be done in specific case subject to prior permission from the Employer.

8 Construction of Pile Cap, Pedestal, Tie Beam etc.

The Contractor shall deploy all labour, equipment, tools & tackles and materials required for complete execution of the work in accordance with the drawings and as described herein.

8.1 Excavation

8.1.1 The Contractor shall control the grading in the vicinity of all excavation so that the surface of the ground will be properly slopped or diked to prevent surface water from running into the excavated areas during construction.

8.1.2 Excavation shall include the removal of all materials required to execute the work properly and shall be made with sufficient clearance to permit the placing, inspection and setting of forms and completion of all works for which the excavation was done.

8.1.3 Side and bottoms of excavation shall be cut sharp and true, undercutting shall not be permitted. Each side of excavation shall be used in lieu of formwork for placement of concrete unless authorised, in special cases, by the Employer, where limitation of space for larger excavation necessitate such decision.

8.1.4 When machines are used for excavation, the last 300mm before reaching the required level shall be excavated by hand or by such equipment that will leave the soil at the required final level, in its natural conditions.

8.1.5 Suitability for bearing of the bottoms of excavations shall be determined by the Employer.

8.1.6 The bottom of excavation shall be trimmed to the required level and when carried below such levels, by error, shall be brought to level by filling with lean concrete 1:4:8 mix, with aggregate of 40mm maximum nominal size at no additional cost to the Employer.

8.1.7 The Contractor shall be responsible for assumptions and conclusions regarding the nature of materials to be excavated and the difficulty of making and maintaining the required excavations and performing the work required as shown on the drawing and in accordance with these specifications. The Contractor shall be responsible for any damage to any part of the work and property caused by collapse of sides of excavations. Materials may be salvaged, if it can be done with safety for the work and structure, as approved by the Employer.

However, no extra claim shall be entertained for materials not salvaged or any other damage to Contractor's property as a result of the collapse. He shall not be entitled to any claim for redoing the excavation as a result of the same.

8.1.8 Excavations for foundations specified shall be carried out at least 75mm or as specified in relevant drawings below the bottom of structural concrete and then be brought to the required level by placing lean concrete of 1:4:8 mix or as specified in drawings with aggregate of 40mm maximum nominal size.

8.1.9 When excavation requires coffer dams, sheet piling, bracing, sheeting, shoring, draining, dewatering etc. the Contractor shall have to provide the same as required and the cost there of shall be included in the unit rate quoted for the item of excavation and contractor shall submit necessary drawings showing arrangement and details of proposed installation and shall not proceed until he has received approval from the Employer.

8.1.10 The Contractor shall have to constantly pump out the water collected in pits due to rain water, springs, seepage etc. and maintain dry working conditions at no extra cost to the Employer.

8.1.11 For the purpose of excavation in earthwork, all types of soil including kankar, morum, shingle and boulders up to 150mm size are included and no separate payment shall be made for different type of soils encountered.

8.2 Form work

8.2.1 General

8.2.1.1 If it is so desired by the Employer, the Contractor shall prepare, before commencement of the actual work, design and drawings for form work and centering and get them approved by the Employer. The form work shall conform to the shape, alignment and dimensions as shown in the drawings.

Form work shall be composed of steel and/or best quality shuttering wood of non-absorbent type or plywood. Timber shall be free from significant knots and shall be of medium grain as far as possible and hard woods shall be used as caps and wedges under or over posts. Plywood or equivalent shall be used where specified to obtain smooth surfaces for exposed concrete work. Struts shall generally be mild steel tubes, and strong sal ballis of 150mm in diameter or above. Bamboos, small diameter ballis, etc. shall not be used unless approved by the Employer in specified cases.

Supports or props should not be supported on an unpropped lower suspended floor or beam unless calculations are submitted to the Employer to confirm the strength of the lower floor or beam and no propping shall be taken out until the Employer approval has been given.

8.2.1.2 The form work shall be true and rigid and thoroughly braced both horizontally and diagonally. The forms shall be sufficiently strong to carry without undue deformation, the dead weight of the concrete as well as working load. Where the concrete is vibrated, the formwork shall be strong enough to withstand the effects of vibration, without appreciable deflection, bulging, distortion or loosening off its components. The joints in the formwork shall be sufficiently tight to prevent any leakage of mortar. The formwork shall be such as to ensure a smooth uniform surface free from honeycombs, air bubbles, bulges, fins and other blemishes. Any blemish or defect found on the surface of the concrete must be brought to the notice of Employer immediately and rectified free of charge as directed by him. To achieve the desired rigidity, the bolts, space blocks, the wires and clamps as approved by the Employer shall be used but they must in no way impair the strength of concrete or leave stains or marks on the finished surface, where there are chances of these fixtures being embedded, only mild steel or concrete of adequate strength shall be used. Bolts passing completely through liquid retaining walls/slabs for the purpose of securing and aligning the formwork should not be used.

8.2.1.3 Temporary openings for cleaning, inspection and for pouring concrete may be provided at the base of vertical forms and as may be directed by the Employer. The temporary openings shall be so formed that they can be conveniently closed when required and must not leave any mark on the concrete.

8.2.2 Cleaning and Treatment of Forms

8.2.2.1 All forms shall be thoroughly cleaned of old concrete wood shavings, saw dust, dirt and dust sticking to them before they are fixed in position. All rubbish loose concrete, chippings, shavings, saw dust etc. shall be scrupulously removed from the interior of the forms before the concrete is poured. Along with wire brushes, brooms, etc. compressed air jet and/or water jet shall be kept handy for cleaning, if directed by the Employer.

8.2.2.2 Before shuttering is placed in position the form surface in contact with concrete shall be treated with approved non-standing oil or composition of other material approved by the Employer. Care shall be taken that the oil or composition does not come in contact with reinforcing steel or existing concrete surface. They shall not be allowed to accumulate at the bottom of the shuttering.

8.2.2.3 If formwork for pedestal/chimney is erected for the full height of the section, as placing of concrete proceeds, wedges, spacer bolts, clamps or other suitable means shall be provided to allow accurate adjustment of the formwork and to allow it to be removed gradually without jarring the concrete.

8.2.3 Removal of Forms

8.2.3.1 The Contractor shall begin the removal of formwork only after approval of Employer. He shall place on record the date on which the concrete is placed in different parts of the work and the date of the removal of formwork there from. This record shall be checked and countersigned by the Employer. The Contractor shall be responsible for the safe removal of formwork but the Employer may delay the time of removal if he considers it necessary. Any work showing signs of damage through premature removal of formwork or loading shall be entirely reconstructed without any extra cost to Employer.

8.2.3.2 Forms for various types of structural components shall not be removed before the minimum periods specified below which shall also be subject to the approval of the Employer.

8.2.3.3 No supporting forms shall be removed suddenly in such manner as to create shock loading. Forms for sides shall not be removed before 2 days. Bottom forms shall not be removed before 28 days unless this period is reduced with specified concurrence of the Employer.

8.2.3.4 However, in any case, formwork shall not be struck until the concrete has reached a strength at least twice the stress to which the concrete may be subjected to, at the time of removal of forms.

8.2.4 Re-use of Forms

Before re-use, all forms shall be thoroughly scrapped cleaned and joints, etc. shall be examined, ~~and~~ when necessary repaired and inside surface treated as specified. Formwork shall not be used/re-used, if declared unfit or unserviceable by the Employer.

8.3 Back Filling

8.3.1 General Requirement

8.3.1.1 After completion of foundation footings, pile caps, pedestals, tie beams and other constructions below the elevation of the grades, and prior to back filling, all forms of temporary shoring, timber etc. shall be removed and the excavation cleaned of all trash, debris and perishable materials, back filling shall begin only with the approval of the Employer.

8.3.1.2 The soil to be used for back filling purpose shall be inorganic material and shall be free from any foreign substance which can harm or impair the strength of footing in any manner. In any case the soil to be used for back filling purpose shall have the prior approval of the Employer.

8.3.1.3 The soil to be used for back filling purpose shall be either from the excavated earth or from the borrow pits, as directed by the Employer. The soil may have to be brought from a distance up to 2 km. By the shortest haulage route as approved by the Employer. If directed by the Employer, the excavated earth from the adjoining areas (which is to be disposed off up to a distance of 500 meters by manual labour) shall be used as for back filling purpose.

8.3.1.4 Back filling shall not be dropped directly upon or against any structure where there is danger of displacement or damage.

8.3.1.5 Back filling shall be placed in horizontal layers not to exceed 200mm in thickness. Each layer shall be compacted with proper moisture content and with such equipment as may be required to obtain a density equal to or greater than 95% of maximum dry density as determined by the relevant Indian Standard. The method of compaction shall be subject to the approval of the Employer. Pushing of earth for back filling shall not be adopted under any circumstances.

8.3.1.6 On completion of structures, the earth surrounding them shall be accurately finished to line and grade as shown on the drawings or as per the instruction of the Employer. Finished surface shall be free of irregularities and depressions and shall be within 50mm of the specified level.

8.3.1.7 Any additional quantity of back filling, if required, beyond the excavation payment line shall be done by the contractor at his own expense.

8.4 Construction Joints

a) When the work is to be interrupted, the concrete shall be rebated at the joint to such shape and size as may be required by the Employer or as shown on the drawings. All vertical construction joints shall be made with stone boards, which are rigidly fixed and slotted to allow for the passage of the reinforcing steel. If desired by the Employer, keys and/or dowel bars shall be provided at the construction joints. Construction joints shall be provided in positions as shown or described on the drawing. Where it is not described, the joints shall be in accordance with the following :

i) In a column, the joint shall be formed about 75mm below the lowest soffit of the beams framing into it.

ii) Concrete in tie beam shall be placed throughout without a joint, but if the provision or a joint is unavoidable, the joint shall be vertical and at the middle of the span.

iii) In forming a joint, concrete shall not be allowed to slope away to thin edge. The locations of construction joints shall be planned by the Contractor well in advance of pouring and have to be approved by the Employer.

b) Before the fresh concrete is placed, the cement skin of the partially hardened concrete shall be thoroughly removed and surface made rough by hacking, sand blasting, water jetting, air jetting or any other method as directed by the Employer. The rough surface shall be thoroughly wetted for about two hours and shall be dried and coated with 1:1 freshly mixed cement sand slurry immediately before placing the new concrete. The new concrete shall be worked against the prepared surface before the slurry sets. Special care shall be taken to see that the first layer of concrete placed after a construction joint is thoroughly rammed against the existing layer. Old joints during pour shall be treated with 1:1 freshly made cement sand slurry only after removing all loose materials.

c) The unit rate of concrete work shall include the cost of construction joints.

8.5 Curing and Protection of Concrete

Newly placed concrete shall be protected by approved means from rain, sun & wind. Concrete placed below ground level shall be protected from falling earth during and after placing. Concrete placed in ground containing deleterious substances shall be kept free from contact with such ground or with water leaking from such ground during placing of concrete and for a period of three days or as otherwise instructed by the Employer after placing of concrete. The ground water around newly poured concrete shall be kept to an approved level by pumping or other approved means of drainage. Adequate steps shall be taken to prevent floatation or flooding. Steps, as approved by the Employer, shall also be taken to protect immature concrete from damage by debris, excessive loading, vibration etc. which may impair the strength or durability of the concrete.

All fresh concrete shall be covered with a layer of Hessian or similar absorbent material and kept constantly wet for a period of seven days or more from the date of placing of concrete as per directions of the Employer. Curing can also be made by ponding. Concrete shall be cured by flooding with water of minimum 25mm depth for the period mentioned above. Step shall also be taken to protect immature concrete from damage debris by excessive loading, vibrations, abrasions, deleterious ground water, mixing with earth or foreign materials, floatation etc. that may impair the strength and durability of the concrete. Approved curing compound can be used with the permission of the Employer. Such compound shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set.

9 Pile Installation

Installation of piles shall be carried out as per pile layout drawings, installation criteria, technical specifications and the directions of the Employer.

9.1 Equipment and Accessories

9.1.1 The equipment and accessories for installation of bored cast-in-situ piles shall be selected giving due consideration to the sub soil conditions, ground water conditions and the method of casting, etc. These shall be of standard type and shall have the approval of the Employer.

9.1.2 The capacity of the rig shall be adequate so as to reach the specified founding level.

9.1.3 Provision shall be kept for chiseling within the pile bore, as specified in this specification. Chiseling shall be carried out only with the approval of Employer. The contractor must have the provision of equipment/accessories which can bore in the hard rock strata if required, without any additional cost implication to the Employer.

9.2 Installation Criteria

9.2.1 The Contractor while boring the pile bores, shall constantly collect the bore spoils and these shall be compared with the layer wise soil classifications reported in the bore-log details of the location, reported in the soil investigation report. Should there be any variation between the two soil classification, these shall be immediately reported to the Employer.

9.2.2 Whenever the rock strata is encountered in the pile bore, the Contractor shall immediately report the matter to the Employer and shall take up the work of rock chiseling or any other suitable method only after the certification/approval of the Employer. Since the piles are required to be terminated in the firm/hard strata and as stipulated in the construction drawing the Contractor shall demonstrate such founding strata and seek approval of the Employer before terminating the piles.

9.2.3 The pile should be socketed and founded in good rock only. Whenever rock strata is encountered at any pile bore and the level of good rock (i.e. rock strata is not highly fractured and weathered and core recovery is not less than 80% with RQD 70%) is different than that is given in the Geotechnical Investigation report, in that case to establish the level of good rock, core drilling is necessary to be carried out at least upto 5m depth in rock strata encountered by the contractor without any additional cost implication to EMPLOYER and no time extension will be permitted on this account.

9.2.4 In order to verify the terminating depth, where rock strata is met with, the rock samples obtained from the bore spoils of pile shall also be tested for point load strength index and these shall then be compared/correlated to the values of uniaxial compression strength test shown in the soil investigation report. Accordingly, the termination of piles in the socketing zone shall be done with prior approval of the Employer.

9.3 Control of position and alignment

Piles shall be installed vertically as accurately as possible as per the construction drawing. The permissible limits for deviation with respect to position and inclination/alignment shall conform to IS-2911 (Part I/Sec.2), as reproduced below.

9.3.1 Maximum permissible deviation in alignment is 1.5% . Piles should not deviate more than 75mm or D/10 which ever is less from their positions at the working level. In case of piles deviating beyond these limits, the piles should be replaced or supplemented by one or more additional piles including the revised cap size(as the situation may be) at no additional cost to the Employer. Any extra claim whatsoever from the contractor on this account shall not be entertained.

9.4 Boring

9.4.1 Boring operations shall be done by rotary or percussion type drilling rigs using Direct Mud Circulation (DMC), Reverse Mud Circulation (RMC) methods or grab method. In soft clays and loose sands bailer method, if used, shall be used with caution to avoid the effect of suction. In cohesive soils, use of water for boring shall be restricted to a minimum, while boring

in cohesion less deposits water level in the bore hole shall be maintained at or slightly above the standing water table.

Boring operations by any of the above methods shall be done using drilling mud. The bidder shall be required to furnish along with their bid, complete details regarding the installation of piles and the method by which they wish to install the piles.

9.4.2 The Contractor shall satisfy himself about the suitability of the method to be adopted for site. If DMC or RMC is used, bentonite slurry shall be pumped through drill rods by means of high pressure pumps. The cutting tools shall have suitable pores for the bentonite slurry to flow out at high pressure. If the Contractor fails to make proper bore for any reason, the Contractor has to modify the boring technique and switchover to other boring methods as approved by the Employer at no extra cost to the Employer.

9.4.3 Working level shall be above the pile cut off level. After the initial boring of about 1.0 to 2.0m temporary guide casing shall be lowered in the pile bore. The diameter of guide casing shall be of such diameter to give the necessary finished diameter of the concrete pile. The center line of guide casing shall be checked before continuing further boring. Guide casing shall be minimum 2.0m length. Additional length of guide casing shall be used depending on the conditions of the strata, ground water level etc. as required by the Employer without any additional cost to the Employer.

9.4.4 Use of drilling mud (Bentonite slurry) for stabilising the sides of the pile bore is necessary wherever subsoil is likely to collapse in the pile bore. Drilling mud to be used shall meet the requirement as given in Annexure-C.

9.4.5 The Bentonite slurry and the cuttings, which are carried to the surface by the rising flow of the slurry shall pass through settling tanks of adequate size to remove the sand and spoils from the slurry before the slurry is re-circulated back to the boring. The Bentonite slurry mixing and re-circulation plant shall be suitably designed and installed.

9.4.6 The Bentonite slurry shall be maintained at 1.5m above the ground water level during boring operations and till the pile is concreted. When DMC or RMC method is used the Bentonite slurry shall be under constant circulation till start of concreting.

9.4.7 The size of cutting tools shall not be less than the diameter of the pile as specified in the drawing and not more than 75mm.

9.5 Chiseling

9.5.1 Chiseling, if required, may be resorted to with the permission of the Employer below the socketing horizon. The chiseling tool or bit shall be of adequate size and weight so as to reach the desired depth.

9.6 Cleaning of Pile bore

9.6.1 After completion the pile bore up to the required depth, the bottom of the pile bore shall be thoroughly cleaned. Cleaning shall ensure that the pile bore is completely free from sludge/bored material, debris of rock/boulder etc. Necessary checks shall be made as given in this Section to confirm the thorough cleaning of the pile bore.

9.6.2 Pile bore shall be cleaned by fresh drilling mud through tremie pipe before start of concreting and after placing reinforcement.

9.6.3 Pile bore spoil along with used drilling mud shall be disposed off from site up to 2 Km. or as directed by the Employer.

9.7 Adjacent Structures

9.7.1 When working near existing structures care shall be taken to avoid any damage to such structures.

9.8 Concreting

9.8.1 Concreting shall not be done until the Employer is satisfied that the bearing strata (soil/rock) met with the termination level of pile, satisfied the installation criteria/approved founding depth.

9.8.2 The time between the completion of boring and placing of concrete shall not exceed 6 hrs. In case the time interval exceed 6 hrs the pile bore shall be abandoned. However, the Employer may allow concreting, provided the Contractor extends the pile bore by 0.5 m beyond the proposed depth, and clean the pile bore

properly. The entire cost of all operation and materials for this extra length shall be borne by the Contractor.

9.8.3 Pile bore bottom shall be thoroughly cleaned to make it free from sludge or any foreign matter before and after placing the reinforcement cage.

9.8.4 Proper placement of the reinforcement cage to its full length shall be ensured before concerting.

9.8.5 Entire concreting in pile bores shall be done by tremie method. The operation of tremie concreting shall be governed by IS:2911 Part I/Sec.2. Drilling mud shall be maintained sufficiently above the ground water level.

9.8.6 Concreting operations shall not proceed if the contaminated drilling mud at the bottom of the pile bore posses density more than 1.25 T/Cu.m. or sand content more than 7%. The drilling mud sample shall be collected from the bottom of pile bore. This shall be checked at regular intervals, as decided by the Employer thereafter.

9.8.7 Consistency of the drilling mud suspension shall be controlled throughout concreting operations in order to keep the bore stablised as well as to prevent concrete getting mixed up with the thicker suspension of the mud.

9.8.8 It shall be ensured that volume of concrete poured is at least equal to the theoretically computed volume of pile shaft being cast.

9.8.9 The temporary guide casing shall be entirely withdrawn cautiously, after concreting is done up to the required level. While withdrawing the casing concrete shall not be disturbed.

9.8.10 Tests on concrete cubes shall be carried out as specified in this section of the Specifications.

9.9 Cut-off-level (COL)

9.9.1 Cut-off-level of piles shall be as indicated in approved construction drawings or as directed by the Engineer-in-Charge.

9.9.2 The top of concrete in pile shall be brought above the COL to remove all laitance and weak concrete and to ensure good concrete at COL for proper embedment into pile cap.

9.9.3 When the pile cut off level is less than 1.0 meter below the working level, concrete shall be cast up to the piling platform level to permit overflow of concrete for visual inspection. In case COL of pile is more than 1.0 meter below working level then concrete shall be cast to minimum of one meter above COL.

9.9.4 In the circumstances where COL is below ground water level, the need to maintain a pressure on the unset concrete equal to or greater than water pressure shall be

observed and accordingly length of extra concrete above COL shall be determined by the Contractor with prior approval of Employer.

9.10 Sequence of Piling

9.10.1 Each pile shall be identified with a reference number and date wise proper record of construction shall be maintained by the Contractor.

9.10.2 The convenience of installation may be taken into account while scheduling the sequence of piling in a group. This scheduling shall avoid piles being bored close to other recently constructed piles.

9.11 Building up of Piles

9.11.1 If any pile, already cast as per construction drawing, requires any extra casting due to any change in cut off level or the cast pile top level is less than the specified level or for any other reason, then the pile shall be built up by using M-25 grade of concrete with minimum cement content 400kg/m^3, ensuring proper continuity with the existing concrete and to the satisfaction of the Employer. Necessary reinforcement as per design requirement and suitable shuttering shall be provided before casting the concrete. Surrounding soil shall also be built up to the required level by proper compaction to ensure lateral capacity of the pile.

9.12 Breaking off of Piles

9.12.1 If any pile already cast requires breaking due to lowering in cut off level or for any other reason, then the same shall be carried out, (not before seven days of casting of concrete in the piles) without affecting the quality of existing pile such as loosening, cracking etc. to the satisfaction of the Employer. No extra payment shall be made on this account.

9.13 Preparation of Pile head

9.13.1 The soil surrounding the piles shall be excavated up to the bottom of the lean concrete below the pile cap with provision for working space sufficient enough to place shuttering, reinforcement, concreting and any other related operations.

9.13.2 The exposed part of concrete above the COL, shall be removed/chipped off and made square at COL not before seven days of casting of pile.

9.13.3 The projected reinforcement above COL shall be properly cleaned and bent to the required shape and level to be anchored into the pile cap as shown in the drawing.

9.13.4 The pile top shall be embedded into the pile cap by minimum 50mm or clear cover to reinforcement, whichever is higher.

9.13.5 All loose material on the top of pile head after chipping to the desired level shall be removed and disposed off up to a lead of 2km or as directed by the Employer.

9.14 Rejection and Replacement of Defective Piles

9.14.1 The Employer reserve the right to reject any pile which in his opinion is defective with reference to technical specification & construction drawings on account of load capacity, structural integrity, position, alignment, concrete quality etc. Piles that are judged defective shall be pulled out or left in place as decided by the Employer without affecting the performance of adjacent piles. The Contractor shall install additional piles to substitute the defective piles as per the directions of the Employer at no extra cost to the Employer.

9.14.2 During execution of pile foundation work, if the bore holes need to be abandoned due to any reason and pile position to be shifted or realigned, other than for any design requirement by the Employer, fresh bore holes are to be executed at a suitable new position, which may vary from 2D to 3D (where, D is diameter of pile) as decided by the Employer, which may demand for resizing of pile cap including possible increase in reinforcement quantity due to resizing of pile cap. In all such cases the abandoned bore holes are to be filled up with plain cement concrete (1:3:6) so that no cavity remain in the bore hole of the abandoned pile. Any extra claim whatsoever from the contractor on account of abandoned bore hole, filling up of abandoned bore hole with concrete and any extra cost due to resizing of pile cap including increase in reinforcement quantity shall not be entertained by the Employer & the same have to be born by the contractor.

9.15 CRITERIA FOR TERMINATING THE PILES

9.15.1 The piles can be terminated at a depth based on design developed by the Employer, where loads on the piles can be transmitted to the soil in a proper manner or the depth where specified `N' value is achieved, whichever occurs later. However, in no case piles should be terminated at a higher level than that indicated in the construction drawing.

9.15.2 Standard penetration test (SPT) shall be carried out starting from 1.0 M above the specified pile termination depth and there after @ 1m. up to the pile termination depth.

9.15.3 The Standard Penetration Test (SPT) shall be carried out based on the following test procedures:

The test shall be conducted by driving a standard split spoon sampler in the borehole by means of a 650 N hammer having a free fall of 0.75 M. The sampler

shall be driven for 450 mm using the hammer and the number of blows shall be recorded for every 150mm penetration. The number of blows for the last 300 mm drive shall be reported as N value. The test shall be discontinued when the blow count is equal to 100 or the penetration is less than 25mm for 50 blows, whichever is earlier.

At the location where the test discontinued, the penetration and the number of blows shall be reported. Sufficient quantity of disturbed sample shall be collected from the split spoon sampler for identification/classification of soil. The sample shall be visually classified and recorded at the site.

The specification for the equipments and other accessories, procedure for conducting the test and collection of the disturbed soil sample shall conform to IS:2131.

9.16 Recording of Piling Data

9.16.1 The Contractor shall record all the information during installation of piles. Typical data sheet for recording pile data as shown in Appendix D of IS:2911 Part I/Sec.2 shall be maintained by the contractor. The pile data shall also include all the details as in Annexure-D. On completion of each pile installation, pile record in triplicate shall be submitted to Employer within two days of completion of concreting of the pile.

9.17 Check for Pile bore

9.17.1 On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by the Employer, to ensure that it is free from pile bore spoil/debris and any other loose material, before concreting. Concreting shall be done only after the approval of the Employer.

9.17.2 For sampling of drilling mud from the pile bore the following method or any other suitable method shall be adopted.

A solid cone shall be lowered by a string to the bottom of pile bore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimise the leakage while lifting the cone assembly to the ground surface. The slurry collected in the sampler tube shall be tested for density and sand content.

9.18 Properties of drilling mud

9.18.1 Properties of drilling mud shall be checked as per requirements indicated in Annexure ‘C’ prior to the commencement of piling work and thereafter at least

once in a week or as found necessary by the Employer, one sample consisting of 3 specimens shall be tested.

9.18.2 Density and sand content of the drilling mud shall be checked in each pile.

10 Erection of Steel Embedded Parts

10.1 This covers the technical requirements for the supply and fabrication and/or erection of all embedded steel parts by the Contractor. The extent and type of embedded steel parts to be erected shall be as per detailed drawings.

10.2 The supply of embedded steel parts like ladders, steel pieces set in concrete inserts, dowel bars required for construction joints etc. are in the scope of the Contractor. However, supply of anchor bolts/stubs, as the case may be, will be supplied by tower contractor.

10.3 Embedded steel parts shall include items such as foundation anchor bolts, stubs, ladders, steel pieces set in concrete inserts, dowel bars for concrete work, , etc. shown on the drawing or as required by the Employer. Material shall also include setting in forms for connecting in place and grouting as required. The grouting operations, if required, shall be performed as per the direction of Employer.

10.4 The Contractor shall erect all embedded steel parts in accordance with the drawings and these specification including setting materials in concrete or grouting pieces in place, furnishing all labour, materials, scaffolding, tools and services necessary for and incidental to the work to its transporting, unloading, storing, handling and erection. Contractor shall furnish welding rods and arrange for field welding as required in accordance with IS : 816.

10.5 Exposed surface of embedded material are to be painted with one coat of approved anticorrosive and/or bituminous paint without any extra cost to the Employer. The threads of holding down bolts shall be greased and protected with water proof tape.

11 Installation

11.1 During erection, the Contractor shall provide necessary temporary bracing or supports to ensure proper installation of the materials. All materials shall be erected in the true locations as shown in the drawings, plumb and level. Extreme care shall be taken to ensure that the threads of holding down bolts and comparable items are protected from damage.

11.2 Groups of holding down bolts shall be set in such a manner that the tolerance of whole group is not more than 3mm from its true position in plan at the top of the bolt and not more than 3mm from the required level. The top ends of all bolt shanks shall be in one plane to the tolerance stated above.

Holding down bolt assemblies shall be set vertically to a tolerance of not more than 1:500.

12 Protection Against Damage in Transit

12.1 All steel work shall be efficiently and sufficiently protected against damage in transit to site from any cause whatsoever. All protecting plates or bars and all ends of members at joints shall be stiffened, all straight bars and plates shall be bundled, all screwed ends and machined surface shall be suitably packed and all bolts, nuts, washers and small loose parts shall be packed separately in cases so as to prevent damage or distortion during transit. Should there be any distortion of fabricated members, the Contractor shall immediately report the matter to the Employer. Distorted reinforcement bars or plates received from stores or distorted during transport from stores to the fabrication yard shall not be used in fabrication unless the distortions are minor which in the opinion of the Employer can be removed by acceptable methods. The cost of all such straightening shall be borne by the Contractor within his unit rates.

These distortions shall be rectified by the Contractor by cold bending. If heating is necessary to rectify the defects, the details of the procedure shall be intimated to the Employer whose approval shall be taken before such rectification. The temperature of heat treatment shall not exceed the limits beyond which the original properties of steel are likely to be impaired.

13 Foundations Bolts

13.1 The foundation bolts / stubs, as required, for the tower structures shall be supplied by the respective tower contractor. These shall be embedded in concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate and also co-ordinate with the respective tower contractor for its correctness. The final adjustment of these bolts and their grouting are included in the scope of this contract. Grouting of block outs and the gap between the base plate and top of concrete shall be done by the Contractor after finalisation of alignments. The unit rate of concreting shall include the cost of above adjustments, grouting, and skins etc. required for this purpose.

13.2 The Contractor shall be responsible for the correct alignment and levelling of all steel work on site to ensure that the towers are in plumb.

13.3 Before erection of towers, by tower contractor, on the foundations the top surface of base concrete shall be thoroughly cleaned with wire brushes and by chipping to remove all laitance and loose materials and shall be chipped with a chisel to ensure proper bond between the grout and the foundation concrete. The piling Contractor shall also be responsible for bringing down the top of concrete to the desired level by chipping. In case the foundation as cast is lower than the desired level, the Contractor shall make up the difference by providing additional pack plates without extra cost for any such work or material. No steel structures shall be erected on their foundations unless such foundations have been certified fit for erection by the

Employer. Adequate number of air release holes and inspection holes shall be provided in the base plate.

14 Stability of Structure

14.1 The Contractor shall be responsible for the stability of the structure at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations. Guying and bracing shall be done for erection equipment and their operations. Guying and bracing shall be done in such a way that it does not interface with the movement or working of other agencies working in the area. For the purpose of guying, the Contractor shall not use other structures in the vicinity which are likely to be damaged by the guy.

Such temporary bracings shall neither be included in the measurement nor extra rate shall be payable. Such temporary bracings used shall be the property of the Contractor and may be removed by him at the end of the job from the site of work.

15 Grouting and under Pinning

15.1 General requirement

15.1.1 Furnishing of all labour materials and equipment and performance of all operations necessary to complete the work of grouting of block outs and foundation bolt holes and under pinning of base plates is in the scope of the Contractor. The cost of the above shall be included in the unit concreting rate.

15.1.2 Grouting shall be adopted for filling the block outs, pockets below foundation bolt holes. The block out and bolt holes which have to be grouted shall be cleaned thoroughly by use of compressed air immediately before taking up the grouting operations.

15.1.3 Cement and aluminium powder or anti-shrinkage admixture of approved quality shall be first blended thoroughly in the required proportions as per manufacturer's specification. The mix of grouting shall contain one part of cement and two parts of coarse sand. Admixture should be according to IS:9103.

15.1.4 15.1.4 The quantity of aluminum powder shall usually be of the order of 0.005% by weight of cement. Any grout which has been mixed for a period longer than half an hour shall not be used on the work. Immediately after preparation the grout shall be poured into the block outs, pockets and foundation bolt holes either from the sides or through the holes provided for this purpose in the base plate, by using special equipment for pressure grouting. It shall be ensured by rodding and by tapping of bolts that the block out is completely filled without leaving any voids. The pouring shall cease as soon as each hole is filled and any excess grout found on

the surface of the concrete foundation shall be completely removed and the surface dried.

15.1.5 Under pinning ~~It~~ shall be resorted to for filling the space between the underside of base plate and the top of foundation concrete. After grouting has been completed as specified above, space between the top surface of the foundation concrete and the underside of the base plate shall be filled with mortar or concrete depending upon thickness to be filled as follows :

Less than 40mm	Dry packed cement mortar
Over 40mm	Dry packed fine concrete

Mortar, fine concrete shall be blended with aluminium powder about 0.005% by weight of cement or with anti-shrinkage admixture in a suitable proportion to the cement mortar in accordance with the recommendations of the manufacturer and subject to the approval of the Employer. Mortar shall comprise cement, sand and water in proportion of approx. 1:3:0.4 by weight. Concrete shall comprise cement, sand, 10mm max. sized aggregate and water in proportion of 1:1.25:2:0.4 by weight. In all cases minimum 28 days cube strength should not be less than $25N/mm^2$.

Shims provided for the alignment of bases shall be positioned at the edges of the base to permit subsequent removal which shall take place not less than 7 days after the underpinning has been executed. The resulting cavities shall be made good with the same grade of mortar or concrete as has been used for the underpinning of the rest of the base plate.

15.1.6 Cement, sand and aluminium powder or approved anti-shrinkage admixture, shall first be blended thoroughly in the required proportion. The mortar shall then be prepared by mixing with quantity of water which will produce a sufficiently workable mix to enable complete and proper compaction of the mortar.

15.1.7 The mortar shall then be placed below the base plate and rammed in a horizontal direction for each edge until the mortar oozes out through the grout holes provided in the base plate.

15.1.8 When it is clear that the center of base has been properly filled, the mortar outside the base plate shall be briefly rammed to ensure compaction below the edges. Any mortar which has been mixed for a period longer than half an hour, shall not be used in the work.

15.2 Materials

15.2.1 Cement shall conform to the stipulations contained in IS:8112and shall have a fineness (specific surface of cement) not less than 225 sq.m./kg when tested for fineness by Blaine's air permeability method as per IS:4031.

15.2.2 Sand shall conform to the stipulations contained in IS:383.

15.2.3 Water shall be clean and fresh and shall be of potable quality.

15.2.4 Aluminium powder or anti-shrinkage admixture like 'Groutex' CRS-NS grout or its equivalent shall be of standard brand from reputed manufacturer and shall be approved by the Employer prior to its use for work.

15.3 CURING

The work shall be cured for a period of 7 days commencing 24 hours after the completion of the grouting and under pinning operations. The curing shall be done by covering the surfaces with wet gunny bags.

16 Bar Grips

16.1 This covers the technical requirement for furnishing and installation of bar grips complete including all labour materials, equipment, staging, etc.

16.2 The Contractor shall furnish and install the bar grips for various diameter of deformed bars as indicated in drawings and as required by these specifications. The bar grip splicing system shall be of approved manufacturer and of the best quality available subject to approval of the Employer.

17 Splicing

17.1 a) The reinforcement bars are to be joined without any gap and the sleeve placed in position.

b) Pressure is applied by means of a hydraulic press which swages the sleeve down on the bar ends in a series of bites which are applied at high pressure.

c) The job can also be done in two stages. The 1st stage is to press the half sleeve on the loose bar at the reinforcement yard. The 2nd stage work is to be done at the actual site after the loose bar is inserted through the unpresented end of the sleeve and pressed insitu.

17.2 The joints shall be staggered as far as possible. Necessary staging arrangements are to be made by the Contractor.

17.3 It may be necessary to fix the sleeve to the reinforcement bars at one end in the open yard for the facility of working. All these working details are to be furnished earlier subject to the approval of the Employer.

17.4 The length of the sleeve should be adequate, that it is safe under the pull out loading conditions.

17.5 One percent representative samples of each dia, bars shall be sent for laboratory testing at the cost of the Contractor to check the efficiency of the joints under ideal condition. These samples of sleeves will be sent in the Laboratory for pull out tests.

17.6 All bar grips installation shall be subject to inspection and approval by the Employer before concreting operation are performed. In case of any defect or joint being not up to mark, the same shall be replaced by the Contractor at no extra cost.

18 MS Liner

MS liner shall be provided wherever included in the construction drawings released by the Employer and/or otherwise required by the Employer. For MS liner the technical specifications stipulated at Part-V shall apply.

SECTION – 14.2 (Part-III)
RATES & MEASUREMENT

CONTENTS

SECTION – 14.2 (Part-III)
RATES & MEASUREMENT

1 Excavation

1.1 The unit rate for excavation shall be quoted by the Bidder in the respective schedule of BPS. The unit rate quoted shall hold good for excavation (other than boring) for all depth and size in all types of soil including sheet piling, sheeting, shoring, bracing, draining, dewatering, cofferdams etc. as required for successful completion of job. The excavation shall be carried out in accordance with stipulations in Part-II of this Specification.

1.2 The unit of measurement shall be in cu.m. The design excavation volume shall be calculated considering dimension of pile cap plus 150mm on all sides of the pile cap and depth as shown in the drawing below the lean concrete level. The payment shall be made based on unit rate quoted, for excavation actually carried out or as per the design excavation volume as calculated above, whichever is less. No extra payment shall be admissible for excavations if required to be carried out in slope to maintain stability of pit.

1.3 The Contractor shall arrange to transport the excavated soil to a distance as directed by Employer and the rates quoted for excavation in Price schedule shall include all lead, lift, carriage etc.

2 Form Work

2.1 Formworks of different types / shapes shall be measured with reference to actual surface area in contact with the concrete and paid on area basis. The unit of measurement will be in sq.m. corrected upto second place of decimal.

2.2 No payments for formwork for construction joints shall be made.

2.3 Opening up to 0.1 sq.m. of boxing left for inserts etc. shall not be considered as if non-existent for the purpose of formwork measurement of surface in which the opening occur. If the cross-sectional area of any openings exceeds 0.1 sq.m., area of such openings shall be measured and deducted from the area payble for the form work**.**

2.4 No payment shall be made for making the formwork water proof or for supports, scaffolding, centering, approaches, etc.

2.5 No separate payment shall be made for using fillets for rounding of chamfering junctions, corners, etc.

3 Back filling

3.1 The actual volume of backfilling shall be measured in cubic meter rounded off up to 2nd place of decimal and the unit rate wherever applicable shall include all the necessary operations required to complete the work as per drawing & Part-II of this Specifications.

4 Reinforcement Steel

4.1 The unit rate for reinforcement steel shall include supply and placement of reinforcement steel of specific grade, stirrups, annealed wire for binding the reinforcement, chairs, hangers, spacers, welding, tack welding etc. as required to complete the RCC work in pile, pile cap, pedestal/chimney, tie beam (if required) including cleaning, straightening, cutting, bending, binding etc. The unit rate shall also include placement of reinforcement cage in pile shaft/bore and all other cost for tools, plants, materials, labour, transportation to site by appropriate means as required. The payment of reinforcement steel shall be made based on working drawing. Wastage, overlaps, spacer bars, chairs, stays, hangers, annealed steel wire shall not be measured for the payment and cost of these items shall be deemed to be included in the rates of reinforcement.

4.2 Standard hooks, cranks, bends, authorised laps, etc. shall be measured.

4.3 Separator pieces between two or more layers of steel shall not be measured.

4.4 No payment shall be made for supports, spacers, chairs, hangers, etc. of height/length of 300mm and less, required for keeping the steel in position. For supporting horizontal reinforcement at heights, drawings for supports, spacers, chairs, hangers, etc. larger than 300mm, shall be prepared by the Contractor and got it approved from Employer. Payment shall be made for these supports as approved by the Employer, or as actually provided, whichever is less, as per the unit rate quoted for reinforcement.

4.5 No extra payment shall be made for modification of already embedded reinforcement, if required due to faulty fabrication or placement.

4.6 Dowels as required for completion of the work shall be provided by the contractor which will not be separately calculated for payment.

5 Piling work

5.1 The items of works are briefly described in the BPS. The various items in the BPS shall be read in conjunction with the corresponding sections/parts in the Technical Specifications, including amendments, and additions, if any. The unit rate quoted for items shall include all the activities covered in the description of the item (including concrete) as well as all necessary operations described in the specification and any other specific requirements.

5.2 The unit rates wherever applicable shall also include all minor activities which are obviously and fairly intended, though may not have been clearly brought out in the description of items or in these documents, but are essential for the satisfactory completion of the work.

5.3 Unit rates shall also include for all safety measures as required by codal provisions, local regulations, acts, bye-laws, etc. and mobilization of all plant, equipment, scaffolding, materials, skilled and unskilled labour, de-mobilisation after completion of work, supervision, establishing level and coordinates at each location by carrying levels from one established bench mark and distances from one set of grid lines furnished by the Employer.

5.4 Unit rate wherever applicable wherever applicable on per meter length basis for a particular diameter of pile shall remain unchanged irrespective of the actual length/depth of individual piles executed at any location

5.5 Unit rate wherever applicable for pile boring through all kind of soil, including weathered rocks, laterite, shell, hard rock shall be inclusive of cost of boring by approved method, bailing out all the pile bore spoils from the pile bore, keeping the bore hole free from bored material/debris etc. and disposing same along with the drilling mud up to a distance of 2 km., flushing the pile bore by fresh Bentonite before concreting, collection of samples from bottom of pile bore, transporting to laboratory, testing and reporting of results including necessary materials, equipment and manpower.

5.6 Unit rate wherever applicable quoted for pile boring through soil including weathered rocks, laterite, shell, hard rock shall include shifting of plant and equipment from one pile location to another location**,** providing temporary casing as required and removal of the same after completing concreting. The quoted unit rate for boring/installation of pile shall also be inclusive of the empty boring and extra concreting required above the pile cut off level.

5.7 Unit rate wherever applicable for pile boring through soil including weathered rock / laterite shall also include chiseling, if any required, the chiseling through rock in the pile below socketing horizon up to the specified level shall be inclusive of bailing out the pile bore debris/spoils from the pile bore and disposing off the chiseled materials/debris along with the sludge/mud up to 2 kms., flushing the pile bore by fresh betonies before concreting, collection of samples from bottom of the pile bore, transporting to laboratory, testing and reporting of results.

5.8 Unit rate wherever applicable of pile boring shall include concreting in piles by tremie method, cost of preparation of pile head and disposal of debris etc., resulting from breaking off of pile up to COL, up to a distance of 2 km.

5.9 Unit rates wherever applicable shall include for all quality assurance requirements, but not limited to providing for technical inspection, transportation of samples to laboratory, testing samples, maintaining and submitting all test records, etc.

5.10 The rate quoted for boring and installation shall be inclusive of performing point load test on the rock samples obtained from bore spoils during the chiseling operations, and shall be inclusive of transportation to laboratory, testing and reporting of the results.

5.11 Measurement for the item of boring through soil including weathered rock shall be done by linear measurement for the length bored from the pile cut off level or ground level whichever is lower through soil/weathered rock up to termination/founding level as per drawing or actual length achieved of the pile in meters, up to second place of decimal.

6 Pile Integrity Test

The actual quantity of pile integrity test done shall be calculated in nos. and the unit rate wherever applicable quoted shall be include all necessary equipment, manpower, labour, materials, operations etc. required to complete the work as per Part-IV of this Specification. The payment shall only be made after successful completion of the job and submission of complete report for each no. of test.

SECTION –14.2 (Part-IV)
TESTING AND ACCEPTANCE CRITERIA

CONTENT

SECTION –14.2 (Part-IV)
TESTING AND ACCEPTANCE CRITERIA

1 Construction Materials

1.1 Any material considered to be Sub-standard or not meeting the Specifications as described in Section – X, Part-II, of this Specification and as declared/certified accordingly by the Purchaser shall not be used by the Contractor and shall be removed from the site immediately at no extra cost to the Purchaser.

2 Cement Concrete

2.1 Testing

2.1.1 The Contractor shall carry all sampling and testing in accordance with Standard Field Quality Plan (SFQP) as enclosed with this Specification, relevant Indian Standards and this Specification at his own cost in field and in a laboratory approved by the Purchaser. For the tests carried in the laboratory contractor shall the test results to the Purchaser in triplicate within 7(seven**)** days after completion of the test.

2.1.2 Facilities required for sampling and testing materials, concrete, etc. in field and in laboratory shall be provided by the Contractor. Where no specific testing procedure is mentioned the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the Purchaser. Tests shall be done in the presence of the Purchaser or his authorised representative. In case the Purchaser requires additional test, the Contractor shall arrange to get these tests done and submit to the Purchaser the test results in triplicate within three days after completion of any test.

2.1.3 The Contractor shall maintain records of all inspection and testing, which shall be made available to the Purchaser, whenever required.

2.1.4 The testing apparatus/equipment installed in the filed laboratory shall be calibrated / corrected by the qualified person as frequently as possible to give accurate testing results.

2.1.5 Frequency of sampling and testing, etc. and Acceptance Criteria should be as per SFQP. However, Purchaser shall have the full authority to call for tests as frequently as he may deem necessary to satisfy himself that the materials and works comply with the Specifications. The materials shall be tested to meet all the specified requirements before acceptance at manufacturer's premises or at independent government approved laboratory. Tests indicated in the tables of Standard Field Quality Plan are for cross checking at site to ascertain the conformity of the materials to the Specifications.

2.1.6 One sample consisting of six test cubes shall be made from the concrete used in each pile, three to be tested after 7 days and three after 28 days.

2.1.7 In preparation of test cubes/specimens vibrators shall not be used.

2.1.8 Concrete shall be tested for slump at every 1 hour interval.

2.2 Acceptance Criteria for Concrete

a) The acceptance criteria of concrete shall be in accordance with Field Quality Plan (FQP) and as per Section – IV A of this Volume II**.**

b) Concrete work found unsuitable for acceptances shall have to be dismantled and replacement is to be done as per specification by the Contractor. No payment for the dismantled concrete, the relevant form work and reinforcement, embedded fixtures, etc. wasted in the dismantling shall be made to the Contractor. If any damage is done to the embedded items of adjacent structures, the same shall be made good free of charge by the Contractor, to the satisfaction of Purchaser.

c) The dimensions of concrete as cast, when compared with the drawing, shall be within the tolerances given below. Steps in surface alignment shall not exceed 2mm. No reduction will be permitted in the cover to reinforcement because of a specified negative tolerance in a concrete section.

Structural Element Detail Deviation in mm.	Permissible	
Faces of concrete in foundations and structural members against which backfill is placed	+25	-5
Exposed concrete foundations	+10	-5
Top surfaces of Pedestal/chimney and for concrete to receive grouted plant or structural steel work	+5	-5
Alignment of tie beams, Pedestal/chimney**,** pile cap	+5	0
Cross sectional dimensions of tie beams, Pedestal/chimney, cap	+5	-5
Level and alignment of holding	+5	-5

down bolts		
Level of holding down bolt assemblies	+10	-5
Alignment of holding down bolts assemblies	+5	-5
Centers of pockets or holes with greatest lateral dimensions not exceeding 150mm	+5	-5
Centers of pockets or holes with greatest lateral dimension exceeding 150mm.	+10	-5

2.3 Acceptance criteria of Finished Concrete

2.3.1 Finished concrete shall be true to shape, lines, levels plumb and dimensions as shown on drawings.

2.3.2 All embedded fixtures shall be of correct type and in correct position as shown in drawings.

2.3.3 Finished concrete surface shall be free from blemishes like honey-combs, air bubbles, fins, etc.

2.3.4 Exposed concrete surface shall be free from rust stains, grease and mould oil stains etc. and shall have uniform pleasing appearance to the satisfaction of the Purchaser.

2.3.5 The finished concrete shall be of a standard quality and equal to the accepted sample.

3 Reinforcement Steel

Reinforcement shall be checked for cleanliness, proper bending, binding, placing and securing in position with provision for proper cover. The reinforcement should conform to the requirement of Section – X, Part-II of this Specification.

4 Testing for position and alignment

4.1 Each pile shall be checked for its position with respect to specified location. Each pile bore shall be checked for its alignment.

4.2 Permissible limits for deviation shall be as specified under SECTION-X, Part-II of this Specification.

5 Properties of drilling mud

5.1 Properties of drilling mud shall be checked as per requirements indicated in Annexure 'C'. Prior to the commencement of piling work and thereafter at least once in a week or as found necessary by the Purchaser, one sample consisting of 3 specimens shall be tested.

5.2 Density and sand content of the drilling mud shall be checked in each pile.

6 Check for Pile bore

6.1 On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by the Purchaser, to ensure that it is free from pile bore spoil/debris and any other loose material, before concreting. Concreting shall be done only after the approval of the Purchaser.

6.2 For sampling of drilling mud from the pile bore the following method or any other suitable method shall be adopted.

A solid cone shall be lowered by a string to the bottom of pile bore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimise the leakage while lifting the cone assembly to the ground surface. The slurry collected in the sampler tube shall be tested for density and sand content.

7 Pile Integrity Test

7.1 Pile Integrity test is used to assess the as-installed pile characteristics as well quality achieved during the construction of pile. The parameters to be evaluated through the Pile Integrity Test (also known as dynamic pile testing) should generally cover True static capacity of the pile at the time of testing, total skin friction and end bearing of the pile, skin friction variation along the length of the pile, compressive and tensile stress, displacement of pile, changes in cross-section if any etc.

7.2 The equipment consists of an electronic control unit, a hand-held instrumented hammer and an accelerometer and computer.

7.3 The pile top is prepared to make a plane surface (by placing a thin cement mortar in an area of 200mm x 200mm) after removal of weak lattiance. The accelerometer is fixed to the top of the pile and the instrumented hammer is struck firmly on the pile top. This generates a wave form that travels down the pile and gets reflected from the bottom as well as from any discontinuities in the pile.

7.4 The results to be stored in a compact control unit and transferred to computer and detail analysis to be carried out.

7.5 The contractor is to submit a detailed report for the data specified in cl. 7.1 above and as required by the Purchaser.

SECTION –14.2 (Part-V)

M.S.LINER

SECTION –14.2 (Part-V)

M.S.LINER

1 Structural steel MS liner for R.C.C Vertical bored piles

1.1 General Requirements

This specification covers general requirements for supply, fabrication, shop painting (if required), and delivery at site mild steel liners of specified diameters and lengths for piles.

M.S. liner shall be provided to piles at locations, as directed by the Purchaser. The extent up to which the MS liners for piles required to be provided shall be as shown in the approved drawings and as per direction and written approval of the Purchaser.

1.2 Drawings

1.2.1 Contractor shall submit calculations and fabrication details for connection/splice/joint for fabrication of liners and get these approved by the Purchaser before starting any fabrication works. The approval of fabrication drawings prepared by the Contractor shall not relieve the Contractor of the responsibility for the liners in place.

Fabrication drawing (drawn to large enough scale) to convey all information clearly shall include the following:

i) Reference of the design drawings based on which fabrication had been prepared. The reference should include and indicate the latest revision of design drawing.

ii) layout, elevations and sections with erection marking of all members.

iii) Quality of Structural Steel, Welding electrodes, and standards to which these conform to.

iv) Detailing of structural joints and shop/field splices.

v) Details of shop and field joints/connections.

vi) Bill of material indicating size and weight of members/component.

vii) Erection assemblies and sub-assemblies identifying all transportable parts.

viii) Method of erection, special erection instructions, and special precautions to be taken during erection, as required.

1.2.2 Purchaser reserves the right to make changes in the fabrication drawings. Revisions to drawings may be made to reflect more updated requirements. Revisions to drawings and any new drawings made to include additional work by Contractor shall be considered as a part of this specification and the Purchaser shall entertain no extra claim on this account. All revisions in the drawings should be highlighted in the drawing distinctly.

1.2.3 Unless otherwise specified, the drawings and specifications are intended to include everything obviously requisite and necessary for the proper and entire completion of the work and the job shall be carried out accordingly for the completeness as required.

1.2.4 In the case of variations in drawings and specifications, the decision of the Purchaser shall be final. In case Contractor in the execution of his work, find discrepancies in the information furnished by Purchaser, he shall refer such discrepancies to the Purchaser before proceeding with such work.

1.3 Fabrication

1.3.1 General

The fabrication work shall be carried out generally in accordance with IS:800 as well as the stipulation contained in these specifications. All materials shall be completely shop fabricated and finished with proper connection materials for ready assembly in the field. All the workmanship and finish shall be of the best quality and shall conform to the best approved method of fabrication. All materials shall be finished straight and shall be machined true and square where so specified. All edges shall be free of burrs, shearing and chipping shall be neatly and accurately done. Material at the shop shall be kept clean and protected from weather, Checklist format, inspection certificate for fabrication and protocol for handing over of structural steel shall be submitted by the Contractor in the form as agreed to by the Purchaser.

1.4 Straightening

All material shall be straight and free from bends or twists. If necessary, before being worked, the materials shall be straightened, unless otherwise required/specified. In case plates are distorted or twisted, straightening or flattening shall be done by methods that will not injure the plates. Long plates shall

be straightened by passing through mangle of leveling rolls. Heating or forging shall not be resorted to without the prior approval of Purchaser in writing.

1.5 Welding

1.5.1 Welding shall be in accordance with IS:816, IS:819, IS:1024, IS:1261, IS:1323, IS:4353 and IS:9595, as appropriate.

1.5.2 For welding of any particular type of joint, Contractor shall give evidence acceptable to the Purchaser of having satisfactorily completed appropriate tests as described in any of the Indian Standards - IS:817,IS:1393,IS:7307 (Part J), as relevant and as per the checklists given in the Annexure to this section of the specification.

1.5.3 The works shall be done as per approved fabrication drawings which would clearly indicate various details of joints to be welded, type of weld, length and size of weld, whether shop or site weld. Symbols for welding on shop drawings shall be according to IS:813. Efforts shall be made to reduce site welding so as to avoid improper welding due to constructional difficulties.

1.5.4 Welding of Structural Steel shall be done by an electric arc process. The procedure to be followed, materials, plant and equipment to be applied shall be subject to the approval of the Purchaser and shall conform generally to relevant acceptable standards viz. IS:816, IS:9595, IS:814, and Indian Standard Hand Book for metal arc welding, and other standard codes of practice internationally accepted.

1.5.5 "Open-Arc-Welding" process employing coated electrodes shall be employed for fabrication of other welded connections and field welding.

1.5.6 Wherever welding is done for assembling the components of liner, the job shall be so positioned that down hand welding is possible. In cases where such positioning of job is not possible other manual welding positions could be resorted to.

1.5.7 Any structural joints shall be welded only by those welders who are qualified for all welding procedures and positions required in such joint that is welded. The entire weld of any liner joint shall be made by one welder.

1.5.8 All welds shall be free from defects like blow holes, slag inclusions, lack of penetration, undercutting, cracks and show uniform Sections, smoothness of Weld metal, feather edge without overlap and freedom from porosity.

1.5.9 Proper edge preparation shall be made for jointing of materials before welding. Suitable edge preparation shall be done for all processes of welding except for square butt welds. Type of edge preparation shall depend on the thickness of parent materials that are to be joined. The edge forms shall be chosen to suit the design, technology and production conditions and shall be subject to the approval of the Purchaser. The edge form of weldments shall be prepared either by machines or by

automatic gas cutting with surface rougher of the welding area not exceeding 50sq.mm. All edge cut by flame shall be ground before they are welded.

1.5.10 The electrodes used for welding shall be of suitable type and size depending upon specifications of the parent material, the method of welding, the position of welding and quality of welds desired e.g. normal penetration welds or deep penetration welds.

1.5.11 Where bare electrodes are used these shall correspond to specification of the parent material. The type of flux wire combination for submerged arc welding shall conform to the requirements of F-60 class of AWSA-5-17-69 and IS:3613 (Latest). The electrodes shall be sorted properly and the flux shall be baked before use in an oven in accordance with the manufacturer's requirements as stipulated.

1.5.12 Specific approval of the Purchaser shall be taken by the Contractor for the various electrodes proposed to be used on the work before any welding is started.

1.5.13 Electrodes larger than 5mm diameter shall not be used for root-runs in butt-welds.

1.5.14 Welding plant and accessories shall have capacity adequate for the welding procedure laid down and shall satisfy appropriate standards and be of approved make and quality. All the electrical plant in connection with the welding operation shall be properly and adequately earthed and adequate means of measuring the current shall be provided.

1.5.15 Voltage and current (and polarity if direct current is used) shall be set according to the recommendations of the manufacturer of the electrode being used and suitability to thickness of material, joint form etc.

1.5.16 Prequalified welding procedures recommended by appropriate welding standards and known to provide satisfactory welds shall be followed. For non-standard procedures, qualification tests as prescribed in IS:9595 (latest) shall be made to verify the adequacy of the procedures. A welding procedure shall be prepared by Contractor and submitted to the Purchaser for approval before start of welding. This shall include all details of welding procedures with references to provisions of IS:9595 and IS:4353. Approval of the welding procedure by Purchaser shall not relieve Contractor of his responsibility for correct and sound welding without undue distortion in the finished structure.

1.5.17 No welding shall be done, when the surface of the members is wet, during periods of high wind, unless the welding operator and the work are properly protected.

1.5.18 In joints connected by fillet welds, the minimum sizes of single run fillet welds for first run and minimum full sizes of fillet welds shall conform to requirements of IS:816.

1.6 Pre-Heating Inter-run Temperature and Post Weld Heat Treatment.

i) Welding of mild steel shall not be undertaken when the plate temperature is 0^0 C or below.

ii) Mild steel plates conforming to IS:226 and thicker than 20 mm and plates conforming to IS:2062 and thicker than 25 mm may require preheating of the parent plate prior to welding. In welding materials of unequal thickness the thicker part shall be taken for this purpose.

Minimum Preheat and Interpass Temperature

Thickness of thicker part at point of welding	Other than low hydrogen welding electrodes	Low hydrogen welding electrodes	
	IS:226 IS:8500 steel or IS:2062 steel	IS:8500 steel	IS:226 or steel IS:2062 steel
Up to 20mm incl.	None 10 deg.C by this electrode	Welding	None

iii) Base metal shall be preheated, as required to the temperature given in table above prior to welding or tack welding. When base metal not otherwise required to be preheated is at a temperature below 0 deg. C, it shall be preheated, prior to tack welding or welding. Preheating shall bring the surface of the base metal to the specified preheat temperature and this temperature shall be maintained as minimum inter-pass temperature while welding is in progress.

iv) Pre-heating may be applied by external flame heating equipment, by electric resistance or electric induction process such that uniform heating of the surface extending up to a distance or four times the thickness of the plate on either side of the welding joint is obtained.

v) Thermo-Chalk or other approved methods shall be used for measuring the plate temperature.

1.7 Sequence of Welding

i) The sequence of welding shall be carefully chosen to ensure that the components assembled by welding are free from distortion and large residual stresses are not developed. The distortion should be effectively controlled either by a counter effect of by counter distortion. The direction of welding should be away form the point of restraint and towards the point of maximum freedom.

ii) Each case shall be carefully studied before finally following a particular sequence of welding.

1.7.1 Approval of welding sequence and procedure shall not relieve the Contractor of the responsibility for the correct welding and for minimising the distortion in the finished structure which in no case shall exceed that laid down in Indian Standards.

1.7.2 All welds shall be finished full and made with correct number of runs, the welds being kept free from slag and other inclusions, all adhering slag being removed from exposed faces immediately after such run.

1.7.3 Current shall be appropriate for the type of electrode used. To ensure complete fusion, the weaving procedure should go proper and rate of arc advancement should not be so rapid so as to leave the edges un-melted.

1.7.4 Pudding shall be sufficient to enable the gases to escape from the molten metal before it solidifies.

1.7.5 Non-uniform heating and cooling should be avoided to ensure the excessive stresses are not locked up resulting ultimately in cracks.

1.7.6 The fusion faces shall be carefully aligned. Angle shrinkage shall be controlled by presenting. Correct gap and alignment shall be maintained during the welding operation.

1.7.7 All main butt welds shall have complete penetration and except where it is impracticable they shall be welded from both sides, back surface of the weld being gouged out clean before first run of the weld is given from the back.

1.7.8 Intermittent welds shall not be permitted without the approval of the purchaser. These shall be permitted only when specifically approved in the fabrication drawings.

1.7.9 Inspection of Welds: All Welds shall be inspected for flaws by any of the methods described under Clause “Inspection”. The choice of the method adopted shall be determined by Purchaser.

1.7.10 The Contractor shall carry out tests which establish soundness of welds. In case the tests uncover defective work, the Contractor shall correct such defects at his own cost and prove the soundness of rectified work at his own cost.

1.7.11 The correction of defective welds shall be carried out as directed by Purchaser without damaging the parent metal. When a crack in the weld is removed, magnetic particles inspection or any other equally positive means as prescribed by purchaser shall be used to ensure that the whole of the crack and material up to 25 mm beyond each end of the crack has been removed. Cost of all such test and operations incidental to correction shall be to Contractor's account.

2 Inspection and Rectification

2.1 Visual Inspection

100 percent of the welds shall be inspected visually for external defects. Dimensions of welds shall be checked. The length and size of weld shall be as per approved fabrication drawing. It may be slightly over sized but should not be under sized. The profile of weld is affected by the position of the joint but it should be uniform. In case of butt and corner welds the profile shall be convey and in case of submerged are fillet weld, it shall be slightly concave. The welds should have regular height and width of beads. The height and spacing or ripples shall be uniform. The joints in the weld run where welding has been recommended shall as far as possible be smooth and should not show any humps or craters in the weld surface. Welds shall be free from the unfilled craters on the surface under cuts slags on the surface visible cracks. Such inspection shall be done after clearing the welds surface with steel wire brushes and chisel to remove the sputter metal, scales, slag, etc. If external defects mentioned above are noticed the work shall be dismantled and redone duly replacing the defective materials including the base members.

2.2 Rectification of Defective Welding Work

Wherever defects like improper penetration, extensive presence of blow holes, undercuts cracking, slag inclusion etc. are noticed by visual inspection/other tests, the welds at such locations shall be removed by gouging process. The joints shall be prepared again by cleaning the burrs and residual matters with wire brushes and grinding, if necessary and re-welded. The gouging as far as possible, be done using gouging electrodes. Flame gouging shall be resorted to only in special cases with specific permission of the Purchaser.

2.3 Acceptance of the Welded Structures

The acceptance of the welded work shall depend upon correct dimensions and alignment, absence of distortion in the structure, satisfactory results from the

examination and testing of the joints and the test specimens as per I.S. soundness of the welds and upon general workmanship being good.

2.3.1 Random die penetration tests shall be conducted after welding of M.S. liner plates.

3 ERECTION MARKS

3.1 Before any steel work leaves the Contractor's fabrication shop, it shall be suitably marked in accordance with the approved fabrication drawing and according to an approved marking plan. Copies of all drawing showing such erection marks on the various steel works to be furnished to the purchaser well in advance of the erection.

3.2 The erection marks assigned to various components of the structural steel work shall also contain an erection sequence number indicating the sequence in which the various components are to be erected.

3.3 Erection marks shall be clearly painted on the work, each piece being marked in al least two places. Each piece shall also have its weight marked thereon. In order to help identification, each piece shall bear the erection marks and erection sequence number. Erection marks shall be painted on the structures, during the process of fabrication to facilitate their identification during inspection. Where a number of components are identical and bear the same erection marks, these components shall be
further identified by assigning numerals in addition to the common erection mark.

4 Errors

Any error in shop work which prevents proper assembling and fitting of parts in the field, moderate use of drift pins or moderate amount of reaming will be classified by Purchaser as defective workmanship. All charges incurred by Purchaser either directly or indirectly because of workmanship will be deducted from the amount due to Contractor, before payment is made. The amount of such deduction will consist of the sum total of the costs of labour direct or indirect, material, plants, transportation, equipment, rental and overhead expense. In case purchaser chooses to reject the material because of poor workmanship the cost of all handling and returning the material to Contractor, if he so desires, shall entirely be to Contractor's account and in such cases, the cost of handling, transport and delivery to site shall be borne by Contractor.

5 Protection Against Damage in Transit

All steel work shall be efficiently and sufficiently protected against damage in transit to site from any cause whatsoever to prevent damage or distortion during transit. Should there be any distortion of fabricated members the Contractor shall immediately report the matter to the Purchaser. Distorted steel shall not be used in fabrication unless the distortion are minor which in the opinion of the Purchaser

can be removed by acceptable methods. These distortions shall be rectified by the Contractor by cold-bending. If heating is necessary to rectify the defects the details of the procedure shall be intimated to the Purchaser whose approval shall be taken before such rectification. The temperature of heat treatment shall not exceed the limits beyond which the original properties of steel are likely to be impaired.

6 Anti Corrosive Treatment for Mild Steel Liners

6.1 After inspection and issue of test and acceptance certificate, all steel surfaces shall be coated with a coat of direct to rust primer i.e. Densotrol or equivalent and thereafter these shall be provided with a final coat of minimuM-250 microns of high built epoxy coal tar, as specified below. The fabricated mild steel liners to be used for the piling work shall be cleaned from grease or any other contaminant, by mechanical/manual cleaning. the primer shall be applied with a brush or spray to develop a dry film thickness or minimum 25 microns. The primer surface shall be left for curing for at least 24 hours before it is coated with the final coat. The final coat shall consist of high built epoxy coal tar with a thickness of minimuM-250 microns. The physical properties of primer and top coat shall be as given below.

6.2 Technical data of Priming material

Binder content	45%
Total Solids	45%
Solvent	55%
Viscosity	16 (Ford Cup No.4)
Density	0.88
Flash point	$+40^0$C
Anti-porosity	80/99 in one and two layers, respectively
Heat-resistance	170/220 continuously & short period strain.
Contact angle	5^o (Lorentzon & Westtress)
Covering Capacity	12-20 Sq.m./litre
Layer thickness	12/25 on glossy/coarse surface
Homogeneity	No sediment

Thinning	Normally, no thinner shall be used.
Drying time	Dust-free in 2 hrs, Solid in 4/5 hrs. Between layers from wet-in-wet 2 hrs.for continuous penetration between layers
Lustre	Semi-glossy
Colour	Lightly yellowish
YSAM group	2
Injurious to health	No
Physiological condition	No dangerous gas generation when welding
Application	Airless spray equipment or conventional painting with roll/brush.
Cleaning of equipment	White spirit

6.3 Technical particulars of final coat

System Component A : Base Part Component B : Accelerator Part	Two Components
Colour	Black
Mixing Ratio	1:1 by Weight
% Solid by Weight	More than 95%
Pot Lift (Temp.27^{O}C Relative humidity 65%)	2 hours
Setting Time (At 22^{O}C Relative humidity 65%)	4-5 hours
Fully cured	7 days

Density of cured mass	1.35
Flash Pt. of blended product	40^{O}C (104^{O}F)
Hardness	75 Shore D
Finish	Semi glossy
Water absorption after 6 mths.	Negligible
Covering Capacity	1.5 sq.m./Kg (400 Microns thk.)
Storage Life	1 year in sealed condition.

7 Shop Connections

Surfaces to be permanently in contact shall receive a priming coat immediately at the works except where jointed by welding.

SECTION-14.2 (Part-VI)

LIST OF INDIAN STANDARDS

The construction work of pile foundation shall conform to the following Indian Standards, which shall mean latest revisions, amendments/changes adopted and published, unless otherwise specified hereinbefore. Some of the important relevant applicable codes for this section are as follows :

IS : 226	Structural Steel (Standard Quality)
IS : 432	Specification for mild steel and high tensile steel bars and hard drawn steel wire for concrete reinforcement.
IS : 456	Code of practice for plain and reinforcement concrete
IS : 516	Methods of test for strength of concrete
IS : 800	Code of Practice for General Construction in Steel
IS : 813	Scheme of symbols for Welding
IS : 814	Specification for Covered Electrodes for Metal Arc Welding of Structural Steels
IS : 816	Code of Practice for use of Metal Arc Welding for General Construction in Mild Steel.
IS : 817	Code of Practice for Liquid Penetrant Flaw Detection.
IS : 1199	Methods of sampling and analysis of concrete.
IS : 1200 Part-I	Method of measurement of Building and civil Engineering work -–earthwork.
IS : 1200 Part-23	Method of measurement of Building and civil Engineering work -–Piling
IS : 1786	Cold worked steel high strength deformed bars for concrete reinforcement.
IS : 1838	Performed fillers for expansion joints in concrete non-extruding and resilient type (bitumen impregnated filler).
IS : 2062	Weld able structural steel
IS : 2074	Ready Mixed Paint, air drying, Red Oxide Zinc Chrome, Priming.
IS : 2386 Part-III	Specific gravity, density, voids absorption and bulking.
IS : 2502	Code of Practice for bending and fixing of bars for concrete reinforcement.
IS : 2505	General requirements for concrete vibrators immersion type.

IS : 2506	Screed board concrete vibrators.
IS : 2514	Concrete vibrating tables.
IS : 2911 (Part/Sec. 2)	Code of practice for design and construction of pile foundation-Bored cast-in-situ concrete piles.
IS : 3025	Methods of sampling and test (Physical and chemical) for water used in Industry.
IS : 3350	Methods of tests for routine control for water used in Industry.
IS : 3370	Code of Practice for concrete structure for the storage of liquids.
IS : 3613	Acceptance Tests for Wire Flux Combinations for submerged Arc welding of structural steels.
IS : 3658	Recommended Practice for Radiographic Examination of Fusion Welded Butt Joints in Steel Plates.
IS : 3764	Safety codes for Excavation work.
IS : 4353	Recommendations for Submerged Arc Welding of Mild Steel and Low Alloy Steels.
IS : 4656	Form vibrators for concrete.
IS : 4701	Code of practice for earth work on canals.
IS : 8500	Specification for weldable structural steel (medium and high strength qualities)
IS : 9103	Admixtures for concrete.
IS : 10262	Recommended guidelines for concrete mix design.

ANNEXURE - A

SPECIFICATION OF DRILLING MUD (BENTONITE SLURRY)

1.0 Bentonite suspension used for piling work shall satisfy the following requirements:

a) Liquid limit of Bentonite when tested in accordance with IS:2720 (Part V) shall be more than 300 percent and less than 450 percent.

b) Sand content of the Bentonite powder shall not be greater than 7 percent.

c) Bentonite solution should be made by mixing it with fresh water using pump for circulation. The density of the freshly prepared Bentonite suspension shall be between 1.024 and 1.10 gm/ml depending upon the pile dimensions and type of soil in which the pile is to be met. However, the density of Bentonite suspension after mixing with deleterious materials in the pile bore may be up to a maximum of 1.25 gm/ml.

d) The Marsh viscosity when tested by a Marsh cone shall be between 30 to 60 seconds.

e) The differential free swell shall be more than 540 percent.

f) The pH value of the Bentonite suspension shall be between 9 and 11.5.

ANNEXURE - B

PILE DATA SHEET

1. Reference No. Location (Co-ordinates)_____ area.
2. Sequence of Piling
3. Pile diameter & Type
4. Working level (Platform level)
5. Cut off level (COL)
6. Actual length below COL
7. Pile termination level
8. Top of finished concrete level
9. Date and time of start and completion of boring
10. Depth of Ground water table in the vicinity
11. Type of strata at pile tip
12. Method of boring operation
13. Details of drilling mud as used :
    i) Freshly supplied mud

    liquid limit sand content density marsh viscosity Swelling index pH value

    ii) Contaminated mud density sand content
14. SPT, N values in soil (from the nearest bore hole). UCS value in rock (from the nearest bore hole).
15. Chiseling if any, from....m to.....m.
16. Date and time of start and completion of concreting
17. Method of placing concrete
18. Concrete quantity :

Actual
Theoretical

19. Ref. Number of test cubes

20. Grade and slump of concrete

21. Results of test cubes

22. Reinforcement details :

Main Reinforcement	Stirrups : Type
No._____	No._____
Dia_____	Dia_____
Depth_____	Spacing_____

23. Any other information regarding constructions, delay and other interruption to the sequence of work.

NOTE : The above details are required to be furnished by the Contractor before starting the installation work.

ANNEXURE - C

INSPECTION & TESTING FOR STRUCTURAL STEEL WORKS

1.0 GENERAL

Contractor shall carry out a comprehensive inspections and testing programme during fabrication and erection. An indicative programme of inspection/testing envisaged by Purchaser is given below. This is however not intended to form a comprehensive programme as it is the Contractor's responsibility to draw up and carry out such a programme duly approved by the Purchaser. Such approval shall not relieve the Contractor of the responsibility about the correctness and adequacy of workmanship, materials etc.

1.1 Raw Materials Inspection

1.1.1 Steel

i) Specifications

Check the specification of steel and availability of the relevant Test Certificates.

ii) Physical Conditions

a) Steel shall not be pitted and should be free from scales and rust.

b) If the plates are bent or distorted, bent to distortion shall normally be removed by the cold treatment etc.

c) Straightening under hot stage shall be resorted to only under specific permission from the Purchaser.

d) If any rolling defect viz, laminations, cracks etc. are found in the steel during processing it shall be rejected.

iii) Storage

a) Steel plates of different specifications shall be stacked separately.

b) Steel of IS:2062 quality shall be given a distinctive identification mark.

c) Steel sections shall be stacked over spacers supported on posts of about 50 cm height above round. Passage and space between the stacks shall be sufficient for rigging operations.

1.1.2 Electrodes

i) Electrodes for manual metal arc welding shall be procured

envisaged in the welding procedure sheet predetermined before actual welding operation starts.

ii) Electrodes shall be properly stored dry as required by the IS Code or by the manufacturer.

iii) Electrodes shall bear the I.S.I or equivalent Certification mark.

iv) The approval for all the consumables for welding shall be specifically obtained before hand.

1.1.3 Paints/Primers

i) The relevant I.S or equivalent mark on sealed tins shall be checked.

ii) A few tins shall be opened at random to check the condition of the paints. Paint from old stock and showing signs of solidification shall not be accepted.

1.2 Welding Procedure Qualification.

As per ASME section (ix) or equivalent Indian Standards, Welding procedures, Specification shall be submitted by the Contractor for review and approval of Purchaser.

1.3 Welders Qualification Test

As per ASME section (ix) or equivalent Indian Standard.

1.4.0 Inspection for Tack Assembly set up for:

i) Level

ii) Gap

iii) Offsetting

iv) Shrinkage allowance

v) Fitment sequence

vi) Principal overall size.

1.5 Preheating

Temperature control by thermo chalk or suitable equivalent method.

1.6 Inspection of Main welds

a) Fillet welds for

i) Size

ii) Dye Check

iii) Visual examination

iv) Dye penetration test/MPI shall be carried out.

b) Butt welds for

i) Dye check for root after back gauging shall be carried out.

ii) Mechanical testing of welds (Destructive Tests) Minimum on joint per liner length/piece.

iii) Non-destructive - as per FCL: SS:4

- 100% visual examination.

B. FABRICATION CHECK LIST (STANDARD)

Title : Welding Tests on welds and Weld Defects

Mechanical testing of welds (Destructive test) Butt welds having one or more of the following defects are not acceptable.

i) Bend test	:	No crack on root/face on being bent through 180 deg. with mandrel of 4t where t is the thickness of plate.
ii) Tensile test	:	Weld strength not to be less than part metal's strength.

VISUAL EXAMINATION

Following defects are not allowed :

1) Unsatisfactory appearance
2) Incomplete weld
3) Molten metal flow
4) Pits
5) Surface crack, lack of penetration
6) Insufficient length
7) Surface defects exceeding 5% of weld seam area

DYE PENETRATION TEST

All surfaces to be examined shall be free from :

a) Relevant linear indications

b) Four or more rounded defects in a line separated by 1/16" or less (edge to edge) except where the specification for the material establishes requirements for acceptance so far as defects are concerned.

C. TYPICAL WELDING PROCEDURE DATA SHEET

Contractor.....Address.....
....

Quality of weld metal.....Specification.....

Inspection and Test Schedule .....Specification.....

Material Specification.....Thickness.....Batch/Cast
No.....

Joint Preparation (Fig.).....Gap.....

Location of Specimens.....

Weather Conditions.....Time of day.....Wind brake used.....

Electrode Group No..... Make.....Specimen.....

Pre and Post Heating.....

Welding positition.....

Size of Reinforcement.....Whether removed.....

Welding Sequence.....

Backing Strip use.....Type.....

Welding Process.....

Current Conditions-Polarity.....

Size of Electrode.....

Amperage and Voltage.....

Number of Electrodes used per run.....

Cleaning method.....

Remarks.....

Engineer-in-Charge Signature
Power-Grid For and on behalf of Contractor
(Inspecting Authority) Date :

D. FABRICATION CHECK LIST : ACCEPTANCE PROFORMA

No. _____

Dt. _____

Project

_____

Work

Sub-Assy

Sl. No.	Characteristic	As per DRG/FCL	Actual	Accept/ Reject	Remarks

NEA Representative Contractor's Representative

CHAPTER-15: CONTROL AND RELAY PANELS

Table of contents

CHAPTER 15: CONTROL, RELAY & PROTECTION PANELS

1. TYPE OF PANELS

1.1 Simplex Panel

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

1.2 Duplex Panel

Duplex panel shall be walk-in tunnel type comprising two vertical front and rear panel sections connected back-on-back by formed sheet steel roof tie members and a central corridor in between. The corridor shall facilitate access to internal wiring and external cable connections. In case of number of duplex panels located in a row side by side, the central corridor shall be aligned to form a continuous passage. Both ends of the corridor shall be provided with double leaf doors with lift off hinges. Doors shall have handles either with built-in locking facility or shall be provided with pad-locks. Separate cable entries shall be provided for the front and rear panels. However, inter-connections between front and back panels shall be by means of inter panel wiring at the top of the panel.

2. CONSTRUCTIONAL FEATURES

2.1. Control and Relay Board shall be of panels of simplex or duplex type design as indicated in bill of quantity. It is the responsibility of the Contractor to ensure that the equipment specified and such unspecified complementary equipment required for completeness of the protective/control schemes be properly accommodated in the panels without congestion and if necessary, **either add more number of panels or** provide panels with larger dimensions. No price increase at a later date on this account shall be allowed. However, the width of panels that are being offered to be placed in existing switchyard control rooms, should be in conformity with the space availability in the control room.

2.2. Panels shall be completely metal enclosed and shall be dust, moisture and vermin proof. The enclosure shall provide a degree of protection not less than IP-31 in accordance with IEC 60529 (Part-1).

2.3. Panels shall be free standing, floor mounting type and shall comprise structural frames completely enclosed with specially selected smooth finished, cold rolled sheet steel of thickness not less than 3 mm for weight bearing members of the panels such as base frame, front sheet and door frames, and 2.0mm for sides, door, top and bottom portions. There shall be sufficient reinforcement to provide level transportation and installation.

2.4. All doors, removable covers of panels shall be gasketed all around with synthetic gaskets Neoprene/EPDM. However, XLPE gaskets can also be used for fixing protective glass doors. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh

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

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

2.7. Cable entries to the panels shall be from the bottom. Cable gland plate fitted on the bottom of the panel shall be connected to earthing of the panel/station through a flexible braided copper conductor rigidly.

2.8. Relay/protection panels of modern modular construction would also be acceptable.

3. MOUNTING

3.1. All equipment on and in panels shall be mounted and completely wired to the terminal blocks ready for external connections. The equipment on front of panel shall be mounted flush.

3.2. Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent devices and are readily accessible without use of special tools. Terminal marking on the equipment shall be clearly visible.

3.3. The Contractor shall carry out cut out, mounting and wiring of the free issue items supplied by others which are to be mounted in his panel in accordance with the corresponding equipment manufacturer's drawings. Cut outs if any, provided for future mounting of equipment shall be properly blanked off with blanking plate.

3.4. The centre lines of switches, push buttons and indicating lamps shall not be less than 750mm from the bottom of the panel. The centre lines of relays, meters and recorders shall not be less than 450mm from the bottom of the panel.

3.5. The centre lines of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Like wise the top lines of all meters, relays and recorders etc. shall be matched.

3.6. No equipment shall be mounted on the doors.

3.7. At existing station, panels shall be matched with other panels in the control room in respect of dimensions, colour, appearance and arrangement of equipment (centre lines of switches, push buttons and other equipment) on the front of the panel.

4. PANEL INTERNAL WIRING

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

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

- All circuits except current transformer circuits and voltage transfer circuits meant for energy metering - one 1.5mm sq. per lead.
- All current transformer circuits - one 2.5 sq.mm per lead.
- Voltage transformer circuit (for energy meters): Two 2.5 mm sq. per

lead.

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

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

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

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

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

5. TERMINAL BLOCKS

5.1. All internal wiring to be connected to external equipment shall terminate on terminal blocks. Terminal blocks shall be 650 V grade and have 10 Amps. continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Markings on the terminal blocks shall correspond to wire number and terminal numbers on the wiring diagrams. All terminal blocks shall have shrouding with transparent unbreakable material.

5.2. Disconnecting type terminal blocks for current transformer and voltage transformer secondary leads shall be provided. Also current transformer secondary leads shall be provided with short circuiting and earthing facilities.

5.3. At least 20% spare terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks.

5.4. Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors of external cable on each side

- All CT & PT circuits: minimum of two of 2.5mm Sq. copper.
- AC/DC Power Supply Circuits: One of 6mm Sq. Aluminium.
- All other circuits: minimum of one of 2.5mm Sq. Copper.

5.5. There shall be a minimum clearance of 250mm between the first row of terminal blocks and the associated cable gland plate or panel side wall. Also the clearance between two rows of terminal blocks edges shall be minimum of 150mm.

5.6. Arrangement of the terminal block assemblies and the wiring channel within the enclosure shall be such that a row of terminal blocks is run in parallel and close proximity along each side of the wiring-duct to provide for convenient attachment of internal panel wiring. The side of the terminal block opposite the wiring duct shall be reserved for the external cable connections. All adjacent terminal blocks shall also

share this field wiring corridor. All wiring shall be provided with adequate support inside the panels to hold them firmly and to enable free and flexible termination without causing strain on terminals.

5.7. The number and sizes of the Owner's multi core incoming external cables will be furnished to the Contractor after placement of the order. All necessary cable terminating accessories such as gland plates, supporting clamps & brackets, wiring troughs and gutters etc. (except glands & lugs) for external cables shall be included in the scope of supply.

6. PAINTING

The painting shall be carried out as detailed in Chapter 2–GTR.

7. MIMIC DIAGRAM

7.1. Coloured mimic diagram and symbols showing the exact representation of the system shall be provided in the front of control panels.

7.2. Mimic diagram shall be made preferably of anodised aluminium or plastic of approved fast colour material, which shall be screwed on to the panel and can be easily cleaned. The mimic bus shall be 2mm thick. The width of the mimic bus shall be 10mm for bus bars and 7mm for other connections. Painted overlaid mimic is also acceptable.

7.3. Mimic bus colour will be decided **during detailed Engineering.**

7.4. When semaphore indicators are used for equipment position, they shall be so mounted in the mimic that the equipment in close position shall complete the continuity of mimic.

7.5. Indicating lamp, one for each phase, for each bus shall be provided on the mimic to indicate bus charged condition.

8. NAME PLATES AND MARKINGS

8.1. All equipment mounted on front and rear side as well as equipment mounted inside the panels shall be provided with individual name plates with equipment designation engraved. Also on the top of each panel on front as well as rear side, large and bold nameplates shall be provided for circuit/feeder designation.

8.2. All front mounted equipment shall also be provided at the rear with individual name plates engraved with tag numbers corresponding to the one shown in the panel internal wiring to facilitate easy tracing of the wiring.

8.3. Each instrument and meter shall be prominently marked with the quantity measured e.g. KV, A, MW, etc. All relays and other devices shall be clearly marked with manufacturer's name, manufacturer's type, serial number and electrical rating data.

8.4. Name Plates shall be made of non-rusting metal or 3 ply lamicoid. Name plates shall be black with white engraving lettering.

8.5. Each switch shall bear clear inscription identifying its function e.g. 'BREAKER' '52A', "SYNCHRONISING" etc. Similar inscription shall also be provided on each device whose function is not other-wise identified. If any switch device does not bear this inscription separate name plate giving its function shall be provided for it. Switch shall also have clear inscription for each position indication e.g. "Trip- Neutral-Close", "ON-OFF", "R-Y-B-OFF" etc

8.6. All the panels shall be provided with name plate mounted inside the panel bearing LOA No & Date, Name of the Substation & feeder and reference drawing number.

9. MISCELLANEOUS ACCESSORIES

9.1. **Plug Point**: 230V, Single phase 50Hz, AC socket with switch suitable to accept 5 Amps and 15 Amps pin round standard Indian plug, shall be provided in the interior of each cubicle with ON-OFF switch.

9.2. **Interior Lighting**: Each panel shall be provided with a fluorescent lighting fixture rated for 230 Volts, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch. Adequate lighting shall also be provided for the corridor in Duplex panels.

9.3. **Switches and Fuses**: Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with Fuses. Selection of the main and sub-circuit Fuses rating shall be such as to ensure selective clearance of sub-circuit faults. Voltage transformer circuits for relaying and metering shall be protected by fuses. All fuses shall be HRC cartridge type conforming to IS: 13703 mounted on plug-in type fuse bases. The short time fuse rating of Fuses shall be not less than 9 KA. Fuse carrier base shall have imprints of the fuse 'rating' and 'voltage'.

9.4. **Space Heater**: Each panel shall be provided with a thermostatically connected space heater rated for 230V, single phase, 50 Hz AC supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with switch unit.

10. EARTHING

10.1. All panels shall be equipped with an earth bus securely fixed. Location of earth bus shall ensure no radiation interference from earth systems under various switching conditions of isolators and breakers. The material and the sizes of the bus bar shall be at least 25 X 6 sq.mm copper with threaded holes at a gap of 50 mm with provision of bolts and nuts for connection with cable armours and mounted equipment etc for effective earthing. When several panels are mounted adjoining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply of Contractor. Provision shall be made for extending the earth bus bars to future adjoining panels on either side.

10.2. Provision shall be made on each bus bar of the end panels for connecting Substation earthing grid. Necessary terminal clamps and connectors for this purpose shall be included in the scope of supply of Contractor.

10.3. All metallic cases of relays, instruments and other panel mounted equipment including gland plate, shall be connected to the earth bus by copper wires of size not less than 2.5 sq. mm. The colour code of earthing wires shall be green.

10.4. Looping of earth connections which would result in loss of earth connection to other devices when the loop is broken, shall not be permitted. However, looping of earth connections between equipment to provide alternative paths to earth bus shall be provided.

10.5. VT and CT secondary neutral or common lead shall be earthed at one place only at the terminal blocks where they enter the panel. Such earthing shall be made through links so that earthing may be removed from one group without disturbing continuity of earthing system for other groups.

10.6. An electrostatic discharge **arrangement** shall be provided in each panel **so as to discharge human body before he handles the equipments inside the panels**.

11. INDICATING INSTRUMENTS & TRANSDUCERS FOR CONTROL PANEL:

All instruments, meters and transducers shall be enclosed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. All megawatt , megavar, Bus voltage and frequency indicating instruments shall be provided with individual transducers and these shall be calibrated along with transducers to read directly the primary quantities. They shall be accurately adjusted and calibrated at works and shall have means of calibration check and adjustment at site. The supplier shall submit calibration certificates at the time of delivery. However no separate transducers are envisaged for digital bus voltmeters and digital frequency meters and the indicating meters provided in the synchronising equipment.

11.1. Indicating Instruments

11.1.1. Unless otherwise specified, all electrical indicating instruments shall be of digital type suitable for flush mounting.

11.1.2. Instruments shall have 4-digit display; display height being not less than 25 mm

11.1.3. Instrument shall confirm to relevant IEC and shall have an accuracy class of 1.5 or better. Watt and Var meters shall have an indication of (+) and (-) to indicate EXPORT and IMPORT respectively.

11.1.4. Digital voltage and frequency meters shall be of class: 0.5 and shall have digital display of 5 and 4 digits respectively, with display size, not less than 25mm (height).

11.2. Transducers

11.2.1. Transducers (for use with Indicating Instruments and Telemetry/Data Communication application) shall in general conform to IEC:688-1

11.2.2. The transducers shall be suitable for measurement of active power, reactive power, voltage, current and frequency in three phase four wire unbalanced system.

11.2.3. The input to the transducers will be from sub-station current & potential transformers. The output shall be in milli ampere D.C. proportional to the input & it shall be possible to feed the output current directly to the telemetry terminal or indicating instruments.

11.2.4. The transducer characteristic shall be linear throughout the measuring range.

11.2.5. The transducer output shall be load independent.

11.2.6. The input & output of the transducer shall be galvanically isolated.

11.2.7. Each transducer shall be housed in a separate compact case and have suitable terminals for inputs & outputs.

11.2.8. The transducers shall be suitably protected against transient high peaks of voltage & current.

11.2.9. The transducer shall withstand indefinitely without damage and work satisfactorily at 120% of the rated voltage and 120% of the rated input current as applicable.

11.2.10. All the transducers shall have an output of 4-20 mA.

11.2.11. The response time of the transducers shall be less than 1 second.

11.2.12. The accuracy class of transducers shall be 1.0 or better for voltage/current transducer, 0.5 or better for watt/VAR transducer and 0.2 or better for frequency transducer.

11.2.13. The transducers shall have a low AC ripple on output less than 1%.

11.2.14. The transducer shall have dual output.

12. ANNUNCIATION SYSTEM for Control Panel

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

12.2. The visual annunciation shall be provided by annunciation facia, mounted flush on the top of the control panels.

12.3. The annunciation facia shall be provided with translucent plastic window for alarm point with approximate size of 35mm x 50mm. The facia plates shall be engraved in black lettering with respective inscriptions. Alarm inscriptions shall be engraved on each window in not more than three lines and size of the lettering shall not be less than 5 mm.

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

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

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

Hooter	Alarm Annunciation
Bell	Annunciation DC failure
Buzzer	AC supply failure

12.7. Sequence of operation of the annunciator shall be as follows :

Sl. NO.	Alarm Condition	Fault Contact	Visual Annunciation	Audible Annunciation
1.	Normal	Open	OFF	OFF
2.	Abnormal	Close	Flashing	ON
3.	Accept Push Button Pressed	Close	Steady On	OFF
		Open	Steady On	OFF
4.	Reset Push Button Pressed	Close	On	OFF
		Open	Off	OFF
5.	Lamp Test Push Button Pressed	Open	Steady On	OFF

12.8. Audible annunciation for the failure of DC supply to the annunciation system shall be provided and this annunciation shall operate on 230 Volts AC supply. On failure of the DC to the annunciation system for more than 2 or 3 seconds (adjustable setting), a bell shall sound. A separate push button shall be provided for the cancellation of this audible alarm alone but the facia window shall remain steadily lighted till the supply

to annunciation system is restored.

12.9. A separate voltage check relay shall be provided to monitor the failure of supply (230V AC) to the scheme mentioned in Clause above. If the failure of supply exists for more than 2 to 3 seconds, this relay shall initiate visual and audible annunciation. Visual and audible annunciation for the failure of AC supply to the annunciation system shall be provided and this annunciation shall operate on Annunciation DC and buzzer shall sound.

12.10. The annunciation system described above shall meet the following additional requirements :

a) The annunciation system shall be capable of catering to at least 20 simultaneous signals at a time.

b) One set of the following push buttons shall be provided on each control panel:

- Reset push button for annunciation system
- Accept push button for annunciation system
- Lamp test push button for testing the facia windows

c) One set of the following items shall be provided common for all the control panel (not applicable for extension of substation) :

- Flasher relay for annunciation system
- Push button for Flasher test
- Three Push buttons for test of all audible alarm systems

d) These testing circuits shall be so connected that while testing is being done, it shall not prevent the registering of any new annunciation that may land during the test.

e) The annunciation shall be repetitive type and shall be capable of registering the fleeting signal. Minimum duration of the fleeting signal registered by the system shall be 15 milli seconds.

f) In case of static annunciator scheme, special precaution shall be taken to ensure that spurious alarm condition does not appear due to influence of external electromagnetic/ electrostatic interference on the annunciator wiring and switching disturbances from the neighbouring circuits within the panels and the static annunciator shall meet the high voltage susceptibility test , impulse voltage withstand test , high frequency disturbance test– class III and fast transient disturbance test –level III as per IEC 60255.

12.11. The annunciation system to be supplied for existing sub-stations shall be engineered as an extension to the existing scheme.

13. SWITCHES

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

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

Breaker, Isolator control switches : Pistol grip, black

Synchronising switches	:	Oval, Black, Keyed handle (one common removable handle for a group of switches or locking facility having common key)
synchronising Selector switches	:	Oval or knob, black
Instrument switches	:	Round, knurled, black
Protection Transfer switch	:	Pistol grip, lockable and black.

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

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

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

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

13.7. The contacts of all switches shall preferably open and close with snap action to minimise arcing. Contacts of switches shall be spring assisted and contact faces shall be with rivets of pure silver or silver alloy. Springs shall not be used as current carrying parts

13.8. The contact combination and their operation shall be such as to give completeness to the interlock and function of the scheme.

13.9. The contact rating of the switches shall be as follows :

Description	**Contact Rating in Amps**		
	220V DC	**50V DC**	**230V AC**
Make and carry	10	10	10
Continuously			

Make and carry for 0.5 sec.	30	30	30
Break for Resistive load	3	20	7
Break for Inductive load with L/R = 40m sec.	0.2	-	-

14. INDICATING LAMPS

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

14.2. The lamps shall be provided with suitable resistors.

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

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

15. POSITION INDICATORS (if Applicable)

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

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

15.3. The rating of the indicator shall not exceed 2.5 W.

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

16. SYNCHRONISING EQUIPMENT

16.1. For sub-station equipped with sub-station Automation system, the requirement of synchronisation is specified in chapter Sub-station Automation System and the same shall prevail. For other sub-station which is not equipped with Sub-sub-station automation system following shall be applicable as per requirement.

16.1. The synchronising instruments shall be mounted either on a synchronising trolley or on a synchronising panel. The panel/ trolley shall be equipped with double analog

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

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

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

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

16.1. At existing sub-stations, the synchronising scheme shall be engineered to be compatible with the existing synchronising scheme and synchronising socket/switch on the panel. In substations, where synchronising panels are available, the bidder shall carry out the shifting of the above panels, if required, to facilitate the extension of control panel placement.

17. RELAYS

17.1. All relays shall conform to the requirements of IS: 3231/IEC-60255/IEC 61000 or other applicable standards. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear.

17.2. All protective relays shall be of numerical type and communication protocol shall be as per IEC 61850. Further, the test levels of EMI as indicated in IEC 61850 shall be applicable to these relays.

17.3. All protective relays shall be in draw out or plug-in type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied loose and shall be included in contractor's scope of supply.

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

17.5. The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. also required for the complete protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme; contacts shall be silver faced with spring action. Relay case shall have adequate number of terminals for making potential free external connections to the relay coils and contacts, including spare contacts.

17.6. Timers shall be of solid state type. Time delay in terms of milliseconds obtained by the external capacitor resistor combination is not preferred and shall be avoided.

17.7. No control relay, which shall trip the power circuit breaker when the relay is de-energised, shall be employed in the circuits.

17.8. Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.

17.9. Auxiliary seal-in-units provided on the protective relays shall preferably be of shunt reinforcement type. If series relays are used the following shall be strictly ensured:

(a) The operating time of the series seal-in-unit shall be sufficiently shorter than that of the trip coil or trip relay in series with which it operates to ensure definite operation of the flag indicator of the relay.

(b) Seal-in-unit shall obtain adequate current for operation when one or more relays operate simultaneously.

(c) Impedance of the seal-in-unit shall be small enough to permit satisfactory operation of the trip coil on trip relays when the D.C. Supply Voltage is minimum.

(d) Trip-circuit seal-in is required for all trip outputs, irrespective of the magnitude of the interrupted current. The trip-circuit seal-in logic shall not only seal-in the trip output(s),but also the relevant initiation signals to other scheme functions, (e.g. initiate signals to the circuit-breaker failure function, reclosing function etc.), and the alarm output signals.

(e) Two methods of seal-in are required, one based on the measurement of AC current, catering for those circumstances for which the interrupted current is above a set threshold, and one based on a fixed time duration, catering for those circumstances for which the interrupted current is small (below the set threshold).

(f) For the current seal-in method, the seal-in shall be maintained until the circuit-breaker opens, at which time the seal-in shall reset and the seal-in method shall not now revert to the fixed time duration method. For this seal-in method, the seal-in shall be maintained for the set time duration. For the line protection schemes, this time duration shall be independently settable for single- and three-pole tripping.

(g) Seal-in by way of current or by way of the fixed duration timer shall occur irrespective of whether the trip command originates from within the main protection device itself (from any of the internal protection functions), or from an external device with its trip output routed through the main protection device for tripping. Trip-circuit seal-in shall not take place under sub-harmonic conditions (e.g. reactor ring down).

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

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

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

17.13. For numerical relays, the scope shall include the following:

a) Necessary software and hardware to up/down load the data to/from the relay from/to the personal computer installed in the substation. However, the supply of PC is not covered under this clause.

b) The relay shall have suitable communication facility for future connectivity to SCADA. The relay shall be capable of supporting IEC-61850 protocol.

c) In case of line protection and transformer/reactor protection, the features like fault recorder and event logging function as available including available as optional feature in these relays shall be supplied and activated at no extra cost to the owner. Also necessary software/ hardware for automatic uploading to station HMI/DR work station (as applicable) shall be supplied. It is to be clearly understood that these shall be in addition to Fault recorder function as specified at clause no. 28.

18. TRANSMISSION LINE PROTECTION

18.1. All relays shall be suitable for series compensated line.

18.2. The line protection relays are required to protect the line and clear the faults on line within shortest possible time with reliability, selectivity and full sensitivity to all type of faults on lines. The general concept is to have two main protections having equal performance requirement specially in respect of time as called Main-I and Main-II for 220KV transmission lines and Main and back up protection for 132 KV transmission lines.

18.3. The Transmission system for which the line protection equipment are required is **indicated in Chapter 1 – Project Specification Requirement.**

18.4. The maximum fault current could be as high as 63kA but the minimum fault current could be as low as 20% of rated current of CT secondary. The starting & measuring relays characteristics should be satisfactory under these extremely varying conditions.

18.5. The protective relays shall be suitable for use with capacitor voltage transformers having non-electronic damping and transient response as per IEC.

18.6. Fault Recorder, Distance to fault Locator and Over voltage relay (stage -1/2) functions if offered as an integral part of line protection relays, shall be acceptable provided these meet the technical requirements as specified in the respective clauses.

18.7. Auto reclose relay function if offered as an integral part of line distance protection relay, shall be acceptable **for 132 KV lines only** provided the auto reclose relay feature meets the technical requirements as specified in the respective clause.

18.8. The following protections shall be provided for each of the Transmission lines:

For 220KV

Main-I: Numerical distance protection scheme

Main-II: Numerical distance protection scheme of a make different from that of Main –I

For 132KV

Main: Numerical distance protection scheme

Back up: Directional Over Current and Earth fault Protection

The detailed description of line protections is given here under.

18.9. **Main-I and Main-II Distance Protection scheme**:

(a) shall have continuous self monitoring and diagnostic feature

(b) shall be non-switched type with separate measurements for all phase to phase and phase to ground faults

(c) shall have stepped time-distance characteristics and three independent zones (zone 1, zone-2 and zone-3)

(d) shall have mho or quadrilateral or other suitably shaped characteristics for zone-1 , zone-2 and zone- 3

(e) shall have following maximum operating time (including trip relay time, if any) under given set of conditions and with CVT being used on line (with all filters included)

(i) for 220 KV lines:

For Source to Impedance ratio:	**4**	**15**
Relay setting (Ohms)	(10 or 20) and 2	2
Fault Locations (as % of relay setting)	50	50
Fault resistance (Ohms)	0	0
Maximum operating time (Milliseconds)	40 for all faults	45 for 3 ph. Faults & 60 for all other faults

(ii) for 132 KV lines:

A relaxation of 5 ms in above timings is allowed for 132 KV lines.

(f) The relay shall have an adjustable characteristics angle setting range of 30 -85 degree or shall have independent resistance(R) and reactance (X) setting.

(g) shall have two independent continuously variable time setting range of 0-3 seconds for zone-2 and 0-5 seconds for zone-3

(h) shall have resetting time of less than 55 milli-seconds (including the resetting time of trip relays)

(i) shall have facilities for offset features with adjustable 10-20% of Zone-3 setting

(j) shall have variable residual compensation

(k) shall have memory circuits with defined characteristics in all three phases to ensure correct operation during close-up 3 phase faults and other adverse conditions and shall operate instantaneously when circuit breaker is closed to zero-volt 3 phase fault

(l) shall have weak end in-feed feature

(m) shall be suitable for single & three phase tripping

(n) shall have a continuous current rating of two times of rated current. The voltage circuit shall be capable of operation at 1.2 times rated voltage. The relay shall also be capable of carrying a high short time current of 70 times rated current without damage for a period of 1 sec.

(o) shall be provided with necessary self reset type trip duty contacts for completion of the scheme (Minimum number of these trip duty contacts shall be four per phase) either through built in or through separate high speed trip relays. Making capacity of these trip contacts shall be 30 amp for 0.2 seconds with an inductive load of L/R > 10 mill seconds. If separate high speed trip relays are used , the operating time of the same shall not be more than 10 milliseconds

(p) shall be suitable for use in permissive under reach/ over reach/ blocking communication mode

(q) shall have suitable number of potential free contacts for Carrier aided Tripping, Auto reclosing, CB failure, Disturbance recorder & Data acquisition system

(r) include power swing blocking protection which shall

- have suitable setting range to encircle the distance protection described above
- block tripping during power swing conditions
- release blocking in the event of actual fault

(s) include fuse failure protection which shall monitor all the three fuses of C.V.T. and associated cable against open circuit

- inhibit trip circuits on operation and initiate annunciation
- have an operating time less than 7 milliseconds
- remain inoperative for system earth faults

(t) include a directional back up Inverse Definite Minimum Time (IDMT) earth fault relay with normal inverse characteristics as per IEC 60255-3 as a built in feature or as a separate unit for 220KV transmission lines

(u) Must have a current reversal guard feature.

18.10. **Back-up Directional Over Current and Earth fault protection scheme**

(a) shall have three over current and one earth fault element(s) which shall be either independent or composite unit(s)

(b) shall include necessary VT fuse failure relays for alarm purposes

(c) **over current elements** shall

- have IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting

- have a variable setting range of 50-200% of rated current
- have a characteristic angle of 30/45 degree lead
- include hand reset flag indicators or LEDs

(d) **earth fault element** shall

- have IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting
- have a variable setting range of 20-80% of rated current
- have a characteristic angle of 45/60 degree lag
- include hand reset flag indicators or LEDs
- include necessary separate interposing voltage transformers or have internal feature in the relay for open delta voltage to the relay

18.11. **LINE OVER VOLTAGE PROTECTION RELAY** shall

(a) monitor all three phases

(b) have two independent stages

(c) stage- I & II as built-in with line distance relays Main I & II respectively are acceptable

(d) have an adjustable setting range of 100-170% of rated voltage with an adjustable time delay range of 1 to 60 seconds for the first stage

(e) have an adjustable setting range of 100-170% of rated voltage with a time delay of 100-200 mill seconds for the second stage

(f) be tuned to power frequency

(g) provided with separate operation indicators (flag target) for each stage relays

(h) have a drop-off to pick-up ratio greater than 95%

(i) provide separate out-put contacts for each 'Phase' and stage for breaker trip relays, event logger and other scheme requirements

18.12. All trip relays used in transmission line protection scheme shall be of self/electrical reset type depending on application requirement.

19. **CIRCUIT BREAKER PROTECTION:**

This shall include following functions:

19.1. **Numerical AUTO RECLOSING** function shall

(a) have single phase reclosing facilities

(b) have a continuously variable single phase dead time range of 0.1-2 seconds

(c) have a continuously variable reclaim time range of 5-300 seconds

(d) Incorporate a **two** position selector switch, from which single phase auto-reclosure and non-auto reclosure mode can be selected. Alternatively, the mode of auto reclosing can be selected through programming.

(e) be of single shot type

(f) have priority circuit to closing of both circuit breakers in case one and half breaker arrangements to allow sequential closing of breakers

(g) However, Auto-reclose as in built function of bay controller unit (BCU) (if supplied) provided for sub-station automation system is also acceptable.

19.2. **LOCAL BREAKER BACK-UP PROTECTION SCHEME** shall

(a) be triple pole type

(b) have an operating time of less than 15 milli seconds

(c) have a resetting time of less than 15 milli seconds

(d) have three over current elements

(e) be arranged to get individual initiation from the corresponding phase of main protections of line for each over current element. However, common three phase initiation is acceptable for other protections and transformer /reactor equipment protections

(f) have a setting range of 20-80% of rated current

(g) have a continuous thermal withstand two times rated current irrespective of the setting

(h) have a timer with continuously adjustable setting range of 0.1-1 seconds

(i) have necessary auxiliary relays to make a comprehensive scheme

(j) be similar relays for complete scope of work as per specification

20. REACTOR PROTECTION

20.1. **Differential Protection Relay shall**

(a) be triple pole type

(b) have operation time less than 25 milli-seconds at 5 times setting

(c) be tuned to system frequency

(d) have current setting range of 10 to 40% of 1 Amp. or a suitable voltage setting range

(e) be high impedance / biased differential type

(f) be stable for all external faults

20.2. **Restricted Earth Fault Protection Relay** shall

(a) be single pole type

(b) be of current/voltage operated high impedance type

(c) have a current setting of 10-40% of 1 Amp./have a suitable voltage setting range

(d) be tuned to system frequency

(e) have a suitable non-linear resistor to limit the peak voltage to 1000 Volts

20.3. **Back up impedance protection Relay** shall

(a) be triple pole type, with faulty phase identification/ indication

(b) be single step polarised 'mho' distance/ impedance relay suitable for measuring phase to ground and phase to phase faults

(c) have adequate ohmic setting range to cover at least 60% of the impedance of the reactor and shall be continuously variable

(d) have an adjustable characteristic angle of 30-80 degree

(e) have a definite time delay relay with a continuously adjustable setting range of 0.2-2.0 seconds

(f) include VT failure relay which shall block the tripping during VT fuse failure condition

Further, Reactor auxiliary protections contacts (Buchholz, PRV, Oil Temperature, Winding Temperature etc.) can be wired suitably in above protections or provide separate Flag relays/Auxiliary relays as per scheme requirements.

21. TRANSFORMER PROTECTION

All transformer protection functions may be grouped into Group-I and Group-II protections in the following manner:

Group-I Protection: Following protection functions may be provided in Group-I Transformer protection relay:

a) Differential Protection as per clause no. 21.1

b) Over fluxing Protection for HV side as per clause no. 21.2

c) Direction Over current and earth fault protection for HV side as per clause no. 21.4

d) Over Load Protection as per clause no. 21.5

Group-II Protection: Following protection functions may be provided in Group-II Transformer protection relay:

e) REF Protection as per clause no. 21.3

f) Over fluxing Protection for IV/LV side as per clause no. 21.2

g) Direction Over current and earth fault protection for IV/LV side as per clause no. 21.4

h) Neutral Current Relay for Single Phase Transformer Bank

The various protections as built-in function of Group I/II protections shall be accepted only if the functional requirements of corresponding protections as specified in clause no. 21.1 to 21.6 are met otherwise separate protection relay(s) shall be offered.

21.1. Transformer differential protection scheme shall

(a) be triple pole type, with faulty phase identification/ indication

(b) have an operating time not greater than 30 milli seconds at 5 times the rated current

(c) have three instantaneous high set over-current units

(d) have an adjustable bias setting range of 20-50%

(e) be suitable for rated current of 1 Amp.

(f) have second harmonic or other inrush proof features and also should be stable under normal over fluxing conditions. Magnetising inrush proof feature shall

not be achieved through any intentional time delay e.g. use of timers to block relay operation or using disc operated relays

(g) have an operating current setting of 15% or less

(h) include necessary separate interposing current transformers for angle and ratio correction or have internal feature in the relay to take care of the angle & ratio correction

(i) have a fault recording feature to record graphic form of instantaneous values of following analogue channels during faults and disturbances for the pre fault and post fault period:

current in all three windings in nine analogue channels in case of 400kV class and above transformers or 6 analogue channels for lower voltage transformers and Voltage in one channel

The disturbance recorder shall have the facility to record the following external digital channel signals apart from the digital signals pertaining to differential relay:

1. REF protection operated
2. HV Breaker status (Main and tie)
3. IV Breaker status
4. Bucholz /OLTC Bucholz alarm / trip etc.
5. WTI/OTI/PRD alarm/trip of transformer etc.

Necessary hardware and software, for automatic up-loading the data captured by disturbance recorder to the personal computer (DR Work Station) available in the substation, shall be included in the scope.

21.2. **Over Fluxing Protection Relays** shall

(a) operate on the principle of Voltage to frequency ratio and shall be phase to phase connected

(b) have inverse time characteristics, matching with transformer over fluxing withstand capability curve

(c) provide an independent 'alarm' with the time delay continuously adjustable between 0.1 to 6.0 seconds at values of 'v/f' between 100% to 130% of rated values

(d) tripping time shall be governed by 'v/f' Vs. time characteristics of the relay

(e) have a set of characteristics for Various time multiplier settings. The maximum operating time of the relay shall not exceed 3 seconds and 1.5 seconds at 'v/f' values of 1.4 and 1.5 times, the rated values, respectively.

(f) have an accuracy of operating time, better than ±10%

(g) have a resetting ratio of 95 % or better

21.3. **Restricted Earth Fault Protection** shall

(a) be single pole type

(b) be of current/voltage operated type

(c) have a current setting range of 10-40% of 1 Amp./ have a suitable voltage

setting range

(d) be tuned to the system frequency

21.4. **Back-up Over Current and Earth fault protection scheme with high set feature**

(a) Shall have three over current and one earth fault element(s) which shall be either independent or composite unit(s).

(b) The scheme shall include necessary VT fuse failure relays for alarm purposes

(c) Over current relay shall

- have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 50-200% of rated current
- have low transient, over reach high set instantaneous unit of continuously variable setting range 500-2000 % of rated current
- have a characteristic angle of 30/45 degree lead
- include hand reset flag indicators or LEDs.

(d) Earth fault relay shall

- have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current
- have low transient, over reach high set instantaneous unit of continuously variable setting range 200-800 % of rated current
- have a characteristic angle of 45/60 degree lag
- include hand reset flag indicators or LEDs
- include necessary separate interposing voltage transformers or have internal feature in the relay for open delta voltage to the relay

21.5. **Transformer Overload Protection Relay** shall

(a) be of single pole type

(b) be of definite time over-current type

(c) have one set of over-current relay element, with continuously adjustable setting range of 50-200% of rated current

(d) have one adjustable time delay relay for alarm having setting range of 1 to 10.0 seconds, continuously.

(e) have a drop-off/pick-up ratio greater than 95%.

21.6. **Transformer Neutral Current Protection relay** (for 1-Phase transformer bank neutral) shall

(a) have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current

21.7. **Further, Transformer auxiliary protections contacts (Buchholz, PRV, Oil Temperature, Winding Temperature, OLTC Buchholz etc.) can be wired**

suitably in above protections or provide separate Flag relays/Auxiliary relays as per scheme requirements.

22. TEE DIFFERENTIAL PROTECTION RELAYS

22.1. **TEE-1 Differential protection relay** shall

(a) be triple pole type

(b) have an operating time less than 30 milliseconds at 5 times the rated current

(c) have three instantaneous high set over current units

(d) have an adjustable bias setting range of 20-50%

(e) have an operating current setting of 15% of 1 Amp or less

22.2. **TEE-2 Differential Protection relay** shall

(a) be triple pole type

(b) have operating time less than 25 milliseconds at 5 times setting

(c) be tuned to system frequency

(d) have current setting range of 20 to 80% of 1 Amp

(e) be voltage operated, high impedance type

(f) be stable for all external faults

(g) be provided with suitable non linear resistors across the relay to limit the peak voltage to 1000 volts

23. TRIP CIRCUIT SUPERVISION RELAY

(a) The relay shall be capable of monitoring the healthiness of each 'phase' trip-coil and associated circuit of circuit breaker during 'ON' and 'OFF' conditions.

(b) The relay shall have adequate contacts for providing connection to alarm and event logger.

(c) The relay shall have time delay on drop-off of not less than 200 milli seconds and be provided with operation indications for each phase

24. TRIPPING RELAY

High Speed Tripping Relay shall

(a) be instantaneous (operating time not to exceed 10 milli-seconds).

(b) reset within 20 milli seconds

(c) be D.C. operated

(d) have adequate contacts to meet the requirement of scheme, other functions like auto-reclose relay, LBB relay as well as cater to associated equipment like event logger, Disturbance recorder, fault Locator, etc.

(e) be provided with operation indicators for each element/coil.

25. DC SUPPLY SUPERIVISION RELAY

(a) The relay shall be capable of monitoring the failure of D.C. supply to which, it is connected.

(b) It shall have adequate potential free contacts to meet the scheme requirement.

(c) The relay shall have a 'time delay on drop-off' of not less than 100 milli seconds and be provided with operation indicator/flag.

26. BUS BAR PROTECTION

26.1. Single bus bar protection scheme shall be provided for each main bus and transfer bus (as applicable) for 220KV and 132 KV voltage levels

26.2. Each Bus Bar protection scheme shall

(a) have maximum operating time up to trip impulse to trip relay for all types of faults of 25 milli seconds at 5 times setting value.

(b) operate selectively for each bus bar

(c) give hundred percent security up to 63 KA fault level for 220KV and 31.5 KA for 132 KV

(d) incorporate continuous supervision for CT secondary against any possible open circuit and if it occurs, shall render the relevant zone of protection inoperative and initiate an alarm

(e) not give false operation during normal load flow in bus bars

(f) incorporate clear zone indication

(g) be of phase segregated and triple pole type

(h) provide independent zones of protection (including transfer bus if any). If the bus section is provided then each side of bus section shall have separate set of bus bar protection schemes

(i) include individual high speed electrically reset tripping relays for each feeder. However, in case of distributed Bus bar protection, individual trip relay shall not be required if bay unit is having trip duty contacts for breaker tripping.

(j) be transient free in operation

(k) include continuous D.C. supplies supervision

(l) not cause tripping for the differential current below the load current of heaviest loaded feeder. Contractor shall submit application check for the same.

(m) shall include necessary C.T. switching relays wherever C.T. switching is involved and have 'CT' selection incomplete alarm

(n) include protection 'IN/OUT' switch for each zone

(o) shall include trip relays, CT switching relays (if applicable), auxiliary CTs (if applicable) as well as additional power supply modules, input modules etc. as may be required to provide a Bus-bar protection scheme for the complete bus arrangement i.e. for all the bays or breakers including future bays as per the Single line diagram for new substations. However for extension of bus bar protection scheme in existing substations, scope shall be limited to the bay or breakers covered under this specification. Suitable panels (if required) to mount these are also included in the scope of the work.

(p) In case of distributed Bus bar Protection, the bay units for future bays may be installed in a separate panel and the same shall be located in switchyard panel room where bus bar protection panel shall be installed.

26.3. Built-in Local Breaker Backup protection feature as a part of bus bar protection scheme shall also be acceptable.

26.4. At existing substations, Bus-bar protection scheme with independent zones for each bus, will be available. All necessary co-ordination for 'AC' and 'DC' interconnections between existing schemes (Panels) and the bays proposed under the scope of this contract shall be fully covered by the bidder. Any auxiliary relay, trip relay, flag relay and multi tap auxiliary CTs (in case of biased differential protection) required to facilitate the operation of the bays covered under this contract shall be fully covered in the scope of the bidder.

26.5. The test terminal blocks (TTB) to be provided shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material with boxes and barriers moulded integrally. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting and testing facilities for CT circuits.

27. WEATHER PROOF RELAY PANELS (If Applicable)

(a) This panel shall include necessary number of electrically reset relays each with at least eight contacts for isolator auxiliary contacts multiplication and for changing the CT and DC circuits to relevant zones of bus bar protection.

(b) The panel shall be sheet steel enclosed and shall be dust, weather and vermin proof. Sheet steel used shall be at least 2.0 mm thick and properly braced to prevent wobbling.

(c) The enclosures of the panel shall provide a degree of protection of not less than IP-55 (as per IEC-60529).

(d) The panel shall be of free standing floor mounting type or pedestal mounting type as per requirement.

(e) The panel shall be provided with double hinged doors with padlocking arrangement.

(f) All doors, removable covers and panels shall be gasketed all around with synthetic gaskets Neoprene/EPDM. However, XLPE gaskets can also be used for fixing protective glass doors. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh

(g) Cable entries shall be from bottom. Suitable removable cable gland plate shall be provided on the cabinet for this purpose.

(h) All sheet steel work shall be degreased, pickled, phosphated and then applied with two coats of zinc chromates primer and two coats of finishing synthetic enamel paint, both inside and outside. The colour of the finishing paint shall be light grey.

(i) Suitable heaters shall be mounted in the panel to prevent condensation. Heaters shall be controlled by thermostats so that the cubicle temperature does not exceed 30^{o}C. On-off switch and fuse shall be provided. Heater shall be suitable for 230V AC supply Voltage.

(j) The test terminal blocks (TTB) to be provided shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material

with boxes and barriers moulded integrally. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting and testing facilities for CT circuits.

28. **FAULT RECORDER**

28.1. The fault recorder shall be provided for transmission line and the fault recorder as in-built feature of line distance relay is also acceptable provided the requirements of following clauses are met.

28.2. Fault recorder shall be microprocessor based and shall be used to record the graphic form of instantaneous values of voltage and current in all three phases, open delta voltage & neutral current, open or closed position of relay contacts and breakers during the system disturbances.

28.3. The Fault recorder shall consist of individual acquisition units, one for each feeder and an Evaluation unit which is common for the entire Substation. Whenever, more than one acquisition units are connected to an Evaluation unit, necessary hardware and software shall also be supplied for on line transfer of data from all acquisition units to Evaluation unit.

28.4. The acquisition unit is connected with evaluation unit being supplied as described in chapter 17 sub-station automation through bus conforming to IEC 61850. In case of extension sub-station which is equipped with Sub-station Automation System based on IEC 61850, one set of evaluation software shall be supplied and loaded in existing fault recorder evaluation unit. Automatic uploading of disturbance files from acquisition unit to evaluation unit shall be done through existing station bus only conforming to IEC 61850. Necessary configuration/updation including hardware if any shall be in the scope of the contractor.

28.5. In case of extension of existing substation(s) which are without sub-station automation system, one set of Evaluation unit shall be supplied for each substation where ever disturbance recorders are required to be supplied along with necessary evaluation software as specified above. The Evaluation unit shall consist of a desktop personal computer (including at least 17" TFT colour monitor, mouse and keyboard) and printer. The desktop PC shall have Pentium - IV processor or better and having a clock speed 3.0GHz or better. The hard disk capacity of PC shall not be less than 300 GB and RAM capacity shall not be less than 3 GB

28.6. The evaluation unit hardware, for substations having SAS, shall be as described in clause no. 4.0 of chapter sub-station automation system.

28.7. Fault recorder shall have atleast 8 analogue and 16 digital channels for each feeder.

28.8. Acquisition units shall acquire the Disturbance data for the pre fault and post fault period and transfer them to Evaluation unit automatically to store in the hard disk. The acquisition units shall be located in the protection panels of the respective feeders.

28.9. The acquisition unit shall be suitable for inputs from current transformers with 1A rated secondary and capacitive voltage transformers with 63.5V (phase to neutral voltage) rated secondary. Any device required for processing of input signals in order to make the signals compatible to the Fault recorder equipment shall form an integral part of it. However, such processing of input signals shall in no way distort its waveform.

28.10. The equipment shall be carefully screened, shielded, earthed and protected as may be

required for its safe functioning. Also, the Fault recorder shall have stable software, reliable hardware, simplicity of maintenance and immunity from the effects of the hostile environment of EHV switchyard which are prone to various interference signals typically from large switching transients.

28.11. Necessary software for transferring the data automatically from local evaluation unit to a remote station and receiving the same at the remote station through owner's PLCC/VSAT/LEASED LINE shall be provided.

28.12. Evaluation software shall be provided for the analysis and evaluation of the recorded data made available in the PC under WINDOWS environment. The Software features shall include repositioning of analog and digital signals, selection and amplification of time and amplitude scales of each analogue and digital channel, calculation of MAX/MIN frequency, phase difference values, recording of MAX/MIN values etc. of analogue channel, group of signal to be drawn on the same axis etc, listing and numbering of all analogue and digital channels and current, voltage, frequency and phase difference values at the time of fault/tripping. Also, the software should be capable of carrying out Fourier /Harmonic analysis of the current and voltage wave forms. The Disturbance records shall also be available in COMTRADE format (IEEE standard- Common Format for Transient data Exchange for Power System)

28.13. The Evaluation unit shall be connected to the printer to obtain the graphic form of disturbances whenever desired by the operator.

28.14. Fault recorder acquisition units shall be suitable to operate from 220V DC or 110V DC as available at sub-station. Evaluation unit along with the printer shall normally be connected to 230V, single phase AC supply. In case of failure of AC supply, Evaluation unit and printer shall be switched automatically to the station DC through Inverter of adequate capacity which shall form a part of Fault recorder system. The inverter of adequate capacity shall be provided to cater the requirement specified in chapter sub-station automation clause no. 8.0 and DR evaluation unit.

28.15. The acquisition unit shall have the following features

(a) Facility shall exist to alarm operator in case of any internal faults in the acquisition units such as power supply fail, processor / memory fail etc and same shall be wired to annunciation system.

(b) The frequency response shall be 5 Hz on lower side and 250 Hz or better on upper side.

(c) Scan rate shall be 1000 Hz/channel or better.

(d) Pre-fault time shall not be less than 100 milliseconds and the post fault time shall not be less than 2 seconds (adjustable). If another system fault occurs during one post-fault run time, the recorder shall also be able to record the same. However, the total memory of acquisition unit shall not be less than 5.0 seconds

(e) The open delta voltage and neutral current shall be derived either through software or externally by providing necessary auxiliary transformers.

(f) The acquisition unit shall be typically used to record the following digital channels :

1 Main CB R phase open

2 Main CB Y phase open

3 Main CB B phase open

4 Main-1 carrier received

5 Main-1 protection operated

6 Main/Tie /TBC Auto reclosed operated

7 Over Voltage -Stage-1 /2 operated

8 Reactor / Stub/TEE-1/2/UF protection operated

9 Direct Trip received

10 Main-2 carrier received

11 Main- 2/ Back Up protection operated

12 Bus bar protection operated

13 LBB operated of main /tie/TBC circuit breaker

14 Tie/TBC CB R phase open

15 Tie/TBC CB Y phase open

16 Tie/TBC CB B phase open

(g) In case the Fault recorder is in-built part of line distance protection, above digital channels may be interfaced either externally or internally.

(h) Any digital signal can be programmed to act as trigger for the acquisition unit. Analog channels should have programmable threshold levels for triggers and selection for over or under levels should be possible.

28.16. The **colour laser** printer shall be provided which shall be compatible with the desktop PC and shall use Plain paper. The print out shall contain the Feeder identity, Date and time (in hour, minute and second up to 100th of a second), identity of trigger source and Graphic form of analogue and digital signals of all the channels. Two packets of **A4 size** paper (500 sheets in each packet) suitable for printer shall be supplied.

28.17. Each Fault recorder shall have its own time generator and the clock of the time generator shall be such that the drift is limited to $\pm$0.5 seconds/day, if allowed to run without synchronisation. Further, Fault recorder shall have facility to synchronise its time generator from Time Synchronisation Equipment having output of following types

- Voltage signal : (0-5V continuously settable, with 50m Sec. minimum pulse duration)
- Potential free contact (Minimum pulse duration of 50 m Sec.)
- IRIG-B
- RS232C

The recorder shall give annunciation in case of absence of synchronising within a specified time.

28.18. Substations where Time Synchronisation Equipment is not available, time generator of any one of the Fault recorders can be taken as master and time generators of other Fault recorders and Event loggers in that station shall be synchronised to follow the master.

29. **DISTANCE TO FAULT LOCATOR** shall

a) be electronic or microprocessor based type

b) be 'On-line' type

c) be suitable for breaker operating time of 2 cycles

d) have built-in display unit

e) the display shall be directly in percent of line length or kilometres without requiring any further calculations

f) have an accuracy of 3% or better for the typical conditions defined for operating timings measurement of distance relays

g) The above accuracy should not be impaired under the following conditions:

- presence of remote end infeed
- predominant D.C. component in fault current
- high fault arc resistance
- severe CVT transients

h) shall have mutual zero sequence compensation unit if fault locator is to be used on double circuit transmission line

i) built in feature of line distance relay is acceptable provided the requirements of above clauses are met

30. TIME SYNCHRONISATION EQUPMENT

30.1. The Time synchronisation equipment shall receive the co-ordinated Universal Time (UTC) **transmitted** through Geo Positioning Satellite System (GPS) and synchronise equipments to the Nepal Standard Time in a substation.

30.2. Time synchronisation equipment shall include antenna, all special cables and processing equipment etc.

30.3. It shall be compatible for synchronisation of Event Loggers, Disturbance recorders and SCADA at a substation through individual port or through Ethernet realised through optic fibre bus.

30.4. Equipment shall operate up to the ambient temperature of 50 degree centigrade and 80% humidity.

30.5. The synchronisation equipment shall have 2 micro-second accuracy. Equipment shall give real time corresponding to IST (taking into consideration all factors like voltage, & temperature variations, propagation & processing delays etc).

30.6. Equipment shall meet the requirement of IEC 60255 for storage & operation.

30.7. The system shall be able to track the satellites to ensure no interruption of synchronisation signal.

30.8. The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse, as per requirement.

30.9. The equipment offered shall have six (6) output ports. Various combinations of output ports shall be selected by the customer, during detailed engineering, from the following :

- Potential free contact (Minimum pulse duration of 50 milli Seconds.)

- IRIG-B
- RS232C
- SNTP Port

30.10. The equipment shall have a periodic time correction facility of one second periodicity.

30.11. Time synchronisation equipment shall be suitable to operate from 220V DC or 110V DC as available at Substation.

30.12. Equipment shall have real time digital display in hour, minute, second (24 hour mode) & have a separate time display unit to be mounted on the top of control panels having display size of approx. 100 mm height.

31. RELAY TEST KIT

31.1. One relay test kit shall comprise of the following equipment as detailed here under

3 sets	Relay tools kits
2 nos.	Test plugs **for TTB**
2 nos.	Test plugs for using with modular type relays (if applicable)

32. TYPE TESTS

32.1. The reports for following type tests shall be submitted during detailed engineering for the Protective relays, Fault Recorder, Fault locator and Disturbance recorder:

a) Insulation tests as per IEC 60255-5

b) DC Voltage dips and interruptions/Variation as per IEC 6100-4-29.

c) High frequency disturbance test as per IEC 61000-4 16, Class IV (Not applicable for electromechanical relays)

d) Electrostatic discharges as per IEC 61000-4-2, level; 4 (not applicable for Electromechanical relays)

e) Fast transient test as per IEC 61000, Level I**V** (Not applicable for electromechanical relays)

f) Relay characteristics, performance and accuracy test as per IEC 60255

- Steady state Characteristics and operating time
- Dynamic Characteristics and operating time for distance protection relays and current differential protection relays
- Conformance test as per IEC 61850-10.

For Fault recorder, Disturbance recorder; only performance tests are intended under this item.

g) Tests for thermal and mechanical requirements as per IEC 60255-6

h) Tests for rated burden as per IEC 60255-6

i) Contact performance test as per IEC 60255-0-20 (not applicable for Distance to fault locator and Disturbance recorder)

In case there is a change either in version or in model (Except firmware) of the relay, the contractor has to submit the type test reports for the offered revision/model.

32.2. Steady state & Dynamic characteristics test reports on the distance protection relays, as type test, shall be based on test programme specified in Appendix A on simulator/network analyser/PTL. Alternatively, the files generated using Electromagnetic transient Programme (EMTP) can also be used for carrying out the above tests. Single source dynamic tests on transformer differential relay shall be/ should have been conducted based on general guidelines specified in CIGRE committee 34 report on Evaluation of characteristics and performance of Power system protection relays and protective systems.

33. CONFIGURATION OF RELAY AND PROTECTION PANELS

The following is the general criteria for the selection of the equipments to be provided in each type of panel. However, contractor can optimise the requirement of panels by suitably clubbing the feeder protection and CB relay panels. It may be noted that Main-I and Main-II protections for line cannot be provided in single panel. Similarly, Group-I & Group-II protections for transformer cannot be provided in single panel.

CONTROL PANEL

Various types of control panels shall consist of the following

a	Ammeter	3 set	for each Line, BC, TBC Bus section, Bus Reactor and Transformer
b	Ammeter with Selector switch	1 set	for each line reactor
c	Wattmeter with transducer	1 set	for each line, transformer
d	Varmeter with transducer	1 set	for each line,transformer,Bus reactor
e	Varmeter with transducer	1 set	for each Line Reactor
f	CB Control switch	1 no.	for each Circuit breaker
g	Isolator Control switch	1 no.	for each isolator
h	Semaphore	1 no.	for each earth switch
i	Red indicating lamp	1 no.	for each Circuit breaker
j	Red indicating lamp	1 no.	for each isolator
k	Green indicating lamp	1 no.	for each Circuit breaker
l	Green indicating lamp	1 no.	for each isolator
m	White indicating lamp (DC healthy lamp)	2 nos	for each feeder
n	Annunciation windows with associated annunciation relays	18 nos	for each feeder
o	Push button for alarm Accept/reset/lamp test	3 nos	for each control panel
p	Synchronising Socket	1 no.	for each Circuit Breaker if required

q	Synchronising selector Switch required	1 no.	for each Circuit Breaker switch if
r	Protection Transfer Switch	1 no.	for each breaker in case of DMT /DM*/SMT scheme(Except TBC And BC Breaker)-*with Bypass ISO
s	Mimic to represent SLD	Lot	in all control panels
t	Voltmeter with selector Switch	1 no	for each line, transformer , bus reactor
u	Cut out, mounting and wiring for RWTI and selector switch	Lot	for transformers/reactors

Notes:

1 For transformer feeders, all equipments of control panel shall be provided separately for HV and MV sides.

2. In case of incomplete diameter (D and I type layouts), control panel shall be equipped fully as if the diameter is complete, unless otherwise specified. Annunciation relays shall also be provided for the same and if required, necessary panel shall be supplied to accommodate the same.

3. The above list of equipments mentioned for control panel is generally applicable unless it is defined elsewhere and in case of bay extension in existing substations, necessary equipments for matching the existing control panel shall be supplied.

4. Common synchronising switch is also acceptable in Synchronising trolley for new Substations. In this case. individual synchronising selector switch is not required for each Circuit Breaker in control panel

5. Each line /HV side of transformer/MV/LV side of transformer /Bus reactor /TBC /BC/ Bus Section shall be considered as one feeder for above purpose.

LINE PROTECTION PANEL (220 & 132kV)

The Line Protection panel for transmission lines shall consist of following protection features/schemes

Sl. No.	Description	220kV	132kV	66kV
1.	Main-1 Numerical Distance protection scheme	1 Set	1 Set	1 Set
2.	Main-2 Numerical Distance protection scheme	1 Set	NIL	NIL
3.	Over Voltage Protection	NIL	NIL	NIL

Sl. No.	Description Scheme	220kV	132kV	66kV
4.	Fault Recorder	1 Set	NIL	NIL
5.	Distance to fault Locator	1 Set	1 Set	1 Set
6.	3 Phase Trip Relays	2 Nos.	2 Nos.	2 Nos.
7.	Flag relays, carrier receive relays, aux. Relays, timers etc as per scheme requirements	As required	As required	As required
8.	Under Voltage protection relay for isolator/earth switch	2 Nos	2 Nos	2 Nos
9. .	Cut-out and wiring with TTB for POWERGRID supplied energy meter	1 Set	1 Set	1 Set
10.	Directional Back up Over current and E/F protection scheme	NIL	1 Set	1 Set

In a substation where 220 KV lines are under the scope of the contract, bidder is required to give identical Main-1 and Main-2 distance protection schemes for all voltage levels.

a) BUSCOUPLER PANEL

Sl No.	DESCRIPTION	QTY
1	Bay Control Unit/Bay Control & Protection Unit	1NO.
2	Numerical Non Directional Over Current and Earth Fault Relay 1No.with High Set Feature and in built LBB protection(LBB function as part of BCU is acceptable)	1NO.
3	Master Trip Relay with adequate no of contacts 1 No.and Electrical Resettable type	1NO.
5	CB Troubles and Alarm (Part of BCU)	1 SET
6	Metering (part of BCU)	1 SET

b) 220/132kV TRANSFORMER CONTROl & PROTECTION RELAY PANEL

I. The protection panel for 220/33kV Transformer shall consist of the following equipments.

		220kV Side	33kV
1	Transformer Differential protection scheme	1 no	NIL
2	Restricted Earth fault protection scheme	1 no	1 no
3	Directional back up over current and E/F Relay With non-directional high set feature	1set	Nil
4	Non-Directional back up over current and E/F Relay with non-directional high set feature (Part of 33kV BCU is acceptable)	NIL	1 Set

5	Over fluxing protection scheme	Nil	1No.
6	Over load protection scheme	1No.	Nil
7	Three phase trip relays	2No.	2No.
8	Trip supervision relay	2No.	2No.
9	Scheme requirements including transformer Alarms and trip function	Lot	Lot
10	Disturbance Recorder	1No.	-------
11	Revenue Energymeter (As per T.S. Chapter-1)	1No.	1No.

$ BCU for 220kV Bay has been included in the BOQ details of SAS.

c) 33kV BREAKER RELAY PANEL
(Part of Line /transformer Relay panel)

The breaker relay panel for 33kV shall comprise of the following :

	Without A/R
1. DC supply supervision relay	2 no.
2.Trip circuit supervision relays	2 nos.
3. Emergency CB TNC Switches	1 No.
4. Flag relays, aux. relays, timers, trip relays etc. As per scheme requirements. (Acceptable as part of BCU)	Lot

d) <u>TRANSFORMER PROTECTION PANEL (220/132kV)</u>

The protection panel for Auto transformer/Transformer shall consists of the following features/schemes:

S. No.	Description	HV side	MV/LV side
1.	Transformer Differential Protection scheme	1 Nos.	Nil
2.	Restricted Earth fault protection scheme	1 no.	1 no@
	@ Not applicable for auto-transformer		
3.	Directional back up O/C and E/F relay with non directional high set feature	1 set	1 set
4.	Over Fluxing Protection scheme	1 no.	--
5.	Overload protection scheme	1 nos.	NIL
6.	Three phase trip relays	2 nos.	2 nos.
7.	CVT selection relays as per scheme requirement	Lot	Lot
8.	Cut-out and wiring with TTB for energy meter	1 set	1 set
9.	Transformer Neutral Current relay for 1-Phase transformer bank	1 Set	
10.	Flag Relays/Aux. Relays for wiring Transformer auxiliary protection contacts such as Buchholz, Oil Temperature, Winding Temperature, PRV, OLTC Buchholz etc. as per scheme requirements	As required	

e) TRANSFORMER PROTECTION PANEL (132/66kV)

The protection panel for Auto transformer/Transformer shall consists of the following features/schemes:

S. No.	Description	HV side	MV/LV side
11.	Transformer Differential Protection scheme	1 Nos.	Nil
12.	Restricted Earth fault protection scheme	1 no.	1 no@
13.	Directional back up O/C and E/F relay with non directional high set feature	1 set	1 set
14.	Over Fluxing Protection scheme	1 no.	--
15.	Overload protection scheme	1 nos.	NIL
16.	Three phase trip relays	2 nos.	2 nos.
17.	CVT selection relays as per scheme requirement	Lot	Lot
18.	Cut-out and wiring with TTB for energy meter	1 set	1 set
19.	Transformer Neutral Current relay for 1-Phase transformer bank	1 Set	
20.	Flag Relays/Aux. Relays for wiring Transformer auxiliary protection contacts such as Buchholz, Oil Temperature, Winding Temperature, PRV, OLTC Buchholz etc. as per scheme requirements	As required	

132/11kV

S. No.	Description	HV side	MV/LV side
1.	Transformer Differential Protection scheme	1 Nos.	Nil
2.	Restricted Earth fault protection scheme	1 no.	
3.	Directional back up O/C and E/F relay with non directional high set feature	1 set	
4.	Over Fluxing Protection scheme	1 no.	--
5.	Overload protection scheme	1 nos.	NIL
6.	Three phase trip relays	2 nos.	
7.	CVT selection relays as per scheme requirement	Lot	
8.	Cut-out and wiring with TTB for energy meter	1 set	1 set
9.	Transformer Neutral Current relay for 1-Phase transformer bank	1 Set	
10.	Flag Relays/Aux. Relays for wiring Transformer auxiliary protection contacts such as Buchholz, Oil Temperature, Winding Temperature, PRV, OLTC Buchholz etc. as per scheme requirements	As required	

The above protection schemes may be clubbed in Group-I/II as per clause no. 21 of technical specification.

f) **<u>REACTOR PROTECTION PANEL (220kV & 132kV)</u>**

The protection panel for Reactor shall consist of the following protection features/schemes:

Sl. No.	Description	Qty.
1.	Reactor Differential Protection scheme	1 no.
2.	Restricted Earth fault Protection scheme	1 no.
3.	Reactor back up impedance protection scheme	1 set
4.	Three phase trip relays	2 nos.
5.	CVT selection relay as per scheme requirement	Lot
6.	Flag Relays/Aux. Relays for wiring Reactor auxiliary protection contacts such as Buchholz, Oil Temperature, Winding Temperature, PRV etc. as per scheme requirements	As required

g) BREAKER RELAY PANEL (220kV & 132kV&66kV) (Part of the Control and Relay Panel)

The breaker relay panel shall comprise of the following:

Sl. No.	Description	With A/R	Without A/R
1.	Breaker failure Protection Scheme	1 No.	1 No.
2.	DC supply Supervision relay	2 Nos.	2 Nos.
3.	Trip Circuit supervision relays#	6 Nos.	6 Nos.
4.	Auto-reclose scheme (if standalone)	1 Nos.	NIL
5.	Flag relays, aux relays, timers, trip relays as per scheme requirements	As required	As required

Trip supervision relays shall be 2 or 6 numbers as per no. of trip coils for each 132KV Circuit breaker

Note: Equipment/relays to be provided under CB Relay Panel shall be accommodated in the Protection Panels to be provided for Transmission Line/Transformer/Reactor as applicable.

34. ERECTION AND MAINTENANCE TOOL EQUIPMENTS

All special testing equipment required for the installation and maintenance of the apparatus, instruments devices shall be furnished in relevant schedule

35. TROPICALISATION

Control room will be normally air-cooled/air- conditioned. All equipments shall however be suitable for installation in a tropical monsoon area having hot, humid climate and dry and dusty seasons with ambient conditions specified in the specification. All control wiring, equipment and accessories shall be protected against fungus growth, condensation, vermin and other harmful effects due to tropical environment.

Test programme for distance relays

General Comments:

1. These test cases are evolved from the report of working group 04 of study committee 34 (Protection) on evaluation of characteristics and performance of power system protection relays and protective systems. For any further guidelines required for carrying out the tests, reference may be made to the above document.
2. The test shall be carried out using network configuration and system parameters as shown in the figure-1
3. All denotations regarding fault location, breakers etc are referred in figure –1
4. The fault inception angles are referred to R- N voltage for all types of faults
5. The fault inception angle is zero degree unless otherwise specified
6. Where not stated specifically, the fault resistance (Rf) shall be zero or minimum as possible in simulator
7. Single pole circuit breakers are to be used
8. The power flow in double source test is 500 MW

System parameters

System voltage =400KV

CTR= 1000/1

PTR = 400000/110 (with CVT, the parameters of CVT model are shown in figure –2)

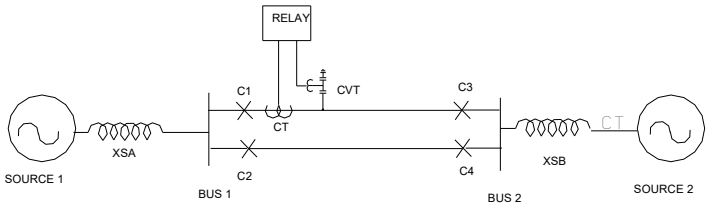

FIGURE 1

Line parameters/km

Positive Sequence Resistance, (r1)	= 0. 02897 Ω
Positive Sequence Reactance (x1)	= 0.3072 Ω
Zero Sequence Resistance (r0)	= 0.2597 Ω
Zero Sequence Reactance (x1)	= 1.0223 Ω

Zero Sequence Mutual Resistance (rm) = 0.2281 Ω
Zero Sequence Mutual Reactance (xm) = 0.6221 Ω
Zero Sequence succeptance (bo) = 2.347 µ mho
Positive Sequence succeptance (b1) =3.630 µ mho

Type of line	Short		Long
Secondary line impedance	2 Ω		20 Ω*
Length of line in Kms	23.57		235.7
SIR	4	15	4
Source impedance (pry) (at a time constant of 50 ms)	29.09 Ω (5500 MVA)	109.09 Ω (1467 MVA)	290.9 Ω (550 MVA)

* Alternatively , the tests can be done with 10 Ω secondary impedance and source impedance may accordingly be modified

CVT Model

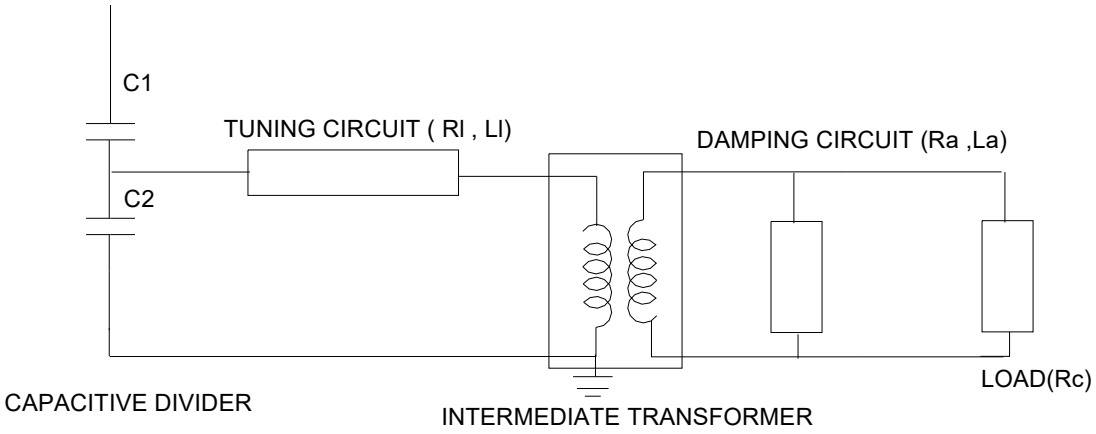

Figure-2

XC1	1.455 µ mho
XC2	27.646 µ mho
Rl	320 Ω
XLl	34243 Ω
Ra	4.200 Ω
Xla	197.92 Ω

Rc	14.00 Ω
Transformation ratio of Intermediate transformer	181.8

Details of fault cases to be done

Sl no	Description	Single source with short line (2 Ω)		Single source long line (20 Ω)	Double source with short double line (2 Ω)	Double source with long single line (20 Ω)
		CLOSE C1, OPEN C2,C3,C4		CLOSE C1, OPEN C2,C3,C4	CLOSE C1, C2,C3,C4	CLOSE C1,C3 OPEN C2,C4
		SIR=4	SIR=15	SIR =4	SIR = 4	SIR=4
1	Dynamic accuracy for zone 1	Tests to be done at 2 locations (84 % and 76 % of line length) X 4 faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°, 90°)= 16 cases	Tests to be done at 2 locations (84 % and 76 % of line length) X 4 faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°,90°)= 16 cases	Tests to be done at 2 locations (84 % and 76 % of line length) X 4 faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°,90°)= 16 cases		Tests to be done at 2 locations (84% and 76% of line length) X 4 faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°, 90°)= 16 cases
2	Operating time for zone 1 at SIR =4	Tests to be done at 3 locations (0% , 40% and 64% of line length) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°, 30°,60° and 90°) = 48 cases	Tests to be done at 3 locations (0 % , 40 % and 64 % of line length) X 4 faults (RN , YB, YBN, RYB) X 4 fault inception angle (0°,30°,60°and 90°)= 48 cases	Tests to be done at 3 locations (0 % , 40 % and 64 % of line length) X 4 faults (RN , YB, YBN, RYB) X 4 fault inception angle (0°, 30°,60° and 90°)= 48 cases	Tests to be done at 1 location (40 % of line length) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°,30°,60° and 90 °)= 16 cases	Tests to be done at 1 location (40 % of line length) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°,30°,60° and 90°)= 16cases

Sl no	Description	Single source with short line (2 Ω)		Single source long line (20 Ω)	Double source with short double line (2 Ω)	Double source with long single line (20 Ω)
3	Operating time for zone II and Zone III	Tests to be done at 1 location (100 % of line length) X 1 faults (RN, YB, YBN, RYB) X 2 zones (II and III) = 2 cases	Tests to be done at 1 location (100 % of line length) X 1 faults (RN , YB, YBN, RYB) X 2 zones (II and III) = 2 cases	Tests to be done at 1 location (100 % of line length) X 1 faults (RN , YB, YBN, RYB) X 2 Zones (II and III) = 2 cases		
4	Switch on to fault feature			Tests to be done at 2 location (0 % and 32 %) X 1 faults (RYB) Any fault inception angle = 2 cases		
5	Operation during current reversal				Tests to be done at 2 location (0 % and 80 % of line length) X 1 faults (RN) X 1 fault inception angle (0 degrees) = 2 cases	
		CLOSE C1, OPEN C2,C3,C4		CLOSE C1, OPEN C2,C3,C4	CLOSE C1, C2,C3,C4	CLOSE C1,C3 OPEN C2,C4
		SIR=4	SIR=15	SIR =4	SIR = 4	SIR=4
6	Operation at simultaneous faults				Tests to be done at 2 location (8 % and 64 % of line length) X 2 faults (	

Sl no	Description	Single source with short line (2 Ω)		Single source long line (20 Ω)	Double source with short double line (2 Ω)	Double source with long single line (20 Ω)
					RN in circuit 1 to BN in circuit 2 and RN in circuit 1 to RYN in circuit 2 in 10 ms) X 1 fault inception angle (0 °) = 4 cases (*1)	
7	Directional sensitivity					Tests to be done at 1 location (0% reverse) X 6 faults (RN ,YB, YBN , RYB,RN with Rf=13.75 ohm(sec) and RYN with Rf= 13.75 Ohm (sec) X 2 fault inception angle (0° ,90°) = 12cases
8	Limit for fault resistance					Tests to be done at 2 location (0% and 68 % of line length) X 1 fault (RN with Rf=13.75 ohm(sec) X 2 fault inception angle (0°,90°) = 4 cases
9	Operation at evolving faults					Tests to be done at 2 location (32 % and 0% of line length) X 2 faults (RN to RYN) x in 2

Sl no	Description	Single source with short line (2 Ω)		Single source long line (20 Ω)	Double source with short double line (2 Ω)	Double source with long single line (20 Ω)
						timings (10 ms and 30 ms) X 2 load direction (from A to B and from B to A) = 16 cases
9	Fault locator function , in case the same is offered as built in feature	Measure fault location for all cases under 1 and 2	Measure fault location for all cases under 1 and 2	Measure fault location for all cases under 1 and 2	Measure fault location for all cases under 2 and 6	Measure fault location for all cases under 2, 7 and 9

CHAPTER 16: PLCC

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CHAPTER 16: PLCC

1. GENERAL

1.1 All the PLCC equipment covered under the package shall conform to the requirements of the latest edition of the relevant IEC Specifications or equivalent National Standards,

2. Standard and Drawing

2.1 The IEC Specifications and international publication relevant to the equipment covered under this specification shall include but not be limited to the list given at Annexure - 'C' of Chapter 2 - GTR:

3. Location of Equipment

3.1 The PLCC Equipment and Line traps as specified shall be installed at the respective ends of the transmission lines. The Contractor shall be responsible for coordinating the equipment supplied by him with the already existing carrier equipment at the respective sub-stations. Contractor shall also be responsible for collecting all the necessary information/data from the respective sub-stations/concerned Electricity Authority for the installation of the equipment.

4. Frequency Planning

4.1 For planning frequency and output power of carrier terminals Bidders may plan for a minimum receive signal to noise ratio of 25 dB for the speech channels without companders. The noise power in 2.1 kHz band (300-2400 Hz) may be taken as -13 dBm referred to the coupling point of the H.T. line. An additional minus two and a half dB may be assumed for psophometric factor. As far as coupling loss (phase to phase) is concerned the Bidders may assume the same as 6dB at one coupling end for evaluating SNR. For protection channels the minimum SNR shall not be less than 15 dB under adverse weather. A safety margin of 9 dB shall be taken over and above these SNR values in order to cater for variations in line attenuation from the computed value as inhand reserve. Frequency and output power of PLC terminals for protection shall be planned such that the protection signal is received with full reliability even when one of the phase is earthed or is on open circuit on the line side causing an additional minimum loss of 6 dB.

The Bidder shall indicate the noise power in the bandwidth used for protection signaling and shall submit the SNR calculations for speech as well as protection channels on all the line section given in at the proposed frequencies. Sample calculations for SNR requirement and power allocation over different channels

must be furnished alongwith the bid. Maximum permissible line attenuation shall be clearly brought out in these calculations. Further, Bidder shall submit details of frequency planning done (including computer studies carried out and facilities available) for PLCC links on EHV lines in the past in the relevant schedule of DRS. Bidder must enclose one copy of computer study result done in the past along with the Bid.

4.2 Successful Bidder shall be fully responsible for the coordination required with concerned Office of NEA for finalising the frequency plan.

4.3 The frequency plan will be referred to concerned Department for clearance and in case any change in the Contractor's recommended carrier frequency and power output is proposed by these authorities, the Contractor shall have to modify his proposal accordingly. Change of power output shall, however, not involve repeater stations.

5. Proposed Arrangement

5.1 The power line carrier communication equipment required by the OWNER is to provide primarily efficient, secure and reliable information link for carrier aided distance protection and direct tripping of remote-end breaker and also for speech communication between 220 kV sub-stations. It shall include separate carrier terminals of multipurpose type for speech and protection purposes. All carrier terminals including those for protection shall be suitable for point to point speech communication also.

5.2 For security reasons each 220kV transmission line shall be protected by Main-I and Main-II protections as given below :

Main-I Numerical Distance protection with permissive inter-tripping.

Main-II Distance protection of a different measuring technique than that of relay under Main I.

132kV transmission lines shall have Main I protection same as above alongwith backup overcurrent and earth fault protections.

5.3 The requirement of carrier information on each link covered under this specification is as below :

a) In case of 220 KV/132 KV lines, speech and data channel can also be used for protection wherever possible.

b) One speech channel with a facility to superimpose data signals upto 1200Baud.

However, the number of channels for protection signaling , speech and data communication for SAS and Load dispatch centre shall be as per the BOQ given in price schedule.

5.4 The equipment for protection signals shall have high degree of reliability and speed. It shall be guaranteed to function reliably in the presence of noise impulse caused by isolator or breaker operation. It shall also be possible to effect direct tripping of breaker at one end when the other end breaker opens out either manually or by relays such as Bus fault relay etc.

5.5 The time intervals between receipt of a trip command on the transmit side, its transmission over the carrier link, reception at the far end and giving command to the trip relays at the distant end shall not exceed 20 mS. for permissive inter-tripping and 30 m sec. for direct inter-tripping even for the longest line section. The above timings are inclusive of operating time for auxiliary relays and interposing relays, if any, included in the PLCC equipment.

5.6 The requirement of protection signaling channel is such that security against incorrect signals being received shall be at least two to three orders higher than reliability against a signal not being received.

5.7 For reasons of security and reliability, phase to phase coupling for 220kV S/C lines shall be employed. Inter-circuit coupling shall be used for 220/132kV D/C lines and phase to ground coupling shall be used for 132 KV S/C lines. Double differential coupling shall also be considered for double circuit lines. Bidders must furnish detailed write-up on methods of coupling and recommend suitable coupling mode for double-circuit lines along-with the bids. The coupling arrangement shall be fully optimized by the Contractor after conducting detailed study of every line section individually, taking into account the temperature variations, transpositions, earth resistivity, conductor configuration, carrier channels requirements, security and reliability criteria and other relevant details. The line attenuation shall be calculated for complete range of frequencies. The earth resistivity data, existing frequency networks and other relevant details of each line will be furnished to the Contractor for carrying out the computer studies and frequency planning. The Contractor shall complete the computer studies wherever required and submit the frequency plan and optimum coupling details within a period of one month from the date of receipt of above data.

5.8 The Contractor shall have to check and prove through the results of his computer studies that attenuation due to transpositions in the EHV lines is within limits and the offered equipment will perform satisfactorily.

5.9 The Bidder shall submit curves illustrating ‘incorrect tripping’ and “Failure to trip” probability plotted against corona noise level, in the presence of impulse noise due to switching of isolator and circuit breaker etc. Details of field tests and laboratory tests for successful operation of his equipment, under such adverse conditions shall be furnished by the Bidder. These are to be related to end-to-end signaling and shall take into account the type of communication link e.g. account shall be taken of transpositions in the phase to phase coupled H.T. line. Details of field tests and laboratory tests for successful operation of

the equipment under the above circumstances shall be submitted by the Bidder illustrating the above parameters.

6. LINE TRAP

6.1 Line trap shall be broad band tuned for its entire carrier frequency range. Resistive component of impedance of the line trap within its carrier frequency blocking range shall not be less than 570 ohms for 220kV and 132 kV systems..

6.2 Line trap shall be provided with a protective device in the form of surge arrestors which shall be designed and arranged such that neither significant alteration in its protective function nor physical damage shall result from either temperature rise or the magnetic field of the main coil at continuous rated current or rated short time current. The protective device shall neither enter into operation nor remain in operation, following transient actuation by the power frequency voltage developed across the line trap by the rated short time current.

The lightning arrestor shall be station class current limiting active gap type. Its rated discharge current shall be 10 kA. Coordination, however, shall be done by taking 20 kA at 8/20 micro-sec. discharge current into account. Bidder has to furnish full justification in case the use of gap-less metal oxide arrestor is recommended by them.

6.3 The lightning arrestor provided with the line trap of each rating shall fully comply with the requirements of IEC-60099-I Part-I. It shall conform to type tests as applicable and type test certificate for the same shall be submitted by the Bidder.

6.4 The lightning arrestor provided with the line trap shall be subject to routine and acceptance tests as per IEC-60099-1 (Part-I).

6.5 Radio interference voltage for 245/132 kV shall not exceed 500 micro volts at 163/97 kV (rms) respectively.

6.6 Line trap shall be equipped with the bird barriers.

6.7 Line trap shall conform to IEC 60353 (latest) fulfilling all the technical requirements. The rated short time current for 1 Second shall be 31.5/40/50/63 kA as per requirement. The mH. rating shall be 0.2/0.5/1.0 mH depending on frequency plan.

6.8 The Bidder shall indicate continuous current rating of the line trap at 65 deg. C ambient.

6.9 Reports for the following type tests on each type of line trap shall be submitted as per clause 9.2 of GTR .

1. Measurement of Inductance of the main coil.

2. Measurement of temperature rise.
3. Insulation test.
4. Short time current test.
5. Corona Extinction Voltage test (procedure for this shall be mutually agreed).
6. Radio Interference Voltage measurement test (procedure for this shall be mutually agreed).

6.10 The Bidder must enclose with his bid the reports of type and routine tests conducted on similar equipment earlier as per IEC-60353.

6.11 Welding

All the welding included in the manufacture of line traps shall be performed by personnel and procedure qualified in accordance with ASME-IX/IEC Standard and all the critical welds shall be subject to NDT as applicable.

6.12 Line Trap Mounting

6.12.1 The Line Trap shall be suitable for outdoor pedestal or suspension mounting and shall be mechanically strong enough to withstand the stresses due to maximum wind pressure of 260 kg/square meter.

6.12.2 For pedestal mounting, each line trap shall be mounted on a tripod structure formed by three insulator stacks arranged in a triangular form. All the accessories and hardware, mounting stool including bolts for fixing the line trap on insulators shall be of non-magnetic material and shall be supplied by the Contractor.

6.12.3 For suspension mounting, Contractor shall be required to coordinate the mounting arrangement with the existing arrangement. Non-magnetic suspension hook/link of adequate length and tensile strength to provide necessary magnetic clearance between the line trap and suspension hardware shall be supplied by the Contractor.

6.13 Terminal Connectors

6.13.1 The line traps shall be suitable for connecting to 4" IPS Aluminium tube or 3" IPS Al. tube or ACSR single/twin/Quad bundle conductor with horizontal or vertical take off. Necessary connector shall be supplied by the Contractor.

6.13.2 No part of clamp or connector (including hardware) shall be of magnetic material.

6.13.3 Clamps and connectors shall be designed corona controlled. All nuts and bolts shall be suitably shrouded.

6.13.4 Radio interference Voltage for 245/132 kV shall not exceed 500 microvolts at 163/97 kV (rms) respectively.

6.13.5 Clamps/connectors shall be designed for the same current ratings as line trap and temperature rise shall not exceed 35 deg. C over 50 deg. C ambient. No current carrying part shall be less than 10 mm thick.

6.13.6 Clamps/connectors type Test reports shall also be submitted for following:

a) Visual Corona Extinction Test
b) Radio Interference Voltage Measurement

6.13.7 Bidders are required to submit alongwith their bid typical drawings clearly indicating the above mentioned features of the line traps, line trap mounting arrangement and terminal connectors. For suspension mounted line traps, Bidder shall submit drawings showing single point as well as multipoint (normally 3 point) suspension arrangements.

7. COUPLING DEVICE

7.1 The coupling devices shall be interposed between the capacitor voltage transformer and coaxial line to the PLC transmitter/receiver, and in conjunction with the capacitor voltage transformer shall ensure :

a) Efficient transmission of carrier frequency signals between the carrier frequency connection and the power line.

b) Safety of personnel and protection of the low voltage parts and installation, against the effects of power frequency voltage and transient over voltages.

7.2 The coupling device, in conjunction with the CVT shall from an electric filter of band pass type :

a) It shall match characteristic impedance of H.T. line to impedance of the carrier frequency connection.

b) Galvanic isolation between primary and secondary terminals of the coupling device shall be performed by the above mentioned transformer.

c) Power frequency currents derived by the CVT may be drained to the earth by a separate inductance termed drain coil of suitable rating.

d) Voltage surges coming from the power line at the terminals of the coupling device shall be limited by a non-linear surge arrestor of suitable rating in the primary side. Requirement of a gas type voltage arrestor in secondary side of the coupling device shall have to be fully

justified, but in any case the input circuit of PLC. equipment shall have protective devices in the form of zener diodes and surge suppressers.

The surge arrester shall have power frequency spark over voltage coordinated with the equipment ahead of it.

e) For direct and efficient earthing of its primary terminals, the coupling device shall be equipped with an earthing switch. The Earth Switch shall be available for earthing of CVT-HT terminals, when the coupling filter units are removed from circuit for maintenance/ replacement. The design shall take due regard of requirements for safety in accordance with the Electricity Rules of Nepal.

7.3 Two numbers 'phase to earth' type coupling filters shall be used to achieve 'phase to phase'/ 'inter-circuit coupling'. Connection between secondaries of the two phase to earth type coupling device shall be through a balancing transformer/hybrid such that reliable communication shall be ensured even when one of the coupled phase is earthed or open circuited on the line side.

7.4 Coupling device shall conform to IEC-60481 and shall have the following carrier frequency characteristics as applicable to a phase to earth type coupling device:

a)	Nominal line side impedance	400 ohms for 220/132 kV line
b)	Nominal equipment side impedance	75 ohms (unbalanced)
c)	Composite loss	Not more than 2 dB
d)	Return Loss	Not less than 12 dB
e)	Bandwidth	Shall suit the frequency plan between 36 and 500 kHz
f)	Nominal peak envelope power (for Inter-modulation product 80 dB down)	Not less than 650 Watt.

7.5 The coupling device shall be suitable for outdoor mounting. Temperature of metallic equipment mounted outdoor is expected to rise upto 65 deg. C during the maximum ambient temperature of 50 deg. C specified. The equipment offered by the Bidder shall operate satisfactorily under these conditions.

7.6 The H.T. Terminal of coupling device shall be connected to H.F. Terminal of the CVT by means of 6 mm sq. copper wire with suitable lugs & taped with 11 kV insulation by the contractor.

7.7 Coupling device shall have at least two terminals for carrier equipment connection. Bidder shall confirm that such a parallel connection to coupling device directly will not result in any additional attenuation.

7.8 The coupling device including the drainage coil, surge arrester and earthing switch shall conform to type tests and shall be subject to routine tests as per IEC-60481.

Routine tests shall include but not be limited to the following :

i) Composite loss and return loss tests on coupling device.

ii) Turns ratio test and insulation tests on the balancing transformer.

iii) Milli volt drop test, power frequency voltage test and mechanical operation test on earthing switch.

iv) Power frequency spark over test for lightning arrester as per relevant IEC.

7.9 Reports for the following type tests on coupling device shall be submitted as per clause 9.2 of GTR .

1.)Return loss test.

2)Composite loss test.

3)Distortion and inter modulation test .

4)Impulse voltage test.

5)Tests on Arrestors

Bidder shall furnish, alongwith his bid copies of all type and routine test conducted earlier on similar coupling device in accordance with relevant standards.

8. **High Frequency Cable**

8.1 High frequency cable shall connect the coupling device installed in the switchyard to the PLC terminal installed indoor.

8.2 The cable shall be steel armoured and its outer covering shall be protected against attack by termites. Bidder shall offer his comments on method employed by him for earthing of screen and submit full justification for the same with due regard to safety requirements.

Bidder must enclose in his bid a detailed construction drawing of the cable being offered, with mechanical and electrical parameters.

8.3 Impedance of the cable shall be such as to match the impedance of the PLC terminal on one side and to that of the coupling device on the other side over the entire carrier frequency range of 40-500 kHz.

8.4 Conductor resistance of cable shall not exceed 16 ohms per Km at 20°C.

8.5 The cable shall be designed to withstand test voltage of 4 kV between conductor and outer sheath for one minute.

8.6 Bidder shall specify attenuation per Km of the cable at various carrier frequencies in the range of 40 to 500 kHz. The typical attenuation figures for H.F. cable shall be in the range of 1 to 5 dB/km in the frequency range of 40-500 kHz.

8.7 The H.F. cable shall conform to type tests and be subjected to routine tests as per IEC -61196-1/IEC60811-1/IS-11967/IS5026/ International standard.

8.8 All HF cables within the scope of this specification shall be laid and termination shall be carried out by the Contractor.

8.9 The cables shall be supplied wound on drums containing nominal length of 500 meters each. However, exact requirement of drum lengths shall be finalised during detailed engineering to avoid joint in HF cable and its wastage.

9. Power Line Carrier Terminal

9.1 As already indicated the information link shall be provided for speech, protection, telex and data services.

9.2 PLC terminal shall use Amplitude Modulation and shall have single side band transmission mode. These shall be equipped for fixed frequency duplex working.

Characteristic input and output parameters of the SSB PLC terminals shall be as per IEC-60495, unless otherwise specified.

9.3 The salient features are detailed out below :

a)	Mode of transmission	Amplitude Modulation single side band with suppressed carrier or reduced carrier.
b)	Carrier frequency	40 to 500 kHz range
c)	Nominal carrier frequency band in either direction of transmission	4.0 kHz

d)	Power output (PEP) at HF terminal	20/40/80 Watt
e)	Frequency difference between a pair of PLC terminals	Frequency difference between VF signal at the transmitting and receiving ends will not exceed 2 Hz with suppressed carrier. With reduced carrier frequency difference shall be zero. This shall include permissible ambient temperature variation and supply frequency and voltage variation of (+) 15% and (-) 10%.
f)	Automatic gain control	For 40 dB change in carrier frequency signal level within the regulation range, change in VF receive levels of both speech and other signals shall be less than 1dB.
g)	Supply voltage	48 V DC + 15%, - 10%. (Positive pole earthed)

9.4 All the PLC terminals shall be of multipurpose type. The Bidder shall confirm that the total transmission time for teleprotection shall not exceed 20 ms for permissive and 30 ms for direct tripping signals. Speech and teleprotection channels shall independently fulfill the SNR requirements out of the power allocated to its channel from the total power of the PLC terminals.

Detailed calculation for SNR requirement and power allocation over different channels should be furnished alongwith the bid.

9.5 In the input circuit of the PLC terminal protective devices shall be provided in the form of zener diodes or surge suppressers in order to eliminate any surge transfer through the coupling device or the surge induced in the connecting path of H.F. cable.

9.6 To improve voice transmission characteristics for the system, compressors and expanders shall be provided. The companders shall have at least 2:1 compression ratio with a corresponding expansion ratio of 1:2. The operating range of compander shall be compatible with the audio power levels specified for 4 wire operation. The improvement gained by companders shall however not be taken into account for power allocation and shall be in-hand reserve.

9.7 Sudden changes in input level to the receiver shall not cause false tripping. The Bidder shall clearly indicate in his offer the methods adopted to ensure above phenomenon. The receiver design shall also provide protection against false tripping from random noise.

9.8 Fail-safe devices shall be provided, so that a malfunction in one unit or subassembly cannot cause damage elsewhere in the system. All plug-in

equipment shall be fitted with features to prevent improper insertion. The electrical cables shall not be routed across sharp edges or near sources of high temperature. The adjustments, which are susceptible to misadjustment from accidental contact/vibration, shall be equipped with suitable locking devices.

9.9 The PLC set shall be designed to give guaranteed performance from 0 deg. C to 50 deg. C ambient temperature. The thermal capability of the equipment shall be so designed that the equipment remains operational successfully upto 60 deg. C ambient temperature. Any ventilation fans provided for circulation of air inside the cabinets shall conform to relevant Nepalese/International Standards..

9.10 The terminals shall be provided with built-in indicating instrument to facilitate checking of important voltages and current values and signal levels in different parts of the PLC Terminals. Protection fuses shall be provided in all important circuits and fuses shall be so mounted as allow their easy inspection and replacement. All test points shall be easily accessible.

The carrier set shall be provided with suitable supervision and alarm facilities. Individual parts of the carrier set should be accessible from front, making it possible to place the carrier cabinets side-by-side. All components and parts of the carrier set shall be suitably tropicalised.

9.11 PLC terminals shall be housed in floor mounting sheet metal cabinets, suitable for mounting on concrete plinth as well as channel frame by means of nuts and bolts or welding. All the panels shall be properly earthed to the OWNER's earthing grid by the Contractor. Contractor shall submit detailed drawings for earthing connections.

9.12 All the panels shall be protected against moisture ingress and corrosion during storage. Panels shall be properly dried before they are installed and energized. Bidder shall indicate measures adopted to prevent ingress of moisture during operation.

9.13 All cabinets having PLC terminals shall be provided with lamps of sufficient wattage for interior illumination with switch. Each panel shall be provided with 230 V AC single phase socket with switch to accept 5 & 15A Nepalese standard /International plugs.

9.14 A name plate shall be provided on the front door of each cabinet indicating channel function, transmitter frequency and direction etc.

9.15 Reports for the following type tests for PLC Terminals shall be submitted as per
clause 9.2 of GTR .
Tests to determine various characteristics of PLC terminals as per IEC –60495.

a)Voltage variation

b)Carrier frequency range band.

c)Frequency accuracy

d)Transmit/Receive frequency difference.

e)Automatic gain control

f)Harmonic distortion

g) Selectivity

h)Output impedence, Return loss&Tapping loss

i)Return loss, Af inputs/Outputs

j)Balance to ground

k)Limiter action

l)Spurious emission

m)Carrier frequency levels and levels

n)Attenuation distortion

o)Noise generated within terminal

p)Near and far end cross talk

q)Group delay distortion

r)Conducted noise

s)Telephone signaling channel

t)Speech levels

u)Voltage withstand test

v)Insulation test

9.16 Heat Soaking of panels

All the solid state equipment/system panels shall be subjected to the Heat Soaking as per the following procedure :

All solid state equipment shall be burn-in for minimum of 120 hours continuously under operation condition. During the last 48 hours of testing, the ambient temperature of the test chamber shall be 50°C. Each PLC panel shall be complete with all associated sub-systems and the same shall be in operation during the above test. During the last 48 hours of the above test, the

temperature inside the panel shall be monitored with all the doors closed. The temperature of the panel interior shall not exceed 65°C.

10. SPEECH COMMUNICATION

10.1 PLC equipment offered shall provide telephone communication between the stations where the transmission lines are terminating. The equipment shall be suitable for providing the following facilities :

a) It shall be possible for subscriber at any of the stations to contact the subscriber at all other stations connected in the system as shown in the specification drawing by dialing his call number. To achieve this a EPAX with 4 wire interface & remote subscriber units shall be provided/available at different stations.

b) The equipment shall contain all normal facilities like ring back tone, dial tone, engage tone & priority tone, and suitable pulses to establish and disconnect communication between subscribers.

c) The equipment shall be provided with necessary alarm circuits and fuses etc.

d) The equipment shall be of 4 kHz bandwidth on either direction and be suitable for providing superimposed data and teleprinter facilities at a later date without major modifications and high cost. The Bidder shall clearly indicate in his bid the provision made in his proposal for future development and the extent to which such additional facilities can be added at a later date.

e) The system shall be completely automatic with definite number allocated for each telephone. The numbering scheme for telephones, exchange and tie lines shall be developed by the Bidder and indicated in the bid. Final numbering scheme shall be fully coordinated with the existing/ proposed future systems by the Contractor.

f) Arrangement for over-riding facilities shall be provided by means of priority keys wherever specified. The over-riding facility shall enable cutting-in ongoing calls with the priority key and ask the concerned parties to finish their conversation. The wanted number should then get automatically connected without having to redial the number.

g) All the carrier telephone conversations shall be secret and it should not be possible for anybody to over hear the conversation going on between any two parties excepting those provided with over-riding facilities.

h) The necessary cables for connecting all the telephone instruments ordered for at each sub-station (including wiring and termination) shall be provided by the Contractor. These telephone instruments shall be located within control room building at respective sub-station.

i) The cabinets housing the equipment for EPAX, four wire E/M interface & remote subscriber units (four wire) shall have mounting arrangement similar to that for PLC terminals.

j) All the terminals for speech shall be with Transit Band Pass Filter suitable for tuning at site and shall be wired for addition of VFTs in future.

k) Equipment for speech communication must be fully compatible with OWNER's existing equipment. Any interfaces required for proper matching and connection with the OWNER's existing equipment shall be provided by the Contractor.

l) Terminals for protection shall be suitable for speech between two ends of each transmission line or on tandem operation basis with back to back connection at the intermediate stations.

n) Each PLC terminal for speech as well as protection purposes shall be provided with a plug-in type service telephone and buzzer. Further, 4 wire remote telephone instruments (parallel to service telephone) shall also be provided on one PLC terminal for protection for each link. These instruments shall be located in respective Switchyard control room to enable the operator to make emergency calls on point-to-point basis. Each such instrument shall be equipped with a buzzer and 'press-to-call' key and shall not require any additional power supply units.

10.2 Remote End Four Wire 'E/M' Interface & Subscriber Unit

10.2.1 The remote end four wire 'E/M' interface & subscriber units, wherever specified, shall be of electronic type and be suitable for working on fixed frequency power line carrier systems with E & M signaling. This shall be housed in the carrier set and be fully wired to the power line carrier terminal equipment.

10.2.2 This unit shall receive and register various signals, on PLCC Channels, from remote end exchanges or other remote end subscriber units and associated four wire interface unit.

10.2.3 The four wire interface unit shall be equipped for routing transit calls and shall be supplied pre-wired to handle calls for minimum eight directions, in a form suitable for transmission over PLCC.

10.2.4 The bidder shall also indicate the total number of trunk-line capacity, available with each four-wire interface unit.

The unit shall be suitable for connecting two-wire telephone sets. Further, the associated telephone cables for locating two subscriber lines, within the control room is in the scope of this specification.

10.3 **Network Protection Equipment (Protection Coupler)**

10.3.1 The Bidder shall offer voice frequency transmission equipment which shall work on frequency shift or coded signal principle for transmission/reception of protection signals as single purpose channel. The equipment shall be suitable for connection to the power line carrier terminal.

10.3.2 The voice frequency transmission equipment shall not only be insensitive to corona noise but shall also remain unaffected by impulse type noise which are generated by electrical discharge and by the opening and closing of circuit breakers, isolators, earthing switches etc. The equipment shall also be made immune to a field strength of 10V/m expected to be caused by portable radio transmitters in the range of 20-1000 MHz. In his offer, bidder shall clearly explain as to what measures have been taken to make the equipment insensitive to corona noise, white noise and to impulse noise of an amplitude larger than the wanted signal and submit full field test and laboratory test reports. The guarantee on design data shall not be acceptable.

10.3.3 The equipment shall be unaffected by spurious tripping signals. The Bidder shall submit proof as to how this is achieved satisfactorily.

10.3.4 The equipment shall be suitable for transmission of direct and permissive trip signal as well as blocking signals for protective gear of power system. The equipment shall be operated in the audio frequency range in speech band or above speech band as superimposed channel in 4 kHz band of SSB carrier. The equipment shall operate with full duplex frequency shift mode of operation or by switching between two frequencies in case of coded signals . The protection signaling equipment shall be of solid state design, modular in construction and have a proven operating record in similar application over EHV systems. Details regarding application of the equipment over 220kV systems shall be submitted along with the bid. Each protection signaling equipment shall provide:

i) Transmission facilities for minimum three protection signals.

ii) Reception facilities for minimum three protection signals.

10.3.5 The equipment shall be designed for remote tripping/ blocking on permissive basis and direct tripping for reactor fault and others. The overall time of PLC, VFT and transmission path for permissive trip/blocking shall be 20 m. Sec. or less and for direct tripping 30 m. Sec. or less even for the longest line section.

Operating time lower than specified above may be preferred provided they fulfill the requirements of security and reliability as mentioned below :

False - trip probability (Noise burst of any amplitude) 10^{-5}

Fail to trip probability 10^{-2}

for S/N 6 dB in 3.1 kHz Band
(white Noise Measurement)

10.3.6 It may be emphasized that specified time, as mentioned above is composed of the following :

a) Back-to-back signal delay in frequency shift or coded signals protection equipment.

b) Back-to-back delay in PLC terminal.

c) Delay in transmission line.

d) Operation time of interposing relay, if any, in frequency shift or coding equipment.

Reference is invited in this regard to the guide lines expressed in CIGRE Publication "Teleprotection" report by Committee 34 and 35.

10.3.7 The following transfer criteria shall be provided by the equipment:

a) Transmit side

One number potential free NO (normally open) contact of protective relays (To be supplied by the OWNER) of under noted rating for each of the following functions:

i) Permissive trip command

ii) Direct trip command

Contact Rating:

Maximum voltage	: 660 Volts
Maximum current rating	: 5 amps
Maximum power rating	: 1250 W/VA

b) Receive Side

Voice frequency transmission equipment for network protection shall be provided with one potential free NO (normally open) contact of the under noted rating for each of the following functions:

i) Permissive trip command

ii) Direct trip command

Contact Rating:

Rated voltage : 250 Volts DC

Rated current	:	0.1 A DC
Other Parameters	:	As per IEC-60255-25

c) Alarm

In addition, the voice frequency protection terminal shall provide at least one number potential free change over contact of the following rating for alarm purposes.

Rated voltage	:	250 volts DC
Rated current	:	0.1 A DC
Other Parameters	:	As per IEC-60255-25

10.3.8 The Contractor shall submit drawings showing inter-connection between PLCC and protection panels for approval by the OWNER.

10.3.9 It has to be ensured that under no circumstances protection channel should share the power. Each protection channel shall be able to transmit power for which system is designed. For example, a 40 W PLC terminal shall transmit 40 Watt (max.) for protection channel alone in the event of fault. Speech and super-imposed data channels, in the same protection terminal must get disconnected momentarily during the operation of protection channels.

10.3.10 The equipment shall be constructed such that in permissive line protection system, operational reliability of the protection channel may be checked over the carrier link by means of a loop test. It shall be possible to carry out the above test from either end of the carrier link. During healthy condition of the transmission line, the loop test shall not initiate a tripping command. In the event of a system fault, while loop test is in progress, protection signal shall over-ride the test signal.

10.4.11 The equipment shall be complete with built in counters for counting the number of trip commands sent and number of trip commands received.

10.3.12 Reports for the following tests as per clause 9.2 of GTR shall be submitted for approval for protection coupler and the relays associated with PLCC equipment for network protection signaling equipment and interface unit with protective relay units if any :

1)Protection coupler (As per IEC 60834 -1)

a)Power supply variation

b)Power supply interruption

c)Reflected noise

d)Reverse polarity

e)Interference by discrete frequency

f)Transmission time

g) Interference by frequency deviation. (Wherever applicable)

h)Alarm function

g)Security

h)Dependability

i)Voltage withstand test

j)Insulation test.

j) Electrical fast transient test (along with carrier terminal)

k)HF disturbance test (along with carrier terminal)

l)Electro static discharge test (along with carrier terminal)

m)Radiated electromagnetic field susceptibility test (along with carrier terminal)

n)Environment test (as per IEC 60068)

2. **Relays.**

a) Impulse voltage withstand test as per IEC 60255-4

b) High Frequency Disturbance test as per IEC 610004-4

11. **Mandatory Testing & Maintenance Equipment**

Print testing kit for PLCC terminal, E/M interface & subscriber unit, Protection coupler comprising of following items of reputed make in addition to any other special items required for testing and maintenance of this equipment packed in a carrying brief case:

1. Screw driver set with multi up fixing feature
2. Nose pliers
3. Cutting pliers
4. Ordinary Pliers
5. Adjustable wrench
6. Soldering iron with tip earthed

a) 150 watts - 1 No.

b) 35 Watts - 1 No

c) 10 watts - 1 No.

operated with isolated (step down) transformer having provision for interchangeable taps.

7. Desoldering pump

8. Print extender

9. Print puller

10. Large selection of test leads

11. Solder wire

12. Large selection of plugs, jacks & pistol probes compatible with equipment supplied

13. Dummy load

14. Interface card/print for Tx to Rx loop-back

15. Test oscillator/tone generator with indicating meters - either built in or separate

16. ESD wrist band

17. ESD conducting mat

12. LIST OF COMMISSIONING TESTS

The following tests shall be carried out on complete system/subsystem during commissioning:

1. Composite loss and return loss on coupling device using dummy load.

2. Composite loss (Attenuation) for HF Cable coupling device.

3. End to end attenuation measurement for verification of optimum coupling mode. Test shall be done for all combinations.

4. End to end return loss for optimum coupling mode.

   a. open behind line trap.

   b. grounded behind line trap.

5. If end to end return loss for optimum coupling mode is not satisfactory, same shall be measured for other coupling modes also.

6. Adjustment of Tx/Rx levels on PLCC equipment as per test schedule.

7. AF frequency response (end to end) for the entire 4 kHz Bandwidth for speech and teleoperation channels.

8. Measurement of noise in 2 kHZ bandwidth with and without line energised.

9. SNR (test-one) with line energised noting down weather conditions.

10. Transmission time for teleprotection and other data channels.

11. Observation of Tx/Rx levels (test-tone) for each channel at both ends by sequential switching on/off parallel channels using dummy load and also with the transmission line.

12. Observation of end to end and trunk dialing performance.

13. Observation of end-to-end protection signaling (command sent & received) in conjunction with protective relays, noting down transmission/receipt of unwanted commands under switching operations in the switchyard during protective relay testing.

Notes

1. All measurements for link attenuation, composite loss and return loss shall be carried out for the entire range of carrier frequencies with specific attention to the frequencies.

   i. within coupling device bandwidth.

   ii. within line trap bandwidth, and

   iii. operating frequencies.

2 Following tests shall be carried out independently at each and

   i. Composite loss & return loss for coupling device.

   ii. Attenuation test for HF cable + coupling device.

   iii. Levels and other local adjustments (on dummy load).
   Final adjustment shall be on end to end basis.

   iv. Test for loading by parallel channels with dummy load.
   This test can be done alongwith tests for coupling device.

v. Protection signaling under local loop test (dummy load).

3. Necessary test instruments required for all the above tests shall be brought by commissioning engineers of the contractor.

CHAPTER 17: SUBSTATION AUTOMATION SYSTEM

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CHAPTER 17: 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.

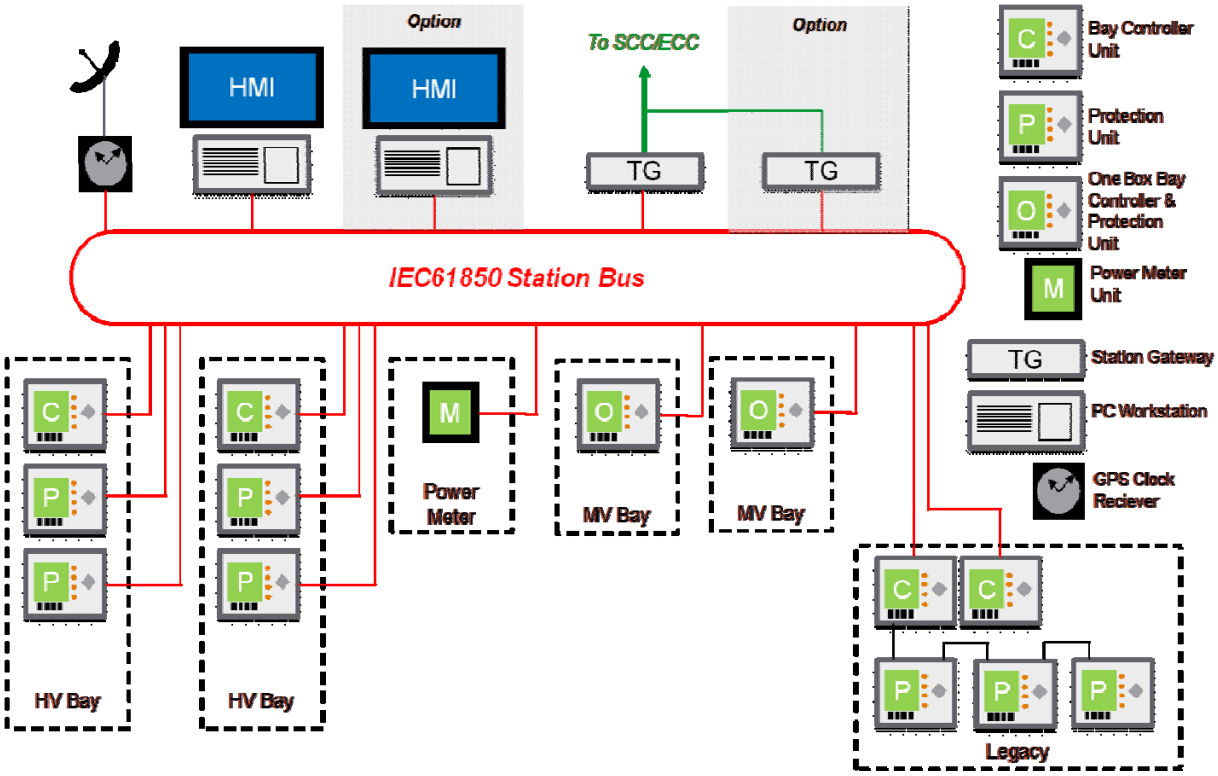
The station level contains the station-oriented functions, which cannot be realised at bay level, e.g. alarm list or event list related to the entire substation, gateway for the communication with remote control centres.

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.

2.3 FUNCTIONAL REQUIREMENTS

The high-voltage apparatus within the station shall be operated from different places:

- Remote control centres
- Station HMI.
- Local Bay controller IED (in the bays)

Operation shall be possible by only one operator at a time.

The operation shall depend on the conditions of other functions, such as interlocking, synchro-check, etc. (see description in"Bay level control functions").

2.3.1 Select-before-execute

For security reasons the command is always to be given in two stages: selection of the object and command for operation under all mode of operation except emergency operation. Final execution shall take place only when selection and command are actuated.

2.3.2 Command supervision

Bay/station interlocking and blocking

Software Interlocking is to be provided to ensure that inadvertent incorrect operation of switchgear causing damage and accidents in case of false operation does not take place.

In addition to software interlocking hardwired interlocking are to be provided for:

(a) Bus Earth switch Interlocking

(b) Transfer Bus interlocking (if applicable)

It shall be a simple layout, easy to test and simple to handle when upgrading the station with future bays. For software interlocking the bidder shall describe the scenario while an IED of another bay is switched off or fails.

A software interlock override function shall be provided which can be enabled to bypass the interlocking function.

2.3.3 Run Time Command cancellation

Command execution timer (configurable) must be available for each control level connection. If the control action is not completed within a specified time, the command should get cancelled.

2.3.4 Self-supervision

Continuous self-supervision function with self-diagnostic feature shall be included.

2.3.5 User configuration

The monitoring, controlling and configuration of all input and output logical signals and binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely.

It shall also be possible to interconnect and derive input and output signals, logic functions, using built-In functions, complex voltage and currents, additional logics (AND-gates, OR gates and timers). (Multi-activation of these additional functions should be possible).

The Functional requirement shall be divided into following levels:

a. Bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer) Level Functions

b. System Level Functions

3.1. Bay level functions

In a decentralized architecture the functionality shall be as close to the process as possible. In this respect, the following functions can be allocated at bay level:

- Bay control functions including data collection functionality in bay control/protection unit.
- Bay protection functions

Separate IEDs shall be provided for bay control function and bay protection function.

3.1.1. Bay control functions

3.1.1.1. Overview

Functions

- Control mode selection
- Select-before-execute principle
- Command supervision:
  - Interlocking and blocking
  - Double command
- Synchrocheck, voltage selection
- Run Time Command cancellation
- Transformer tap changer control (Raise and lower of tap) (for power transformer bays)
- Operation counters for circuit breakers and pumps
- Hydraulic pump/ Air compressor runtime supervision
- Operating pressure supervision through digital contacts only
- Breaker position indication per phase
- Alarm annunciation
- Measurement display
- Local HMI (local guided, emergency mode)
- Interface to the station HMI.
- Data storage for at least 200 events
- Extension possibilities with additional I/O's inside the unit or via fibre-optic communication and process bus

3.1.1.2. Control mode selection

Bay level Operation:

As soon as the operator receives the operation access at bay level the operation is normally performed via bay control IED. During normal operation bay control unit allows the safe operation of all switching devices via the bay control IED.

EMERGENCY Operation

It shall be possible to close or open the selected Circuit Breaker with ON or OFF push buttons even during the outage of bay IED**.**

REMOTE mode

Control authority in this mode is given to a higher level (Remote Control Centre) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

3.1.1.3. Synchronism and energizing check

The synchronism and energizing check functions shall be bay-oriented and distributed to the bay control and/or protection devices. These features are:

- Settable voltage, phase angle, and frequency difference.
- Energizing for dead line - live bus, live line - dead bus or dead line – dead bus with no synchro-check function.
- Synchronising between live line and live bus with synchro-check function

Voltage selection

The voltages relevant for the Synchro check functions are dependent on the station topology, i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronizing and energizing is derived from the auxiliary switches of the circuit breakers, the isolator, and earthing switch and shall be selected automatically by the bay control and protection IEDs.

3.1.1.4. Transformer tap changer control

Raise and lower operation of OLTC taps of transformer shall be facilitated through Bay controller IED.

3.1.2. Bay protection functions

3.1.2.1. General

The protection functions are independent of bay control function. The protection shall be provided by separate protection IEDs (numerical relays) and other protection devices as per section Relay & Protection.

IEDs, shall be connected to the communication infrastructure for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.

Event and disturbance recording function

Each IED should contain an event recorder capable of storing at least 200 time-tagged events. The disturbance recorder function shall be as per detailed in Chapter 15 – Control, Relay & Protection Panels.

3.1.2.2. Bay Monitoring Function:

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated in the Bay control/protection unit.

3.2. System level functions

3.2.1. Status supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, transformer tap changer etc., shall be supervised continuously. Every detected change of position shall be immediately displayed in the single-line diagram on the station HMI screen, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in the case of spontaneous position changes.

The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.

The SAS shall also monitor the status of sub-station auxiliaries. The status and control of auxiliaries shall be done through separate one or more IED and all alarm and analogue values shall be monitored and recoded through this IED.

3.2.2. Measurements

The analogue values acquired/calculated in bay control/protection unit shall be displayed locally on the station HMI and in the control centre. The abnormal values must be discarded. The analogue values shall be updated every 2 seconds.

Threshold limit values shall be selectable for alarm indications.

3.2.3. Event and alarm handling

Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All, or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time-tagged with a time resolution of 1 ms. The tentative list for various feeders and systems are enclosed as Annexure-I

3.2.4. Station HMI

3.2.4.1. Substation HMI Operation:

On the HMI the object has to be selected first. In case of a blocking or interlocking conditions are not met, the selection shall not be possible and an appropriate alarm annunciation shall occur. If a selection is valid the position indication will show the possible

direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object.

Control operation from other places (e.g. REMOTE) shall not be possible in this operating mode.

3.2.4.2. Presentation and dialogues

General

The operator station HMI shall be a redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear on the screen via mouse clicks.

The HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log.

An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from any screen selected by the operator.

The following standard pictures shall be available from the HMI:

- Single-line diagram showing the switchgear status and measured values
- Control dialogues with interlocking or blocking information details. This control dialogue shall tell the operator whether the device operation is permitted or blocked**.**
- Measurement dialogues
- Alarm list, station / bay-oriented
- Event list, station / bay-oriented
- System status

3.2.4.3. HMI design principles

Consistent design principles shall be adopted with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

The object status shall be indicated using different status colours for:

- Selected object under command
- Selected on the screen
- Not updated, obsolete values, not in use or not sampled
- Alarm or faulty state
- Warning or blocked
- Update blocked or manually updated
- Control blocked
- Normal state

3.2.4.4. Process status displays and command procedures

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as

the positions of circuit breakers, isolators and transformer tap-changers shall be displayed in the station single-line diagram.

In order to ensure a high degree of security against undesired operation, a "select-before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen, and all other switchgear shall be blocked. As communication between control centre and device to be controlled is established, the operator shall be prompted to confirm the control action and only then final execute command shall be accepted**.** After the “execution” of the command the operated switching symbol shall flash until the switch has reached its new position.

The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level.

After command execution the operator shall receive a confirmation that the new switching position has been reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

3.2.4.5. System supervision & display

The SAS system shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are recorded as a faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication infrastructure and remote communication links, and printers at the station level, etc.

3.2.4.6. Event list

The event list shall contain events that are important for the control and monitoring of the substation.

The event and associated time (with1 ms resolution) of its occurrence has to be displayed for each event.

The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.

A printout of each display shall be possible on the hard copy printer.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer for at least one month. The information shall be obtainable also from a printed event log.

The chronological event list shall contain:

- Position changes of circuit breakers, isolators and earthing devices
- Indication of protective relay operations
- Fault signals from the switchgear

- Indication when analogue measured values exceed upper and lower limits. Suitable provision shall be made in the system to define two level of alarm on either side of the value or which shall be user defined for each measurands.
- Loss of communication.

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

- Date and time
- Bay
- Device
- Function e.g. trips, protection operations etc.
- Alarm class

3.2.4.7. Alarm list

Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control centre. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated.

The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

- The date and time of the alarm
- The name of the alarming object
- A descriptive text
- The acknowledgement state.

Whenever an alarm condition occurs, the alarm condition must be shown on the alarm list and must be displayed in a flashing state along with an audible alarm. After acknowledgement of the alarm, it should appear in a steady (i.e. not flashing) state and the audible alarm shall stop. The alarm should disappear only if the alarm condition has physically cleared and the operator has reset the alarm with a reset command. The state of the alarms shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent).

Filters for selection of a certain type or group of alarms shall be available as for events.

3.2.4.8. Object picture

When selecting an object such as a circuit breaker or isolator in the single-line diagram, the associated bay picture shall be presented first. In the selected object picture, all attributes like

- Type of blocking
- Authority
- Local / remote control
- RSCC / SAS control

- Errors
- etc.,

shall be displayed.

3.2.4.9. Control dialogues

The operator shall give commands to the system by means of mouse click located on the single-line diagram. Data entry is performed with the keyboard. Dedicated control dialogues for controlling at least the following devices shall be available:

- Breaker and disconnector
- Transformer tap-changer

3.2.5. User-authority levels

It shall be possible to restrict activation of the process pictures of each object (bays, apparatus...) within a certain user authorisation group. Each user shall then be given access rights to each group of objects, e.g.:

- Display only
- Normal operation (e.g. open/close of switchgear)
- Restricted operation (e.g. by-passed interlocking)
- System administrator

For maintenance and engineering purposes of the station HMI, the following authorisation levels shall be available:

- No engineering allowed
- Engineering/configuration allowed
- Entire system management allowed

The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

3.2.6. Reports

The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise:

- Trend reports:
  - Day (mean, peak)
  - Month (mean, peak)
  - Semi-annual (mean, peak)
  - Year (mean, peak)
- Historical reports of selected analogue Values:
  - Day (at 15 minutes interval)
  - Week
  - Month
  - Year

It shall be possible to select displayed values from the database in the process display on-line. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.

Following printouts shall be available from the printer and shall be printed on demand:

i. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.

ii. Weekly trend curves for real and derived analogue values.

iii. Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.

iv. Provision shall be made for logging information about breaker status like number of operation with date and time indications along with the current value it interrupts (in both condition i.e. manual opening and fault tripping)

v. Equipment operation details shift wise and during 24 hours.

vi. Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each feeder and transformer as well as Tap Positions, temperature and status of pumps and fans for transformers.

vii. Printout on adjustable time period as well as on demand system frequency and average frequency.

viii. Reports in specified formats which shall be handed over to successful bidder. The bidder has to develop these reports. The reports are limited to the formats for which data is available in the SAS database.

3.2.7. Trend display (historical data)

It shall be possible to illustrate all types of process data as trends - input and output data, binary and analogue data. The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen. Adjustable time span and scaling ranges must be provided.

It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

3.2.8. Automatic disturbance file transfer

All recorded data from the IEDs with integrated disturbance recorder as well as dedicated disturbance recording systems shall be automatically uploaded (event triggered or once per day) to a dedicated computer and be stored on the hard disc.

3.2.9. Disturbance analysis

The PC-based work station shall have necessary software to evaluate all the required information for proper fault analysis.

3.2.10. IED parameter setting

It shall be possible to access all protection and control IEDs for reading the parameters (settings) from the station HMI or from a dedicated monitoring computer. The setting of parameters or the activation of parameter sets shall only be allowed after entering a password.

3.2.11. Automatic sequences

The available automatic sequences in the system should be listed and described, (e.g. sequences related to the bus transfer). It must be possible to initiate pre-defined automatic sequences by the operator and also define new automatic sequences.

3.3. Gateway

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.

3.3.2 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.

3.3.3 Interface equipment:

The Contractor shall provide interface equipment for communicating between Substation Automation system and Remote control centre and between Substation Automation system and Regional System Coordination Centre (RSCC). However, the communication channels available for this purpose are specified in Chapter 1 - GTS.

In case of PLCC communication any modem supplied shall not require manual equalization and shall include self-test features such as manual mark/space keying, analogue loop-back, and digital loop-back. The modems shall provide for convenient adjustment of output level and receive sensitivity. The modem should be 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.

3.3.4 Communication Protocol

The communication protocol for gateway to control centre must be open protocol and shall support IEC 60870-5-101 and IEC 61850 for all levels of communication for sub-station automation such as Bay to station HMI, gateway to remote station etc.

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)

The display units shall have high resolution and reflection protected picture screen. High stability of the picture geometry shall be ensured. The screen shall be at least 21" diagonally in size and capable of colour graphic displays.

The display shall accommodate resolution of 1280 X 1024 pixels.

4.1.3 Printer

It shall be robust & suitable for operation with a minimum of 132 characters per line. The printing operation shall be quiet with a noise level of less than 45 dB suitable for location in the control room. Printer shall accept and print all ASCII characters via master control computer unit interface.

The printer shall have in built testing facility. Failure of the printer shall be indicated in the Station HMI. The printer shall have an off line mode selector switch to enable safe maintenance. The maintenance should be simple with provisions for ease of change of print head, ribbon changing, paper insertion etc.

All reports and graphics prints shall be printed on laser printer. One dot matrix printer shall be exclusively used for hourly log printing.

All printers shall be continuously online.

4.1.4 Mass Storage Unit

The mass storage unit shall be built-in to the Station HMI. All operational measured values, and indications shall be stored in a mass-storage unit **in form** of **DVD RW** The unit should support at least Read (48X), Write(24X), and Re-Write (10X) operations, with Multi-Session capability. It should support ISO9660, Rockridge and Joliet Filesystems. It should support formatting and use under the operating system provided for Station HMI. The monthly back up of data shall be taken on disc. The facility of back up of data shall be inherent in the software**.**

4.1.5 Switched Ethernet Communication Infrastructure:

The bidder shall provide the redundant switched optical Ethernet communication infrastructure for SAS. One switch shall be provided to connect all IEDs for two bays of 220kV yard to communication infrastructure. Each switch shall have at least two spare ports for connecting bay level IEDs and one spare port for connecting station bus.

4.2 Bay level unit

The bay unit shall use industrial grade components. The bay level unit, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select-before-operate control principles as safety measures for operation via the HMI. They shall perform all bay related functions, such as control commands, bay interlocking, data acquisition, data storage, event recording and shall provide inputs for status indication and outputs for commands. They shall be directly connected to the switchgear. The bay unit shall acquire and process all data for the bay (Equipment status, fault indications, measured values, alarms etc.) and transmit these to the other devices in sub-station automation system. In addition, this shall receive the operation commands from station HMI and control centre. The bay unit shall have the capability to store all the data for at least 24 hours.

One number Bay level unit shall be provided for supervision and control of each 220 kV bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer). The Bay level unit shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All bay level interlocks are to be incorporated in the Bay level unit so as to permit control from the Bay level unit/ local bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out of service.

The bay control unit to be provided for the bays shall be preferably installed in the CB relay panel/feeder protection panel for respective bay.

The bay control unit for future bay (if required as per Chapter 1 – Project Specification Requirement) shall be installed in a separate

panel.

The Bay level unit shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 61850. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.

4.2.1 Input/Output (I/O) modules

The I/O modules shall form a part of the bay level unit and shall provide coupling to the substation equipment. The I/O modules shall acquire all switchgear information (i.e. data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear. The measured values of voltage and current shall be from the secondaries of instrument transformers. The digital inputs shall be acquired by exception with 1 ms resolution. Contact bouncing in digital inputs shall not be assumed as change of state

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

5.1.1.1 Human-machine interface (HMI)

The base HMI software package for the operator station shall include the main SAS functions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. Systems shall contain a library with standard functions and applications.

5.1.2 Bay level software

5.1.1.1 System software

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. The lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance engineer for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage. In case of restoration of links after failure, the software along with hardware shall be capable of automatically synchronising with the remaining system without any manual interface. This shall be demonstrated by contractor during integrated system test.

5.1.1.2 Application software

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They form part of a library.
The application software within the control/protection devices shall be programmed in a functional block language.

5.1.1.3 Network Management System (NMS):

The contractor shall provide a network management system software for following management functions:

a. Configuration Management
b. Fault Management
c. Performance Monitoring

This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in DR work-station and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any fault in the monitored devices. The NMS shall

(a) Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports.
(b) Maintain a graphical display of SAS connectivity and device status.
(c) Issue alarms when error conditions occurs
(d) Provide facility to add and delete addresses and links

5.1.1.4 The contractor shall provide each software in two copies in CD to load into the system in case of any problem related with Hardware/Communication etc.

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:

The supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual bay level IED's applicable type test certificates shall be submitted**.**

The manufacturing and configuration phase of the SAS shall be concluded by the factory acceptance test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the user. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab. During FAT the entire Sub-station Automation System including complete control and protection system to be supplied under present scope shall be tested for complete functionality and configuration in factory itself. The extensive testing shall be carried out during FAT. The purpose of Factory Acceptance Testing is to ensure trouble free installation at site. No major configuration setting of system is envisaged at site.

If the complete system consists of parts from various suppliers or

some parts are already installed on site, the FAT shall be limited to sub-system tests. In such a case, the complete system test shall be performed on site together with the site acceptance test (SAT).

6.2.1 Hardware Integration Tests:

The hardware integration test shall be performed on the specified systems to be used for Factory tests when the hardware has been installed in the factory. The operation of each item shall be verified as an integral part of system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software integration and factory testing of the system. The equipment expansion capability shall also be verified during the hardware integration tests. The vendor specifically demonstrates how to add a device in future in SAS during FAT. The device shall be from a different manufacturer than the SAS supplier.

6.2.2 Integrated System Tests:

Integrated system tests shall verify the stability of the hardware and the software. During the tests all functions shall run concurrently and all equipment shall operate a continuous 100 Hours period. The integrated system test shall ensure the SAS is free of improper interactions between software and hardware while the system is operating as a whole.

6.3 Site Acceptance Tests:

The site acceptance tests (SAT) shall completely verify all the features of SAS hardware and software. The bidder shall submit the detailed SAT procedure and SAT procedure shall be read in conjunction with the specification.

7.0 SYSTEM OPERATION

7.1 Substation Operation

7.1.1 NORMAL OPERATION

Operation of the system by the operator from the remote RCC or at the substation shall take place via industry standard HMI(Human Machine interface) subsystem consisting of graphic colour VDU , a standard keyboard and a cursor positioning device (mouse).

The coloured screen shall be divided into 3 fields :

i) Message field with display of present time and date
ii) Display field for single line diagrams
iii) Navigation bar with alarm/condition indication

For display of alarm annunciation, lists of events etc a separate HMI View node shall be provided.

All operations shall be performed with mouse and/or a minimum number of function keys and cursor keys. The function keys shall have different meanings depending on the operation. The operator shall see the relevant meanings as function tests displayed in the command field (i.e. operator prompting). For control actions, the switchgear (i.e. circuit breaker etc.) requested shall be selectable on the display by means of the cursor keys. The switching element selected shall then appear on the background that shall be flashing in a different color. The operator prompting shall distinguish between:-

- Prompting of indications e.g. fault indications in the switchgear, and

- prompting of operational sequences e.g. execution of switching operations

The summary information displayed in the message field shall give a rapid display of alarm/message of the system in which a fault has occurred and alarm annunciation lists in which the fault is described more fully.

Each operational sequence shall be divided into single operation steps which are initiated by means of the function keys/WINDOW command by mouse. Operator prompting shall be designed in such a manner that only the permissible keys are available in the command field related to the specific operation step. Only those switching elements shall be accessed for which control actions are possible. If the operation step is rejected by the system, the operator prompting shall be supported by additional comments in the message field. The operation status shall be reset to the corresponding preceding step in the operation sequence by pressing one of the function keys. All operations shall be verified. Incorrect operations shall be indicated by comments in the message field and must not be executed.

The offer shall include a comprehensive description of the system. The above operation shall also be possible via WINDOWS based system by mouse.

8.0 POWER SUPPLY

Power for the substation automation system shall be derived from substation 220V DC system.
2No.s of Inverter of minimum 2KVA capacity shall be provided for servers, gateways station HMI disturbance recorder evaluation unit and its peripheral devices e.g. printer etc. In the event of Power failure, necessary safeguard software shall be built for proper shutdown. Inverter shall be connected to 220V DC independent source and should be used to drive 1No. each server/HMI/Gateway so that in case any failure of DC power supply system is not affected.

9.0 DOCUMENTATION

The following documents shall be submitted for employer's approval during detailed engineering:

(a) System Architecture Drawing
(b) Hardware Specification
(c) Functional Design Document
(d) Clear procedure describing how to add an

IED/bay/diameter in future covering all major supplier

The following documentation to be provided for the system in the course of the project shall be consistent, CAD supported, and of similar look/feel. All CAD drawings to be provide in “dxf” format.

- List of Drawings
- Substation automation system architecture
- Block Diagram
- Guaranteed technical parameters, Functional Design Specification and Guaranteed availability and reliability
- Calculation for power supply dimensioning
- I/O Signal lists
- Schematic diagrams
- List of Apparatus
- List of Labels
- Logic Diagram (hardware & software)
- **Switchyard Panel Room** layout drawing
- Control Room Lay-out
- Test Specification for Factory Acceptance Test (FAT)
- Product Manuals
- Assembly Drawing
- Operator’s Manual
- Complete documentation of implemented protocols between various elements
- Listing of software and loadable in CD ROM
- Other documents as may be required during detailed engineering

Two sets of hard copy and Four sets of CD ROM containing all the as built documents/drawings shall be provided.

10.0 TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES

10.1 Training

Contractor personnel who are experienced instructors and who speak understandable English shall conduct training. The contractor shall arrange on its own cost all hardware training platform required for successful training and understanding in Nepal. The Contractor shall provide all necessary training material. Each trainee shall receive individual copies of all technical manuals and all other documents used for training. These materials shall be sent to Employer at least two months before the scheduled commencement of the particular training course. Class materials, including the documents sent before the training courses as well as class handouts, shall become the property of Employer. Employer reserves the right to copy such materials, but for in-house training and use only. Hands-on training shall utilize equipment identical to that being supplied to Employer.

The Contractor shall quote training prices as indicated in BPS.

The schedule, location, and detailed contents of each course will be finalized during Employer and Contractor discussions.

10.2 Computer System Hardware Course

A computer system hardware course shall be offered, but at the system level only. The training course shall be designed to give Employer hardware personnel sufficient knowledge of the overall design and operation of the system so that they can correct obvious problems, configure the hardware, perform preventive maintenance, run diagnostic programs, and communicate with contract maintenance personnel. The following subjects shall be covered:

(a) System Hardware Overview: Configuration of the system hardware.
(b) Equipment Maintenance: Basic theory of operation, maintenance techniques and diagnostic procedures for each element of the computer system, e.g., processors, auxiliary memories, LANs, routers and printers. Configuration of all the hardware equipments.
(c) System Expansion: Techniques and procedures to expand and add equipment such as loggers, monitors, and communication channels.
(d) System Maintenance: Theory of operation and maintenance of the redundant hardware configuration, failover hardware, configuration control panels, and failover switches. Maintenance of protective devices and power supplies.
(e) Subsystem Maintenance: Theory of design and operation, maintenance techniques and practices, diagnostic procedures, and (where applicable) expansion techniques and procedures. Classes shall include hands-on training for the specific subsystems that are part of Employer's equipment or part of similarly designed and configured subsystems. All interfaces to the computing equipment shall be taught in detail.
(f) Operational Training: Practical training on preventive and corrective maintenance of all equipment, including use of special tools and instruments. This training shall be provided on Employer equipment, or on similarly configured systems.

10.3 Computer System Software Course

The Contractor shall provide a computer system software course that covers the following subjects:

(a) System Programming: Including all applicable programming languages and all stand-alone service and utility packages provided with the system. An introduction to software architecture, Effect of tuning parameters (OS software, Network software, database software etc.) on the performance of the system.
(b) Operating System: Including the user aspects of the operating system, such as program loading and integrating procedures; scheduling, management, service, and utility functions; and system expansion techniques and procedures
(c) System Initialization and Failover: Including design, theory of operation, and practice

(d) Diagnostics: Including the execution of diagnostic procedures and the interpretation of diagnostic outputs,

(e) Software Documentation: Orientation in the organization and use of system software documentation.

(f) Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

10.4 Application Software Course

The Contractor shall provide a comprehensive application software courses covering all applications including the database and display building course. The training shall include:

(a) Overview: Block diagrams of the application software and data flows. Programming standards and program interface conventions.

(b) Application Functions: Functional capabilities, design, and major algorithms. Associated maintenance and expansion techniques.

(c) Software Development: Techniques and conventions to be used for the preparation and integration of new software functions.

(d) Software Generation: Generation of application software from source code and associated software configuration control procedures.

(e) Software Documentation: Orientation in the organization and use of functional and detailed design documentation and of programmer and user manuals.

(f) Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

10.5 Requirement of training:

The contractor shall provide training for OWNER'S personnel comprehensively covering following courses.

S. No.	Name of Course
1	Computer System Hardware
2	Computer System Software
3	Application Software

11.0 Maintenance

11.1 Maintenance Responsibility during the Guaranteed Availability Period.

During Guaranteed Availability Period, the Contractor shall take continual actions to ensure the guaranteed availability and shall make available all the necessary resources such as specialist personnel, spare parts, tools, test devices etc. for replacement or repair of all defective parts and shall have prime responsibility for keeping the system operational. **During guarantee period as specified in tender document, contractor shall arrange bi-monthly visit of their representative to site to review the performance of system and in case any defect/shortcoming etc. is observed during the**

period, the same shall be set right by the contractor within 15 days.

12.0 RELIABILITY AND AVAILABILITY

The SAS shall be designed so that the failure of any single component, processor, or device shall not render the system unavailable. The SAS shall be designed to satisfy the very high demands for reliability and availability concerning:

- Mechanical and electrical design
- Security against electromagnetic interference (EMI)
- High quality components and boards
- Modular, well-tested hardware
- Thoroughly developed and tested modular software
- Easy-to-understand programming language for application programming
- Detailed graphical documentation and application software
- Built-in supervision and diagnostic functions
- Security
  - Experience of security requirements
  - Process know-how
  - Select before execute at operation
  - Process status representation as double indications
- Distributed solution
- Independent units connected to the local area network
- Back-up functions
- Panel design appropriate to the harsh electrical environment and ambient conditions
- Panel grounding immune against transient ground potential rise

Outage terms

1) Outage

The state in which substation automation system or a unit of SAS is unavailable for Normal Operation as defined in the clause 7.1 due to an event directly related to the SAS or unit of SAS. In the event, the owner has taken any equipment/ system other than Sub-station Automation System for schedule/forced maintenance, the consequent outage to SAS shall not be considered as outage for the purpose of availability.

2) Actual outage duration (AOD)

The time elapsed in hours between the start and the end of an outage. The time shall be counted to the nearest $1/4^{th}$ of an hour. Time less than $1/4^{th}$ of an hour shall be counted as having duration of $1/4^{th}$ of an hour.

3) Period Hours (PH)

The number of hours in the reporting period. In a full year the period hour 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**

i) Status of each pole of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty
vi) LBB optd
vii) Bus bar protn trip relay optd
viii) REF OPTD
ix) DIF OPTD
x) OVERFLUX ALARM (MV)
xi) OVERFLUX TRIP (MV)
xii) OVERFLUX ALARM (HV)
xiii) OVERFLUX TRIP (HV)
xiv) HV BUS CVT ½ FUSE FAIL
xv) MV BUS CVT ½ FUSE FAIL
xvi) OTI ALARM/TRIP
xvii) PRD OPTD
xviii) OVERLOAD ALARM
xix) BUCHOLZ TRIP
xx) BUCHOLZ ALARM
xxi) OLTC BUCHOLZ ALARM
xxii) OLTC BUCHOLZ TRIP

xxiii) OIL LOW ALARM
xxiv) back-up o/c (HV) optd
xxv) back-up e/f (HV)optd
xxvi) 220v DC-I/II source fail
xxvii) TAP MISMATCH
xxviii) GR-A PROTN OPTD
xxix) GR-B PROTN OPTD
xxx) back-up o/c (MV) optd
xxxi) back-up e/f (MV)optd

3. **Transformer bays**

i) Status of each pole of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty
vi) LBB optd
vii) Bus bar protn trip relay optd
viii) REF OPTD
ix) DIF OPTD
x) HV BUS CVT ½ FUSE FAIL
xi) OTI ALARM/TRIP
xii) PRD OPTD
xiii) BUCHOLZ TRIP
xiv) BUCHOLZ ALARM
xv) OIL LOW ALARM
xvi) Back-up impedance relay
xvii) 220v DC-I/II source fail
xviii) GR-A PROTN OPTD
xix) GR-B PROTN OPTD

4. Line/Bus Reactor bays (as applicable):

i) Status of each pole of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty
vi) LBB optd
vii) Bus bar protn trip relay optd
viii) REF OPTD
ix) DIF OPTD
x) Line/ BUS CVT ½ FUSE FAIL
xi) OTI ALARM/TRIP
xii) PRD OPTD
xiii) BUCHOLZ TRIP
xiv) BUCHOLZ ALARM
xv) OIL LOW ALARM
xvi) Back-up impedance relay
xvii) 220V DC-I/II source fail
xviii) GR-A PROTN OPTD
xix) GR-B PROTN OPTD

5 **Bus bar Protection**

i) Bus bar main-I trip
ii) Bus bar main-II trip
iii) Bus bar zone-I CT open
iv) Bus bar zone-II CT open
v) Bus transfer CT sup. Optd
vi) Bus transfer bus bar protn optd
vii) Bus protection relay fail

6. **Auxiliary system**

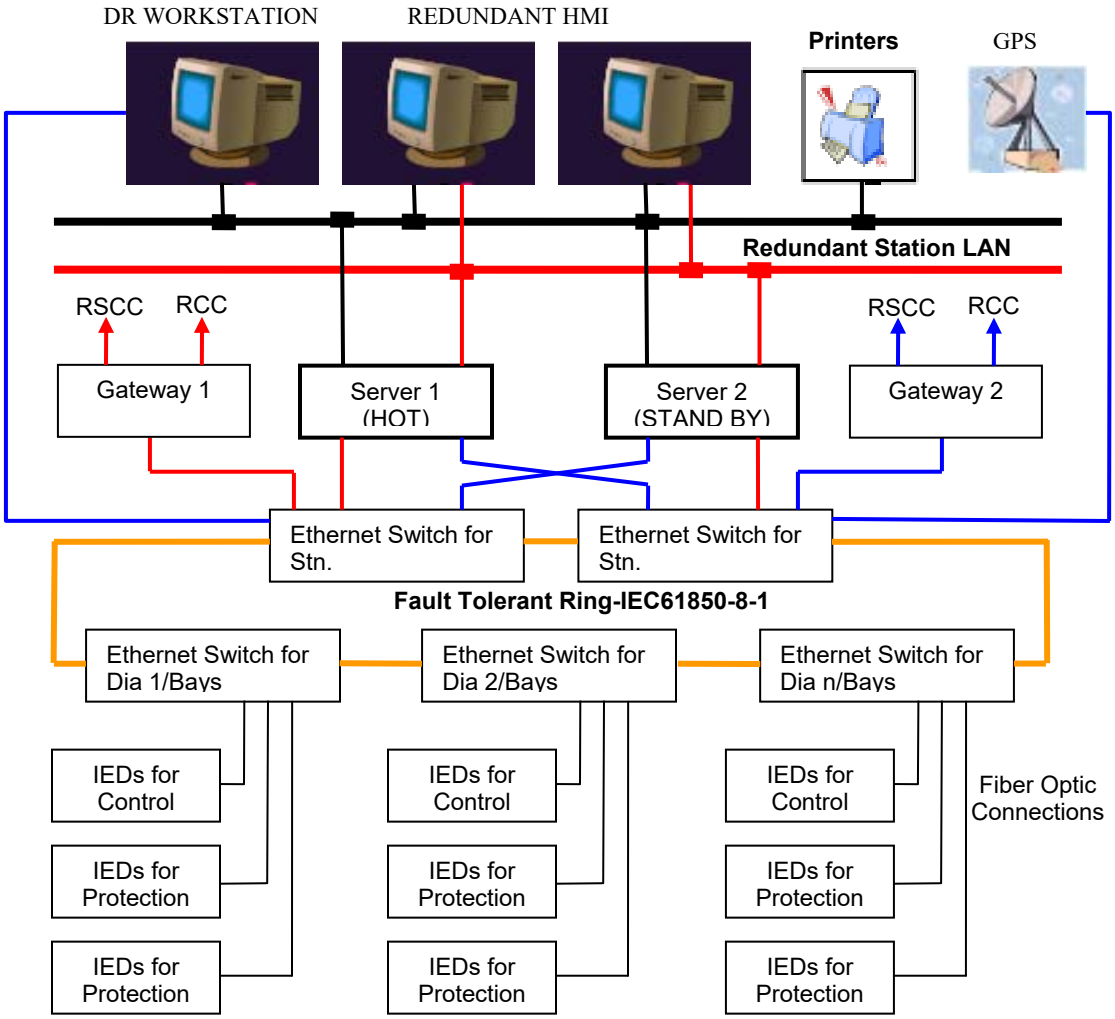
i) Incomer-I On/Off
ii) Incomer-II On/Off
iii) 400V Bus-I/II U/V
iv) 400V bus coupler breaker on/off
v) DG set bkr on/off
vi) Alarm/trip signals as listed in Section: DG set
vii) LT transformer-I Bunchholz Alarm & trip
viii) LT transformer-II Buchloz Alarm & trip
ix) LT transformer-I WTI Alarm & trip
x) LT transformer-II WTI Alarm & trip
xi) LT transformer-I OTI Alarm & trip
xii) LT transformer-II OTI Alarm & trip
xiii) PLCC exchange fail
xiv) Time sync. Signal absent
xv) Alarm/trip signals as listed in Section: Battery and Battery charger
xvi) 220V DC-I earth fault
xvii) 220V DC-II earth fault
xviii) Alarm/trip signals as listed in Section: Fire protection system

7. Switchyard Panel Room:

i) AC Compressor 1 ON/OFF
ii) AC Compressor 2 ON/OFF
iii) Fire Detection 1 ON/OFF
iv) Fire Detection 2 On/OFF
v) Switchyard Panel Room Temperature High Alarm

The exact number and description of digital inputs shall be as per detailed engineering requirement Apart from the above mentioned digital inputs, minimum of 200 inputs shall be kept for future use.

TYPICAL ARCHITECTURAL DRAWING OF SUBSTATION AUTOMATION SYSTEM



Note:

1. The redundant managed bus shall be realized by high speed optical bus using industrial grade components and shall be as per IEC 61850.
2. Inside the sub-station, all connections shall be realized as per IEC 61850 protocol.
3. For gateway, it shall communicate with Remote Supervisory Control Centre (RSCC) on IEC 60870-5-101 protocol.
4. The printer as required shall be connected to station bus directly and can be managed either from station HMI, HMI view node or disturbance recorder work station.
5. The above layout is typical. However if any contractor offers slightly modified architecture based on their standard practice without compromising the working, the same shall be subject to approval during detailed engineering.

2.2 Applicable Standards

2.2.1 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

Type Test Name	Type Test Standard	Conditions
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
		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

Type Test Name	Type Test Standard	Conditions
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)
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	IEC 61000-4-8	Class 4 : 50 Hz – 30 A/m permanent – 300 A/m short time

Type Test Name	Type Test Standard	Conditions
Immunity		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

2.2.2 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.

2.3 Automation standard

- IEC 61131-3

2.3.1 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

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

TECHNICAL SPECIFICATION

SECTION-18

TECHNICAL DESCRIPTION OF Optical Ground Wire (OPGW) Cable

Contents

Chapter-01
Specification for OPGW cabling & associated hardware & fittings

Table of Content

Section-01
Specification for OPGW cabling and associated hardware & fittings

The broad scope of this specification include the survey, planning, design, engineering, manufacturing, supply, transportation, insurance, delivery at site, unloading, handling, storage, , installation, splicing, termination, testing, demonstration for acceptance and commissioning and documentation for:

a) OPGW fibre optic cable including all associated hardware, accessories & fittings
b) Fibre Optic approach cable including installation material
c) Fibre Optic Distribution Panels (FODP) & Joint Box
d) Supply of spares
e) Supply of test equipments
f) All other associated work/items described in the technical specifications.

This section of the technical specification describes the functional and technical specifications of OPGW cabling and associated hardware and fittings.

1.0 Fibre Optic Cabling

In this section of the technical specification, the functional & technical specifications of OPGW cable, associated hardware & fittings for the requirements for G.652D Dual-window Single mode (DWSM) telecommunications grade fibre optic cable is mentioned. Bidders shall furnish with their bids, detailed descriptions of the fibres & cable(s) proposed.

All optical fibre cabling including fibre itself and all associated installation hardware shall have a minimum guaranteed design life span of 25 years. Documentary evidence in support of guaranteed life span of cable & fibre shall be submitted by the Contractor during detailed engineering.

1.1 Required Optical Fibre Characteristics

The optical fibre to be provided should have following characteristics:

1.1.1 Physical Characteristic

Dual-Window Single mode (DWSM), G.652D optical fibres shall be provided in the fibre optic cables. DWSM optical fibres shall meet the requirements defined in Table 1-1(a).

1.1.2 Attenuation

The attenuation coefficient for wavelengths between 1525 nm and 1575 nm shall not exceed the attenuation coefficient at 1550 nm by more than 0.05 dB/km. The attenuation coefficient between 1285 nm and 1330 nm shall not exceed the attenuation coefficient at 1310 nm by more than 0.05 dB/km. The attenuation of the fibre shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.10 dB. The fibre attenuation characteristics specified in table 1-1 (a) shall be “guaranteed” fibre attenuation of any & every fibre reel.

The overall optical fibre path attenuation shall not be more than calculated below :

Maximum attenuation @ 1550 nm : 0.21 dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors.

Maximum attenuation @ 1310 nm : 0.35 dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors.

Table 2-1(a)
DWSM Optical Fibre Characteristics

Fibre Description:	Dual-Window Single-Mode
Mode Field Diameter:	8.6 to 9.5 μm (± 0.6μm)
Cladding Diameter:	125.0 μm ± 1 μm
Mode field concentricity error	≤ 0.6μm
Cladding non-circularity	≤ 1%
Cable Cut-off Wavelength λ_{cc}	≤ 1260 nm
1550 nm loss performance	As per G.652 D
Proof Test Level	≥ 0.69 Gpa
Attenuation Coefficient:	@ 1310 nm ≤ 0.35 dB/km @ 1550 nm ≤ 0.21 dB/km
Chromatic Dispersion; Maximum: **Zero Dispersion Wavelength :** **Zero Dispersion Slope :**	18 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) 1288-1339nm 5.3 ps/(nm x km) 1271-1360nm 1300 to 1324 nm 0.092 ps/(nm^2xkm) maximum
Polarization mode dispersion coefficient	≤ 0.2 ps/km^½
Temperature Dependence :	Induced attenuation ≤ 0.05 dB (-60°C - +85°C)
Bend Performance :	@ 1310 nm (75±2 mm dia Mandrel), 100 turns; Attenuation Rise ≤ 0.05 dB/km @ 1550 nm (75±2 mm dia Mandrel), 100 turns; Attenuation Rise ≤ 0.10 dB/km @ 1550 nm (32±0.5 mm dia Mandrel, 1 turn; Attenuation Rise ≤ 0.50 dB/km

1.2 Fibre Optic Cable Construction

The OPGW (Optical Ground Wire) cable is proposed to be installed on the new transmission lines alongwith transmission line construction. The design of cable shall account for the varying operating and environmental conditions that the cable shall experience while in service. The OPGW cable to be supplied shall be designed to meet the overall requirements of all the transmission lines. The Tower span details shall be collected by the contractor during survey. To meet the overall

requirement of the transmission line(s), the contractor may offer more than one design without any additional cost to Employer, in case single design is not meeting the requirement. OPGW cable to be designed to meet transmission line sag-tension parameters and other details to be provided by Transmission Line contractor. Any other details, as required for cable design etc. shall be collected by the Contractor during survey.

1.2.1 Optical Fibre Cable Link Lengths

The estimated optical fibre link lengths are provided in Appendices as transmission line route length. However, the Contractor shall supply the OPGW cable as required based on the tower schedule. The Contractor shall verify the transmission line route length during the survey and the Contract price shall be adjusted accordingly.

For the purpose of payment, the optical fibre link lengths are defined as transmission line route lengths from Gantry at one terminating station to the Gantry in the other terminating station. The actual cable lengths to be delivered shall take into account various factors such as sag, service loops, splicing, working lengths & wastage etc. and no additional payment shall be payable in this regard. The unit rate for FO cable quoted in the Bid price Schedules shall take into account all such factors.

1.2.2 Optical Fibre Identification

All optical fibres shall be individually coated. Individual optical fibres within a fibre unit and fibre units shall be identifiable in accordance with EIA/TIA 598 or IEC 60304 or Bellcore GR-20 colour-coding scheme.

Colouring utilized for colour coding optical fibres shall be integrated into the fibre coating and shall be homogenous. The colour shall not bleed from one fibre to another and shall not fade during fibre preparation for termination or splicing.

Each cable shall have traceability of each fibre back to the original fibre manufacturer's fibre number and parameters of the fibre. If more than the specified number of fibres is included in any cable, the spare fibres shall be tested by the cable manufacturer and any defective fibres shall be suitably bundled, tagged and identified at the factory by the vendor.

1.2.3 Buffer Tube

Loose tube construction shall be implemented. The individually coated optical fibre(s) shall be surrounded by a buffer for protection from physical damage during fabrication, installation and operation of the cable. The fibre coating and buffer shall be strippable for splicing and termination. Each fibre unit shall be individually identifiable utilizing colour coding. Buffer tubes shall be filled with a water-blocking gel.

1.2.4 Optical Fibre Strain & Sag-Tension chart

The OPGW cable shall be designed and installed such that the optical fibres experience no strain under all loading conditions of transmission lines. Zero fibre strain condition shall apply even after a 25 year cable creep.

For the purpose of this specification, the following definitions shall apply:

- *Maximum Working Tension (MWT)* is defined as the maximum cable tension at which there is *no fibre strain*.
- The *no fibre strain* condition is defined as fibre strain of less than or equal to 0.05%, as determined by direct measurements through IEC/ ETSI (FOTP) specified optical reflectometry
- The *Cable strain margin* is defined as the maximum cable strain at which there is no fibre strain.
- The cable *Maximum Allowable Tension (MAT)* is defined as the maximum tension experienced by the Cable under the worst case loading condition.
- The cable *max strain* is defined as the maximum strain experienced by the Cable under the worst case loading condition.
- The cable *Every Day Tension (EDT)* is defined as the maximum cable tension on any span under normal conditions.
- The *Ultimate /Rated Tensile Strength (UTS/* RTS/ breaking strength) is defined as the maximum tensile load applied and held constant for one minute at which the specimen shall not break.

While preparing the Sag-tension charts for the OPGW cable the following conditions shall be met:

- The Max Allowable Tension (MAT) / max strain shall be less than or equal to the MWT/ Strain margin of the cable.
- The sag shall not exceed the earth wire sag in all conditions.
- The Max Allowable Tension shall also be less than or equal to 0.4 times the UTS.
- The 25 year creep at 25% of UTS (creep test as per IEEE 1138) shall be such that the 25 year creep plus the cable strain at Max Allowable Tension (MAT) is less than or equal to the cable strain margin.
- The everyday tension (EDT) shall not exceed 20% of the UTS for the OPGW cable.

The Sag-tension chart of OPGW cable indicating the maximum tension, cable strain and sag shall be calculated and submitted along with the bid under various conditions as per tower design of the transmission line.

The size of OPGW shall be selected such that max. tension and sag at specified temperature and wind condition remains within the limits of transmission line tower design.

1.2.5 Cable Materials

The materials used for optical fibre cable construction, shall meet the following requirements:

1.2.5.1 Filling Materials

The interstices of the fibre optic unit and cable shall be filled with a suitable compound to prohibit any moisture ingress or any water longitudinal migration within the fibre optic unit or along the fibre optic cable. The water tightness of the cable shall meet or exceed the test performance criteria as per IEC 60794-1-F-5.

The filling compound used shall be a non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, non-hygroscopic, electrically nonconductive and non-nutritive to fungus.

The compound shall also be fully compatible with all cable components it may come in contact with and shall inhibit the generation of hydrogen within the cable.

The waterproofing filling materials shall not affect fibre coating, colour coding, or encapsulant commonly used in splice enclosures, shall be dermatologically safe, non-staining and easily removable with a non-toxic cleaning solvent.

1.2.5.2 Metallic Members

When the fibre optic cable design incorporates metallic elements in its construction, all metallic elements shall be electrically continuous.

1.2.6 Marking, Packaging and Shipping

This section describes the requirements for marking, packaging and shipping the overhead fibre optic cable.

(a) Drum Markings: Each side of every reel of cable shall be permanently marked in white lettering with the vendors' address, the Purchaser's destination address, cable part number and specification as to the type of cable, length, number of fibres, a unique drum number including the name of the transmission line & segment no., factory inspection stamp and date.

(b) Cable Drums: All optical fibre cabling shall be supplied on strong drums provided with lagging of adequate strength, constructed to protect the cabling against all damage and displacement during transit, storage and subsequent handling during installation. Both ends of the cable shall be sealed as to prevent the escape of filling compounds and dust & moisture ingress during shipment and handling. Spare cable caps shall be provided with each drum as required.

The spare cable shall be supplied on sturdy, corrosion resistant, steel drums suitable for long periods of storage and re-transport & handling.

There shall be no factory splices allowed within a continuous length of cable. Only one continuous cable length shall be provided on each drum. The lengths of cable to be supplied on each drum shall be determined by a "schedule" prepared by the Contractor and approved by the Employer.

1.3. Optical Ground Wire (OPGW)

OPGW cable construction shall comply with IEEE-1138, 2009. The cable provided shall meet both the construction and performance requirements such that the ground wire function, the optical fibre integrity and optical transmission characteristics are suitable for the intended purpose. The cable shall consist of optical fibre units as defined in this specification. There shall be no factory splices within the cable structure of a continuous cable length.

The composite fibre optic overhead ground wire shall be made up of multiple buffer tubes embedded in a water tight aluminium/aluminium alloy protective central fibre optic unit surrounded by concentric-lay stranded metallic wires in single or multiple layers. Each buffer tube shall have maximum 12 no. of fibres. All fibres in single buffer tube or directly in central fibre optic unit is not acceptable. The dual purpose of the composite cable is to provide the electrical and physical characteristics of conventional overhead ground wire while providing the optical transmission properties of optical fibre.

1.3.1 Central Fibre Optic Unit

The central fibre optic unit shall be designed to house and protect multiple buffered optical fibre units from damage due to forces such as crushing, bending, twisting, tensile stress and moisture. The central fibre optic unit and the outer stranded metallic conductors shall serve together as an integral unit to protect the optical fibres from degradation due to vibration and galloping, wind and ice loadings, wide temperature variations, lightning and fault current, as well as environmental effects which may produce hydrogen.

The OPGW design of dissimilar materials for stranded wires and tubes are not allowed. Central fibre optic unit may be of aluminium / aluminium alloy tube. There shall be no exposed areas of tubing that can make electrical contact either directly or indirectly through moisture, contamination, protrusions, etc with the surrounding stranded wires. The tube may be fabricated as a seamless tube, seam welded, or a tube without a welded seam.

1.3.2 Basic Construction

The OPGW cable construction shall conform to the applicable requirements of this specification, applicable clauses of IEC 61089 related to stranded conductors and **Table 1.2(a)** OPGW Mechanical and Electrical Characteristics. In addition, the basic construction shall include bare concentric-lay-stranded metallic wires with the outer layer having left hand lay. The wires may be of multiple layers with a combination of various metallic wires within each layer. The direction of lay for each successive layer shall be reversed. The finished wires shall contain no joints or splices unless otherwise agreed to by the Employer and shall conform to all applicable clauses of IEC 61089 as they pertain to stranded conductors.

The wires shall be so stranded that when the complete OPGW is cut, the individual wires can be readily regrouped and then held in place by one hand.

1.3.3 Breaking Strength

The rated breaking strength of the completed OPGW shall be taken as no more than 90 percent of the sum of the rated breaking strengths of the individual wires, calculated from their nominal diameter and the specified minimum tensile strength.

The rated breaking strength shall not include the strength of the optical unit. The fibre optic unit shall not be considered a load bearing tension member when determining the total rated breaking strength of the composite conductor.

1.3.4 Electrical and Mechanical Requirements

Table 1-2(a) provides OPGW Electrical and Mechanical Requirements for the minimum performance characteristics. Additionally, the OPGW mechanical & electrical characteristics shall be similar to that of the earthwire being replaced such that there is no or minimal consequential increase in stresses on towers. OPGW installation sag & tension charts shall be as per transmission line requirement. For the OPGW cable design selection and preparation of sag tension charts, the limits specified in this section shall also be satisfied. The Bidder shall submit sag-tension charts for the above cases with their bids.

Table 1.2(a)
OPGW Electrical and Mechanical Requirements

(1)	**Everyday Tension**	≤ 20% of UTS of OPGW
(2)	**D.C. Resistance at 20ºC:**	< 1.0 ohm/Km or Employer provided values
(3)	**Short Circuit Current**	≥ 6.32 kA for 1.0 second or Employer provided values

Bidder may offer separate design for each short circuit rating however OPGW design with higher short circuit level shall be acceptable.

1.3.5 Operating conditions

Since OPGW shall be located at the top of the transmission line support structure, it will be subjected to Aeolian vibration, Galloping and Lightning strikes. It will also carry ground fault currents. Therefore, its electrical and mechanical properties shall be same or similar as those required of conventional ground conductors.

1.4 Installation Hardware

The scope of supply includes all required fittings and hardware such as Tension assembly, Suspension assembly, Vibration dampers, Reinforcing rods, Earthing clamps, Downlead clamps, splice enclosure etc. The Bidder shall provide documentation justifying the adequacy and suitability of the hardware supplied. The quantity of hardware & fittings to meet any eventuality during site installation minimum@ 1% shall also be provided as part of set/km for each transmission line without any additional cost to Employer.

The OPGW hardware fittings and accessories shall follow the general requirements regarding design, materials, dimensions & tolerances, protection against corrosion and markings as specified in clause 4.0 of EN 61284: 1997 (IEC 61284). The shear strength of all bolts shall be at least 1.5 times the maximum installation torque. The OPGW hardware & accessories drawing & Data Requirement Sheets (DRS) document shall consist of three parts: (1) A technical particulars sheet (2) An assembly drawing i.e. level 1 drawing and (3) Component level drawings i.e. level 2 & lower drawings. All component reference numbers, dimensions and tolerances, bolt tightening torques & shear strength and ratings such as UTS, slip strength etc shall be marked on the drawings.

The fittings and accessories described herein are indicative of installation hardware typically used for OPGW installations and shall not necessarily be limited to the following:

(a) Suspension Assemblies: Preformed armour grip suspension clamps and aluminium alloy armour rods/ reinforcing rods shall be used. The suspension clamps shall be designed to carry a vertical load of not less than 25 KN. The suspension clamps slippage shall occur between 12kN and 17 kN as measured.

The Contractor shall supply all the components of the suspension assembly including shackles, bolts, nuts, washers, split pins, etc. The total drop of the suspension assembly shall not exceed 150 mm (measured from the centre point of attachment to the centre point of the

OPGW). The design of the assembly shall be such that the direction of run of the OPGW shall be the same as that of the conductor.

(b) Dead End Clamp Assemblies: All dead end clamp assemblies shall preferably be of performed armoured grip type and shall include all necessary hardware for attaching the assembly to the tower strain plates. Dead end clamps shall allow the OPGW to pass through continuously without cable cutting. The slip strength shall be rated not less than 95% of the rated tensile strength of the OPGW.

(c) Clamp Assembly Earthing Wire: Earthing wire consisting of a 1500 mm length of aluminium or aluminium alloy conductor equivalent in size to the OPGW shall be used to earth suspension and dead end clamp assemblies to the tower structure. The earthing wire shall be permanently fitted with lugs at each end. The lugs shall be attached to the clamp assembly at one end and the tower structure at the other.

(d) Structure Attachment Clamp Assemblies: Clamp assemblies used to attach the OPGW to the structures, shall have two parallel grooves for the OPGW, one on either side of the connecting bolt. The clamps shall be such that clamping characteristics do not alter adversely when only one OPGW is installed. The tower attachment plates shall locate the OPGW on the inside of the tower and shall be attached directly to the tower legs/cross-members without drilling or any other structural modifications.

(e) Vibration Dampers: Vibration dampers type 4R Stockbridge or equivalent, having four (4) different frequencies spread within the Aeolian frequency bandwidth corresponding to wind speed of 1m/s to 7 m/s, shall be used for suspension and tension points in each span. The Contractor shall determine the exact numbers and placement(s) of vibration dampers through a detailed vibration analysis as specified in technical specifications.

One damper minimum on each side per OPGW cable for suspension points and two dampers minimum on each side per OPGW cable for tension points shall be used for nominal design span of 400 meters. For all other ruling spans, the number of vibration damper shall be based on vibration analysis.

The clamp of the vibration damper shall be made of high strength aluminum alloy of type LM-6. It shall be capable of supporting the damper and prevent damage or chaffing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the OPGW cable without damaging the strands or causing premature fatigue failure of the OPGW cable under the clamp. The clamp groove shall be in uniform contact with the OPGW cable over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the OPGW cable when the clamp is installed. Clamping bolts shall be provided with self locking nuts and designed to prevent corrosion of threads or loosening in service.

The messenger cable shall be made of high strength galvanised steel/stain less steel. It shall be of preformed and post formed quality in order to prevent subsequent droop of weight and to maintain consistent flexural stiffness of the cable in service. The messenger cable other than stainless steel shall be hot dip galvanised in accordance with the recommendations of IS: 4826 for heavily coated wires.

The damper mass shall be made of hot dip galvanised mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkage, inclusions and blow holes etc. The surface of the damper masses shall be smooth.

The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other-than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions.

The contractor must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the OPGW cable shall not cause excessive stress concentration on the OPGW cable leading to permanent deformation of the OPGW strands and premature fatigue failure in operation.

The vibration analysis of the system, with and without damper and dynamic characteristics of the damper as detailed in Technical Specification, shall have to be submitted. The technical particulars for vibration analysis and damping design of the system are as follows:

Sl. No.	Description	Technical Particulars
1	Span Length in meters (i) Ruling design span: (ii) Maximum span: (iii) Minimum Span:	 400 meters 1100 meters 100 meters
2	Configuration:	As per Specifications
3	Tensile load in each:	As per sag tension calculations
4	Armour rods used:	Standard preformed armour rods/AGS
5	Maximum permissible dynamic strain:	+/- 150 micro strains

The damper placement chart for spans ranging from 100m to 1100m shall be submitted by the Contractor. Placement charts should be duly supported with relevant technical documents and sample calculations.

The damper placement charts shall include the following

(1) Location of the dampers for various combinations of spans and line tensions clearly indicating the number of dampers to be installed per OPGW cable per span.

(2) Placement distances clearly identifying the extremities between which the distances are

to be measured.

(3) Placement recommendation depending upon type of suspension clamps (viz Free center type/Armour grip type etc.)

(4) The influence of mid span compression joints, repair sleeves and armour rods (standard and AGS) in the placement of dampers

1.5 Fibre Optic Splice Enclosures (Joint Box)

All splices shall be encased in Fibre Optic Splice Enclosures. Suitable splice enclosures shall be provided to encase the optical cable splices in protective, moisture and dust free environment. Splice enclosures shall comply with ingress protection class IP 66 or better. The splice enclosures shall be designed for the storage and protection of required number of optical fibre splices and equipped with sufficient number of splice trays for splicing all fibres in the cable. No more than 12 fibres shall be terminated in a single splice tray. They shall be filled with suitable encapsulate that is easily removable should re-entry be required into the enclosures.

Splice enclosures shall be suitable for outdoor use with each of the cable types provided under this contract. Splice enclosures shall be appropriate for mounting on transmission line towers above anti-climb guard levels at about 10 metres from top of the tower and shall accommodate pass-through splicing. The actual mounting height and location shall be finalised after Survey. Contractor shall be responsible for splicing of fibres and installation of splice enclosures.

1.5.1 Optical Fibre Splices

Splicing of the optical fibre cabling shall be minimized through careful Contractor planning. There shall be no mid-span splices allowed. All required splices shall be planned to occur on tower structures. All optical fibre splicing shall comply with the following:

(a) All fibre splices shall be accomplished through fusion splicing.

(b) Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.

(c) All splices and bare fibre shall be neatly installed in covered splice trays.

(d) For each link, bi-directional attenuation of single mode fusion splices, shall not average more than 0.05 dB and no single splice loss shall exceed 0.1 dB when measured at 1550 nm.

(e) For splicing, fibre optic cable service loops of adequate length shall be provided so that all splices occurring at tower structures can be performed at ground level.

1.6 Fibre Optic Approach Cables

For purposes of this specification, a fibre optic approach cable is defined as the Armoured underground fibre optic cable required to connect Overhead Fibre Optic Cable (OPGW) between the final in line splice enclosure on the gantry / tower forming the termination of the fibre cable on the power line and the Fibre Optic Distribution Panel (FODP) installed within the building. The estimated fibre optic approach cabling length requirements are indicated in the appendices. However, the Contractor shall supply & install the optical fibre approach cable as required based on

detailed site survey to be carried out by the Contractor during the project execution and the Contract price shall be adjusted accordingly.

1.6.1 Basic Construction

The cable shall be suitable for direct burial, laying in trenches & PVC/Hume ducts, laying under false flooring and on indoor or outdoor cable raceways.

1.6.2 Jacket Construction & Material

The Approach Cable shall be a UV resistant, rodent proof, armoured cable with metallic type of armouring. The outer cable jacket for approach cable shall consist of carbon black polyethylene resin to prevent damage from exposure to ultra-violet light, weathering and high levels of pollution. The jacket shall conform to ASTM D1248 for density.

1.6.3 Optical, Electrical and Mechanical Requirements

Approach cable shall contain fibres with identical optical/ physical characteristics as those in the OPGW cables. The cable core shall comprise of tensile strength member(s), fibre support/bedding structure, core wrap/bedding, and an overall impervious jacket.

1.7 Fibre Optic Distribution Panel

Fibre Optic Distribution Panels is required for each location for termination of fibres in a manner consistent with the following:

(a) FODPs shall be suitable for use with each of the cable types provided as part of this contract. FODPs shall accommodate pass-through splicing and fibre terminations.

(b) FODPs for indoor use shall be supplied in suitable cabinets/racks with locking arrangement

(c) All FODPs shall be of corrosion resistant, robust construction and shall allow both top or bottom entry for access to the splice trays. Ground lugs shall be provided on all FODPs and the Contractor shall ensure that all FODPs are properly grounded. The FODP shall meet or exceed ingress protection class IP55 specifications.

1.7.1 Optical Fibre Connectors

Optical fibres shall be connectorised with FC-PC type connectors preferably. Alternatively connector with matching patch cord shall also be acceptable. Fibre optic couplings supplied with FODPs shall be appropriate for the fibre connectors to be supported. There shall be no adapters.

1.8 Service Loops

For purposes of this specification, cable and fibre service loops are defined as slack (extra) cable and fibre provided for facilitating the installation, maintenance and repair of the optical fibre cable plant.

(a) Outdoor Cable Service Loops: In-line splice enclosures installed outdoors and mounted on the utility towers shall be installed with sufficient fibre optic cable service loops such that the recommended minimum bend radius is maintained while allowing for installation or

maintenance of the cable to be performed in a controlled environment at ground level.

(b) Indoor Cable Service Loops: FODPs shall provide at least three (3) metres of cable service loop. Service loops shall be neatly secured and stored, coiled such that the minimum recommended bend radius' are maintained.

(c) Fibre Units Service Loops: For all fibre optic cable splicing, the cable shall be stripped back a sufficient length such that the fan-out of fibre units shall provide for at least one (1) metre of fibre unit service loop between the stripped cable and the bare fibre fan-out.

(d) Pigtail Service Loops : Connectorised pigtails spliced to bare fibres shall provide at least 1 metre of service loop installed in the FODP fibre organizer and at least one (1) metre of service loop to the couplings neatly stored behind the FODP coupling panels.

(e) Fibre Service Loops : At least 0.5 metre of bare fibre service loop shall be provided on each side of all fibre splices. The bare fibre service loops shall be neatly and safely installed inside covered splice trays.

1.9 Test Equipment

The table 1.3 below provides mandatory test equipment requirements, to be provided as applicable as per BoQ. The parameters / features of the mandatory equipments are enumerated as follows :

Table 1.3

S. No.	Test equipment	Parameter
A.	**Test Equipments for OPGW cable**	
1	OTDR (Optical Time Domain Reflectometer) for 1310/1550 nm with laser source.	Equivalent to Anritsu MW9076B1 or better.
2	Optical Attenuators (variable 1310/1550nm).	Equivalent to JDSU OLA55 or better.
3	Optical Power meter (1310/1550nm)	Equivalent to JDSU OLP55 or better
4	Optical Talk set	Equivalent to JDSU OTS55 or better.
5	Optical Fibre Fusion Splicer incl. Fibre cleaver	Equivalent to Sumitomo T-39-SE or better.
6	Calibrated Fibre	
7	Connectorization kit	FIS – FI-0053-FC-INST or equivalent
8	Splice kit	FIS – FI-0053-FF or equivalent
9	Optical test accessory kit including all necessary connectors, adaptors, cables, terminations and other items required for testing	FIS – FI-0053-TS-ST or equivalent

In case the offered make/model of test equipment has multiple options for the parameters, the option of higher range shall be acceptable. The supplied test equipment shall be suitable for use in the high

EMI/EMC environment. The Contractor shall submit performance certificate for offered test equipment from at least one customer. The Contractor shall offer only reputed make test equipment such as Acterna (JDSU)/Anritsu/Sumitomo/Agilent/EXFO etc.

2.0 Applicable Standards

The following standards and codes shall be generally applicable to the equipment and works supplied for OPGW and associated Items

(1) American Society for Testing and Materials ASTM

ASTM-B415	Standard Specification for Hard-Drawn Aluminium-Clad Steel Wire

(2) Bell Communication Research

GR-20	Generic requirements for optical fibre and optical fibre cable

(3) ITU-T/CCITT Recommendations

G.650	Definitions and test methods for the relevant parameters of single-mode fibres
G.652	Characteristics of a single-mode optical fibre cable

(4) IEEE

IEEE-1138	IEEE Standard Construction of Composite Fibre Optic Ground Wire (OPGW) for Use on Electric Utility power Lines

(5) Telecommunication Industry Association EIA/TIA

EIA/TIA-455-3	Procedure to Measure Temperature Cycling Effects on Optical Fibres, Optical Cable, and Other Passive Fiber Optic Components
EIA/TIA-455-16	Salt Spray (Corrosion) Test for Fibre Optic Components
EIA/TIA-455-20	Measurement of Change in Optical Transmittance
EIA/TIA-455-25	Repeated Impact Testing of Fibre Optic Cables and Cable Assemblies
EIA/TIA-455-32	Fibre Optic Circuit Discontinuities
EIA/TIA-455-33	Fibre Optic Cable Tensile Loading and Bending Test
EIA/TIA-455-41	Compressive Loading Resistance of Fibre Optic Cables
EIA/TIA-455-59	Measurement of Fibre Point Defects Using an OTDR
EIA/TIA-455-62	Measurement of Optical Fibre Macrobend Attenuation
EIA/TIA-455-78	Spectral Attenuation Cutback Measurement for Single- Mode Optical Fibres
EIA/TIA-455-80	Measurement of Cut-Off Wavelength of Single-Mode Fibre by Transmitted Power
EIA/TIA-455-81	Compound Flow (Drip) Test for Filled Fibre Optic Cable
EIA/TIA-455-82	Fluid Penetration Test for Fluid-Blocked Fibre optic Cable
EIA/TIA-455-91	Fibre Optic Cable Twist-Bend Test

EIA/TIA-455-164	Single-Mode Fibre, Measurement of Mode Field Diameter by Far-Field Scanning
EIA/TIA-455-167	Mode Field Diameter Measurement, Variable Aperture Method in the Far-Field
EIA/TIA-455-168	Chromatic Dispersion Measurement of Multimode Graded Index and Single-Mode Optical Fibres by Spectral Group Delay Measurement in the Time Domain
EIA/TIA-455-169	Chromatic Dispersion Measurement of Single-Mode Optical Fibres by the Phase-Shift Method
EIA/TIA-455-170	Cable Cut-off Wavelength of Single-Mode Fibre by Transmitted Power
EIA/TIA-455-174	Mode Field Diameter Measurement
EIA/TIA-455-175	Chromatic Dispersion Measurement of Single-Mode Optical Fibres by the Differential Phase-Shift Method
EIA/TIA-455-176	Method of Measuring Optical Fibre Cross-Sectional Geometry by Automated Grey-Scale Analysis
EIA/TIA-598	Optical Fibre Cable Colour Coding

(6) International Electrotechnical Commission IEC standards

IEC-60793-1 series	Optical fibres – Generic & product specifications, measurement methods & test procedures specification
IEC-60794-1-1	Optical fibre cables – Generic specification
IEC-60794-1-2	Optical fibre cables – Basic optical cable test procedure
IEC-60794-3	Optical fibre cables – Duct, buried and aerial cables – sectional specification
IEC-60794-4	Optical fibre cables – Overhead cables
IEC-61089	Round wire concentric lay overhead electrical stranded conductors
IEC-61232	Aluminium-clad steel wires for electrical purposes
IEC-61284	Overhead lines-Requirements and tests for fittings
IEC-61395	Overhead electrical conductors – Creep test procedures for stranded conductors

Specifications and codes shall be the latest version, inclusive of revisions, which are in force at the date of the contract award. Where new specifications, codes, and revisions are issued during the period of the contract, the Contractor shall attempt to comply with such, provided that no additional expenses are charged to the Employer without Employer's written consent.

In the event the Contractor offers to supply material and/or equipment in compliance to any standard other than Standards listed herein, the Contractor shall include with their proposal, full salient characteristics of the new standard for comparison.

In case values indicated for certain parameters in the specifications are more stringent than those specified by the standards, the specification shall override the standards.

I.10 References

(1) CIGRE Guide for Planning of Power Utility Digital Communications Networks
(2) CIGRE Optical Fibre Planning Guide for Power Utilities
(3) CIGRE New Opportunities for Optical Fibre Technology in Electricity Utilities
(4) CIGRE guide to fittings for Optical Cables on Transmission Lines

…….……..…End of this Section……...

Appendix-A

Data Requirement Sheets

Appendix-B

Data Requirement Sheets

The following sets of Data Requirement Sheets are required to be filled up by the bidders to aid in the evaluation process. The response shall be brief and to the point and shall be supported by the printed product description and other literature. The DRS duly filled and the relevant drawings shall also be submitted during the detailed engineering along with the relevant technical brochures.

DRS Form 1

DATA REQUIREMENTS SHEETS for OVERHEAD FIBRE OPTIC CABLE

OPTICAL GROUND WIRE (OPGW) – 48 Fibre:
(if applicable)

Manufacturer: _____

Part #: _____

Configuration: _____

CABLE CONSTRUCTION			
Seq	**Parameter:**	**As per Technical Specification**	**As per Bidder Offering**
1.	No. of Fibres Dual Window Single-Mode:	48	
2.	Buffer Type:	Loose Tube	
3.	Buffer Tube material	Non-metallic	
4.	No. of Buffer Tubes:	Minimum Four (4)	
5.	No. of Fibers per bufferTube:	Maximum Twelve(12)	
6.	Expected Cable Life:	25 Year	

DRS Form 2

DATA REQUIREMENTS SHEETS for OPTICAL FIBRE

DUAL-WINDOW SINGLE MODE (DW-SM)

OPTICAL PARAMETERS			
Seq	**Parameter:**	**As per Technical Specification**	**As per Bidder offering**
1.	Fiber manufacturer(s) / Type:		
2.	Attenuation Coefficient@ 1310 nm: @ 1550 nm:	≤ 0.35 dB/km ≤ 0.21 dB/km	
3.	Point discontinuity @ 1310nm: @ 1550nm:	≤ 0.05 dB ≤ 0.05 dB	
4.	Nominal Mode Field Diameter @ 1310 nm: @ 1550 nm:	8.6 to 9.5 µm (± 0.6 µm)	
5.	Chromatic Dispersion Coefficient @ 1310 (1288-1339) nm: @ 1310 (1271-1360) nm: @ 1550 nm:	3.5 ps/(nmxkm) 5.3 ps/(nmxkm) 18 ps/(nmxkm)	
6.	Zero dispersion wavelength:	1300 to 1324 nm	
7.	Cutoff wavelength:	≤ 1260 nm	
Physical and Mechanical Properties			
8.	Bend Performance: (37.5 mm radius, 100 turns) @1310 nm (30 mm radius, 100 turn) @1550 nm (16mm radius, 1 turn) @ 1550nm	 ≤ 0.05 dB ≤ 0.05 dB ≤ 0.50 dB	
9.	Cladding Diameter (nominal ± deviation):	125.0 µm ± 1 µm	
10.	Polarisation mode dispersion coefficient	≤ 0.2 ps/km$^{1/2}$	
11.	Proof test level	≥ 0.69 Gpa	

----------End of the Appendix----------

Chapter - 02
Inspection & Testing Requirement

Table of Content

Section - 02
Inspection & Testing Requirement

All materials furnished and all work performed under this Contract shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, and all deficiencies have been corrected to comply with this Specification and approved for shipment by the Employer.

Except where otherwise specified, the Contractor shall provide all manpower and materials for tests, including testing facilities, logistics, power and instrumentation, and replacement of damaged parts. The costs shall be borne by the Contractor and shall be deemed to be included in the contract price.

The entire cost of testing for factory, production tests and other test during manufacture specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector/Employer's representative.

Acceptance or waiver of tests shall not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

All tests shall be witnessed by the Employer and/or its authorized representative (hereinafter referred to as the Employer) unless the Employer authorizes testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.

Should any inspections or tests indicate that specific item does not meet Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies at no cost to the Employer. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

The Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified Type, Acceptance, Routine, or Manufacturing tests to assure the Employer of specification compliance.

2.1 Testing Requirements

Following are the requirements of testing :

1. Type Testing
2. Factory Acceptance Testing
3. Site Acceptance Testing

2.3.1 Type Testing

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type

Testing shall comply with the following:

(a) All cable & equipment being supplied shall conform to type tests as per technical specification.

(b) The test reports submitted shall be of the tests conducted within last seven (7) years for OPGW cable prior to the date of proposal/offer submitted. In case the test reports are older than seven (7) years for OPGW cable on the date of proposal/offer, the Contractor shall repeat these tests at no extra cost to the Employer.

(c) The Contractor shall submit, within 30 days of Contract Award, copies of test reports for all of the Type Tests that are specified in the specifications and that have previously (before Contract award) been performed. These reports may be accepted by the Employer only if they apply to materials and equipment that are essentially identical to those due to be delivered under the Contract and only if test procedures and parameter values are identical to those specified in this specifications carried out at accredited labs and witnessed by third party / customer's representatives.

In the event of any discrepancy in the test reports or any type tests not carried out, same shall be carried out by Contractor without any additional cost implication to the Employer.

In case the Type Test is required to be carried out, then following shall be applicable:-

(d) Type Tests shall be certified or performed by reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer. The test procedures shall be formatted as defined in the technical specifications and shall include a complete list of the applicable reference standards and submitted for Employer approval at least four (4) weeks before commencement of test(s). The Contractor shall provide the Employer at least 30 days written notice of the planned commencement of each type test.

(e) The Contractor shall provide a detailed schedule for performing all specified type tests. These tests shall be performed in the presence of a representative of the Employer.

(f) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.

(g) In case of failure during any type test, the Supplier is either required to manufacture a fresh sample lot and repeat all type tests successfully or repeat that particular type test(s) at least three times successfully on the samples selected from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

2.1.1 Type Test Samples

The Contractor shall supply equipment/material for sample selection only after the Quality Assurance Plan has been approved by the Employer. The sample material shall be manufactured strictly in accordance with the approved Quality Assurance Plan. The Contractor shall submit for Employer approval, the type test sample selection procedure. The selection process for conducting the type tests shall ensure that samples are selected at random. For optical fibres/ Fibre Optic cables, at least three reels/ drums of each type of fibre/cable proposed shall be offered for selection. For FO cable installation hardware & fittings at least ten (10) samples shall be offered for selection. For Splice enclosures at least three samples shall be offered for selection.

2.1.2 List of Type Tests

The type testing shall be conducted on the following items

(a) Optical fibres
(b) OPGW Cable
(c) OPGW Cable fittings
(d) Vibration Damper
(e) Splice Enclosure (Joint Box)
(f) Approach Cable

2.1.2.1 Type Tests for Optical Fibres

The type tests listed below in table 2-1 shall be conducted on DWSM fibres to be supplied as part of overhead cables. The tests specific to the cable type are listed in subsequent sections.

Table 2-1
Type Tests For Optical Fibres

S. No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation	As per Section-01 of TS	IEC 60793-1-40 Or EIA/TIA 455-78A
2	Attenuation Variation with Wavelength	As per Section-01 of TS	IEC 60793-1-40 Or EIA/TIA 455-78A
3	Attenuation at Water Peak	As per Section-01 of TS	IEC 60793-1-40 Or EIA/TIA 455-78A
4	Temp. Cycling (Temp dependence of Attenuation)		IEC 60793-1-52 Or EIA/TIA 455-3A, 2 cycles
5	Attenuation With Bending (Bend Performance)	As per Section-01 of TS	IEC 60793-1-47 Or EIA/TIA 455-62A
6	Mode Field dia.	As per Section-01 of TS	IEC 60793-1-45 Or EIA/TIA 455-164A/167A/174

Table 2-1
Type Tests For Optical Fibres

S. No.	Test Name	Acceptance Criteria	Test procedure
7	Chromatic Dispersion	As per Section-01 of TS	IEC 60793-1-42 Or EIA/TIA 455-168A/169A/175A
8	Cladding Diameter	As per Section-01 of TS	IEC 60793-1-20 Or EIA/TIA 455-176
9	Point Discontinuities of attenuation	As per Section-01 of TS	IEC 60793-1-40 Or EIA/TIA 455-59
10	Core -Clad concentricity error	As per Section-01 of TS	IEC 60793-1-20 Or EIA/TIA 455-176
11	Fibre Tensile Proof Testing	As per Section-01 of TS	IEC 60793-1-30 Or EIA/TIA 455-31B
-End Of table-			

2.1.2.2 Type Tests for OPGW Cables

The type tests to be conducted on the OPGW cable are listed in Table 2-2 Type Tests for OPGW Cables. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

Table 2-2
Type tests for OPGW Cable

S. No.	Test Name	Test Description	Test Procedure	
1	Water Ingress Test	IEEE 1138-2009	IEEE 1138-2009 (IEC 60794-1-2 Method F5 or EIA/TIA 455-82B) : Test duration : 24 hours	
2	Seepage of filling compound	IEEE 1138-2009	IEEE 1138-2009 (EIA/TIA 455-81B)	Preconditioning period:72 hours. Test duration: 24 hours.

Table 2-2
Type tests for OPGW Cable

S. No.	Test Name	Test Description	Test Procedure	
3	Short Circuit Test	IEEE 1138-2009	IEEE 1138-2009	Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. A suitable temperature sensor such as thermocouple shall be used to monitor and record the temperature inside the OPGW tube in addition to monitoring & recording the temperatures between the strands and between optical tube and the strand as required by IEEE 1138. Test shall be conducted with the tension clamps proposed to be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed after the test.
		Or IEC60794-4-10 / IEC 60794-1-2 (2003) Method H1		Initial temperature during the test shall be greater than or equal to ambient field temperature.
4	Aeolian Vibration Test	IEEE 1138-2009 Or IEC60794-4-10 / IEC 60794-1-2, Method E19	IEEE 1138-2009	Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. The vibration frequency and amplitude shall be monitored and recorded continuously. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring. Test shall be conducted with the tension/suspension clamps proposed to be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed after the test.
5	Galloping test	IEEE 1138-	IEEE 1138-2009	Test shall be conducted with

Table 2-2
Type tests for OPGW Cable

S. No.	Test Name	Test Description	Test Procedure	
		2009		the tension/suspension clamps proposed to be supplied. The cable and clamps shall be visually inspected for mechanical damage and photographed after the test. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring.
6	Cable Bend Test	Procedure 2 in IEC 60794-1-2 Method E11		The short-term and long-term bend tests shall be conducted in accordance with Procedure 2 in IEC 60794-1-2 E11 to determine the minimum acceptable radius of bending without any increase in attenuation or any other damage to the fibre optic cable core such as bird caging, deformation, kinking and crimping.
7	Sheave Test	IEEE 1138-2009 OR IEC 60794-1-2 (2003) Method E1B	IEEE 1138-2009	Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. The Sheave dia. shall be based on the pulling angle and the minimum pulley dia employed during installation. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring.
8	Crush Test	IEEE 1138-2009	IEEE 1138-2009 (IEC 60794-1-2, Method E3/ EIA/TIA 455-41B)	The crush test shall be carried out on a sample of approximately one (1) metre long in accordance with IEC 60794-1-2 E3. A load equal to 1.3 times the weight of a 400-metre length of fibre optic cable shall be applied for a period of 10 minutes. A permanent or temporarily increase in optical attenuation value greater than 0.1 dB change in sample shall constitute failure. The load shall be

Table 2-2
Type tests for OPGW Cable

S. No.	Test Name	Test Description	Test Procedure	
				further increased in small increments until the measured attenuation of the optical waveguide fibres increases and the failure load recorded along with results.
9	Impact Test	IEEE 1138-2009	IEEE 1138-2009, (IEC 60794-1-2 E4/ EIA/TIA 455-25B)	The impact test shall be carried out in accordance with IEC 60794-1-2 E4. Five separate impacts of 0.1-0.3kgm shall be applied. The radius of the intermediate piece shall be the reel drum radius ± 10%. A permanent or temporary increase in optical attenuation value greater than 0.1 dB/km change in sample shall constitute failure.
10	Creep Test	IEEE 1138-2009	IEEE 1138-2009	As per Aluminium Association Method, the best-fit straight line shall be fitted to the recorded creep data and shall be extrapolated to 25 years. The strain margin of the cable at the end of 25 years shall be calculated. The time when the creep shall achieve the strain margin limits shall also be calculated.
11	Fibre Strain Test	IEEE 1138-1994	IEEE 1138-1994	
12	Strain Margin Test	IEEE 1138-2009	IEEE 1138-2009	
13	Stress strain Test	IEEE 1138-2009	IEEE 1138-2009	
14	Cable Cut-off wavelength Test	IEEE 1138-1994	IEEE 1138-1994	
15	Temperature Cycling Test	IEEE 1138-2009	IEEE 1138-2009 Or IEC 60794-1-2, Method F1	
16	Corrosion (Salt Spray)	EIA/TIA 455-16A		

Table 2-2
Type tests for OPGW Cable

S. No.	Test Name	Test Description	Test Procedure
	Test		
17	Tensile Performance Test	IEC 60794-1-2 E1 / EIA/TIA 455-33B	The test shall be conducted on a sample of sufficient length in accordance with IEC 60794-1-2 E1. The attenuation variation shall not exceed 0.05 dB/Km up to 90% of RTS of fibre optic cable. The load shall be increased at a steady rate up to rated tensile strength and held for one (1) minute. The fibre optic cable sample shall not fail during the period. The applied load shall then be increased until the failing load is reached and the value recorded.
18	Lightning Test	IEC 60794-4-10 / IEC 60794-1-2 (2003)	The OPGW cable construction shall be tested in accordance with IEC 60794-1-2, Method H2 for Class 1.
19	DC Resistance Test (IEC 60228)	On a fibre optic cable sample of minimum 1 metre length, two contact clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge by placing the clamps initially zero metre and subsequently one metre apart. The tests shall be repeated at least five times and the average value recorded after correcting at 20°C.	
-End Of Table-			

2.1.2.3 Type Test on OPGW Cable Fittings

The type tests to be conducted on the OPGW Cable fittings and accessories are listed below:

(i) Mechanical Strength Test for Suspension/Tension Assembly
Applicable Standards: IEC 61284, 1997.

Suspension Assembly

The armour rods /reinforcement rods are assembled on to the approved OPGW using the Installation Instructions to check that the assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:
The suspension assembly shall be increased at a constant rate up to a load equal to 50% of

the specified minimum Failure Load increased and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. The angle between the cable, the Suspension Assembly and the horizontal shall not exceed 16^{o}. This load shall then be removed in a controlled manner and the Protection Splice disassembled. Examination of all the components shall be made and any evidence of visual deformation shall be documented.

Part 2:
The Suspension clamp shall then be placed in the testing machine. The tensile load shall gradually be increased up to 50% of the specified Minimum Failure Load of the Suspension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load is reached and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value shall be documented.

Tension Assembly

The Tension Assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:
The tension assembly (excluding tension clamp) shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased at a constant rate and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. This load shall then remove in a controlled manner and the Tension Assembly disassembled. Examination of the Tension Dead-End and associated components shall be made and any evidence of visual deformation shall be documented.

Part 2:
The Tension Dead-End and associated components shall then be reassembled and bolts tightened as before. The tensile load shall gradually be increased up shall gradually be increased up to 50% of the specified Minimum Failure Load of the Tension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load is reached and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value shall be documented.

Acceptance Criteria for Tension/Suspension Assembly:

- No evidence of binding of the Nuts or Deformation of components at end of Part 1 of Test.
- No evidence of Fracture at the end of one minute at the minimum failure load during Part 2 of the Test.

Any result outside these parameters shall constitute a failure.

(ii) Clamp Slip Strength Test for Suspension Assembly

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length fibre optical cable shall be fixed in the clamps. Once the Suspension Clamp has been assembled, the test rig is tensioned to 1 kN and the position scale on the recorder 'zeroed'. The test rig is then tensioned to 2.5 kN and the relative positions of the Reinforcing

Rods, Armour Rods and Suspension Clamp shall be marked by a suitable means to confirm any slippage after the test has been completed. The relative positions of the helical Armour Rods and associated Reinforcing Rods at each end shall be marked and also 2 mm relative position between clamp body and Armour Rods shall be marked on one side. The load shall be increased to 12 kN at a loading rate of 3 kN/min and held for one minute. At the end of this one minute period, the relative displacement between clamp body and the armour rods shall be observed. If the slippage is 2 mm or above, the test shall be terminated. Otherwise, at the end of one minute the position of the clamp body and 2 mm. relative positions between clamp body and armour rods shall be marked on the other side. After the one minute pause, the load shall be further increased at a loading rate of 3 kN/min, and recording of load and displacement shall continue until either the relative Position displacement between clamp body and armour rods reaches more than 2 mm or the load reaches the maximum slip load of 17 kN. On reaching either of the above values the test is terminated. Visual examination of all paint marks shall be recorded, and a measurement of any displacement recorded in the Table of Results.

Acceptance Criteria:

The Suspension Clamp has passed the Slip Test if the following conditions are met:

- No slippage* shall occur at or below the specified minimum slip load.

  * Definition of no slippage in accordance with IEC 61284, 1997:- Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the cable as a result of the test itself are not regarded as slippage.

- Slippage shall occur between the specified maximum and minimum slip load of 12 - 17 kN.

- There shall be no slippage of the Reinforcing Rods over the cable, and no slippage of the Armour Rods over the Reinforcing Rods.

- The relative movement (i.e. more than 2 mm between Armour Rods & Clamp body) between minimum 12 kN and maximum slip 17 kN, shall be considered as slip.

- The Armour Rods shall not be displaced from their original lay or damaged**.

  ** Definition of no damage in accordance with convention expressed in IEC 61284: 1997 no damage, other than surface flattening of the strands shall occur.

Any result outside these parameters is a failure.

(iii) Slip Strength Test of Tension Clamp

Tension clamps shall be fitted on an 8 m length of fibre optic cable on both ends. The assembly shall be mounted on a tensile testing machine and anchored in a manner similar to the arrangement to be used in service. A tensile load shall gradually be applied up to 20 % of the RTS of OPGW. Displacement transducers shall be installed to measure the relative movement between the OPGW relative to the Reinforcing Rods and Tension Dead -End relative to Reinforcing Rods. In addition, suitable marking shall be made on the OPGW and Dead-End to confirm grip. The load shall be gradually increased at a constant rate up to 50 %

of the UTS and the position scale of the recorder is zeroed. The load shall then gradually increased up to 95 % of the UTS and maintained for one minute. After one minute pause, the load shall be slowly released to zero and the marking examined and measured for any relative movement.

Acceptance Criteria:

- No movement* shall occur between the OPGW and the Reinforcing Rods, or between the Reinforcing Rods and the Dead-End assembly.
- No failure or damage or disturbance to the lay of the Tension Dead-End, Reinforcing Rods or OPGW.

* Definition of no movement as defined in IEC 61284: Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the conductor as a result of the test itself are not regarded as slippage.

Any result outside these parameters shall constitute a failure.

(iv) Grounding Clamp and Structure Mounting Clamp Fit Test

For structure mounting clamp, one series of tests shall be conducted with two fibre optic cables installed, one series of tests with one fibre optic cable installed in one groove, and one series of tests with one fibre optic cable in the other groove. Each clamp shall be installed including clamping compound as required on the fibre optic cable. The nut shall be tightened on to the bolt by using torque wrench with a torque of 5.5 kgm or supplier's recommended torque and the tightened clamp shall be held for 10 minutes. After the test remove the fibre optic cable and examine all its components for distortion, crushing or breaking. Also the fibre optic cable shall be checked to ensure free movement within the core using dial callipers to measure the diameter of the core tube. The material shall be defined as failed if any visible distortion, crushing, cracking or breaking of the core tube is observed or the fibre optic cable within the core tube is not free to move, or when the diameter of the core tube as measured at any location in the clamped area is more than 0.5 mm larger or smaller of the core diameter as measured outside the clamped area.

(v) Structure Mounting Clamp Strength Test

The clamp and mounting assembly shall be assembled on a vertical 200 mm x 200 mm angle and a short length of fibre optic cable installed. A vertical load of 200 kg shall be applied at the end of the mounting clamp and held for 5 minutes. Subsequently, the load shall be increased to 400 kg and held for 30 seconds. Any visible distortion, slipping or breaking of any component of the mounting clamp or assembly shall constitute failure.

2.1.2.4 Type Test on Vibration Damper

The testing standard of vibration damper for OPGW shall be as per applicable international standard i.e. IEC 61897.

(a) Dynamic Characteristic Test

The damper shall be mounted with its clamp tightened with torque recommended by the manufacturer on shaker table capable of simulating sinusoidal vibrations for Critical Aeolian

Vibration frequency band ranging from 0.18/d to 1.4/d – where d is the OPGW cable diameter in meters. The damper assembly shall be vibrated vertically with a ±1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at 0.5 mm to determine following characteristics with the help of suitable recording instruments.

(i) Force Vs frequency

(ii) Phase angle Vs frequency

(iii) Power dissipation Vs frequency

The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs between the resonance frequencies. The resonance frequencies shall be suitably spread within the Aeolian vibration frequency-band between the lower and upper dangerous frequency limits determined by the vibration analysis of fibre optic cable without dampers.

Acceptance criteria for vibration damper:

(i) The above dynamic characteristics test on five damper shall be conducted.

(ii) The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.

(iii) The above mean reactance response curve should lie within following limits:

V.D. for OPGW - 0.060 f to 0.357 f kgf/mm*

Where f is frequency in Hz.

(iv) The above mean phase angle response curve shall be between 25^{o} to 130^{o} within the frequency range of interest.

(v) If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.

(vi) Visual resonance frequencies of each mass of damper is to be recorded and to be compared with the guaranteed values.

(b) Vibration Analysis

The vibration analysis of the fibre optic cable shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be taken into account for the purpose of analysis.

(i) The analysis shall be done for single fibre optic cable without armour rods. The tension shall be taken as 25% of RTS of fibre optic cable for a span ranging from 100 m to 1100 m.

(ii) The self damping factor and flexural stiffness (EI) for fibre optic cable shall be calculated on the basis of experimental results. The details to experimental analysis with these data shall be furnished.

(iii) The power dissipation curve obtained from Damper Characteristics Test shall be used for analysis with damper.

(iv) Examine the Aeolian Vibration level of the fibre optic cable with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and vibration energy input.

(v) From vibration analysis of fibre optic cable without damper, antinode vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the Aeolian vibration levels exceed the specified limits shall be determined.

(vi) From vibration analysis of fibre optic cable with damper(s) installed at the recommended location, the dynamic strain level at the clamped span extremities, damper attachment point and the antinodes on the fibre optic cable shall be determined. In addition to above damper clamp vibration amplitude and antinodes vibration amplitudes shall also be examined.

The dynamic strain levels at damper attachment point, clamped span extremities and antinodes shall not exceed the specified limits. The damper clamp vibration amplitude shall not be more than that of the specified fatigue limits.

(c) Fatigue Tests

(i) Test Set Up

The fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30m. The fibre optic cable shall be tensioned at 25% of RTS of fibre optic cable and shall not be equipped with protective armour rods at any point.

Constant tension shall be maintained within the span by means of lever arm arrangement. After the fibre optic cable has been tensioned, clamps shall be installed to support the fibre optic cable at both ends and thus influence of connecting hardware fittings are eliminated from the free span. The clamps shall not be used for holding the tension on the fibre optic cable. There shall be no loose parts, such as suspension clamps, U bolts, on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for step less speed control as well as step less amplitude arrangement. Equipment shall be available for measuring the frequency, cumulative number of cycles and amplitude of vibration at any point along the span.

(ii) Fatigue Test

The vibration damper shall be installed on the test span with the manufacturer's specified tightening torque. It shall be ensured that the damper shall be kept minimum three loops away from the shaker to eliminate stray signals influencing damper movement.

The damper shall then be vibrated at the highest resonant frequency of each damper mass. For dampers involving torsional resonant frequencies, tests shall be done at torsional modes also in addition to the highest resonant frequencies at vertical modes. The resonance frequency shall be identified as the frequency at which each damper mass vibrates with the

maximum amplitude on itself. The amplitude of vibration of the damper clamp shall be maintained not less than ±25/f mm where f is the frequency in Hz.

The test shall be conducted for minimum ten million cycles at each resonant frequency mentioned above. During the test, if resonance shift is observed, the test frequency shall be tuned to the new resonant frequency.

The clamp slip test as mentioned herein shall be repeated after fatigue tests without retorquing or adjusting the damper clamp, and the clamp shall withstand a minimum load equal to 80% of the slip strength for a minimum duration of one minute.

After the above tests, the damper shall be removed from fibre optic cable and subjected to dynamic characteristics test. There shall not be any major deterioration in the characteristics of the damper. The damper then shall be cut open and inspected. There shall not be any broken, loose, or damaged part. There shall not be significant deterioration or wear of the damper. The fibre optic cable under clamp shall also be free from any damage.

For purposes of acceptance, the following criteria shall be applied:

(1) There shall not be any resonant frequency shift before and after the test by more than ± 20%

(2) The power dissipation of the damper before and after test at the individual resonant frequencies do not differ by more than ± 20%

Beside above tests, the type tests listed below in the table shall also be conducted on Vibration Damper

Sl No.	Test Name	Test Procedure
1	Visual examination & Dimensional and material verification	IEC 61897 Clause 7.1 & 7.2
2	Clamp Slip test	IEC 61897 Clause 7.5
3	Clamp bolt tightening test	IEC 61897 Clause 7.7
4	Attachments of weights to messenger cable	IEC 61897 Clause 7.8
5	Attachment of clamps to messenger cable	IEC 61897 Clause 7.8
6	Damper effectiveness evaluation	IEC 61897 Clause 7.11.3.2

2.1.2.5 Type Tests for Splice Enclosures (Joint Box)

Following Type tests shall be demonstrated on the Splice Enclosure(s) (Splice Enclosure/Box). For certain tests, lengths of the fibre optic cable shall be installed in the splice box, and the fibres must be spliced and looped in order to simulate conditions of use. The attenuation of the fibres shall be measured, during certain tests, by relevant Fibre Optic Test Procedures (EIA/TIA 455 or IEC 60794-1 procedures).

(i) Temperature Cycling Test

FO cable is installed in the splice enclosure and optical fibres spliced and looped. The box must be subjected to 5 cycles of temperature variations of -40°C to +65°C with a dwell time of at least 2 hours on each extreme.

Fibre loop attenuation shall be measured in accordance with EIA 455-20 / IEC 60794-1-C10. The variation in attenuation shall be less than ±0.05dB. The final humidity level, inside the box, shall not exceed the initial level, at the closing of the box.

(ii) Humid Heat test

The sealed splice enclosure, with fibres spliced and looped inside, must be subjected to a temperature of +55°C ±2°C with a relative humidity rate of between 90% and 95% for 5 days. The attenuation variation of the fibres during the duration of the test shall be less than ±0.05dB, and the internal humidity rate measured, less than 2%.

(iii) Rain Withstand Test / Water Immersion test

The splice enclosure with optical fibres cable installed and fibres spliced fixed, shall be subjected to 24 hours of simulated rain in accordance with IEC 60060 testing requirements. No water seepage or moisture shall be detected in the splice enclosure. The attenuation variation of the fibres after the test shall be less than ±0.05dB.

(iv) Vibration Test

The splice enclosure, with fibres united inside, shall be subjected to vibrations on two axes with a frequency scanning of 5 to 50 Hz. The amplitude of the vibrations shall be constant at 0.450mm, peak to peak, for 2 hours, for each of the vibrations' axes. The variation in attenuation, of the fibres, shall be less than ±0.05dB. The splice enclosure shall be examined for any defects or deformation. There shall be no loosening or visible damage of the FO cable at the entry point.

(v) Bending and Torsion test

The splice enclosure, with fibres spliced inside, shall be firmly held in place and be subjected to the following sequence of mechanical stresses on the cable:

a) 3 torsion cycles of ±180° shall be exercised on the cable. Each cycle shall be less than one minute.

b) 3 flexure cycles of the cable, of ±180° with one cycle less than one minute.

The variation in the attenuation, of the fibres, shall be less than ±0.05dB. The cables connection ring shall remain securely fixed to the box with the connection maintained firmly. No defects/fissures shall be noted on the joint ring or on the splice enclosure

(vi) Tensile test

The splice enclosure with cable fixed to the boxes shall be subjected to a minimum tension of 448 N for a period of two minutes. No fissure shall be noted in the connections or on the box.

(vii) Drop Test

With 2 lengths of 11 metres of cable fixed to the box, it shall be dropped five times from a height of 10 metres. There shall be no fissure, at all, of the box, and the connections shall remain tight. The test surface shall be carried out in accordance with IEC 60068-2-32.

2.1.2.6 Type Tests for Fibre Optic Approach Cable

The type tests to be conducted on the Fibre Optic Approach cable are listed in Table 2-3: Type Tests for Fibre Optic Approach Cable. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

Table 2-3:
Type Tests Fibre Optic Approach Cable

S.NO.	Test Name	Test Procedure
1	Water Ingress Test	(IEC 60794-1-F5 / EIA 455-82B) Test duration : 24 hours
2	Seepage of filling compound	(EIA 455-81A) Preconditioning : 72 hours, Test duration : 24 hours.
3	Crush Test	(IEC 60794-1-E3/ EIA 455-41)
4	Impact Test	(IEC-60794-1-E4/ EIA 455-25A)
5	Stress strain Test	(EIA 455-33A)
6	Cable Cut-off wavelength Test	(EIA 455-170)
7	Temperature Cycling Test	(IEC60794-1-F1/EIA-455-3A) – 2 cycles
-End Of Table-		

2.1.2.6.1 Impact Test

The Impact test shall be carried out in accordance with IEC:60794-1-E4. Five separate impacts of 2.0 kg shall be applied at different locations. The radius of the intermediate piece shall be the reel drum radius ± 10%. A permanent or temporary increase in optical attenuation value greater than 0.05 dB/km shall constitute failure.

2.2 Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Factory acceptance testing shall be carried out on OPGW Cable and associated hardware & fittings, Approach Cable, Joint Box, FODP etc. and all other items for which price has been identified separately in the Bid Price Schedules.

Material shall not be shipped to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employer approval to ship, shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer's authorised representatives unless waiver for witnessing by Employer's representatives is intimated to the contractor.

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

The factory acceptance tests for the supplied items shall be proposed by the Contractor in accordance with technical specifications and Contractor's (including Sub-Contractor's / supplier's) standard FAT testing program. In general the FAT for other items shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces etc.

For Test equipment FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer's final inspection certificate/ report.

2.2.1 Sampling for FAT

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, all required FAT tests in the approved FAT procedures, shall be performed on all samples. The Sampling rate for the Factory acceptance tests shall be minimum 10% of the batch size (minimum 1) for all items. The physical verification shall be carried out on 100% of the offered quantities as per the approved FAT procedure. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected.

For the OPGW cable hardware fittings & accessories, the minimum sampling rate, and batch acceptance criteria shall be as defined in IS 2486.

The Sampling rate for the Factory acceptance tests shall be 10% of the batch size (minimum 2) for FO cable drums, FODPs, Joint box and other similar items.

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/ approvals until such a report is made and remedial actions taken, as applicable.

2.2.2 Production Testing

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by

him. The production tests to be carried out at each stage of production shall be based on the Contractor's standard quality assurance procedures. The production tests to be carried out shall be listed in the Manufacturing Quality Plan (MQP), alongwith information such as sampling frequency, applicable standards, acceptance criteria etc.

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

2.2.3 Factory Acceptance Tests on Optical Fibre to be supplied with OPGW

The factory acceptance tests listed in table below are applicable for the Optical fibres to be supplied. The listed tests follow testing requirements set forth in IEEE standard 1138/IEC 60794. The referenced sections specify the detailed test description. The acceptance norm shall be as specified in the above mentioned IEEE standards unless specified otherwise in the technical specifications.

Table 2-4
Factory Acceptance Tests for Optical Fibres: Optical Tests

S. No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation Coefficient	T S,Table 1-1(a)	EIA/TIA 455- 78A
2	Point Discontinuities of attenuation	TS, Section 1.1.2	EIA/TIA 455-59
3	Attenuation at Water Peak	TS ,Table 2-1(a)	EIA/TIA 455- 78A
4	Chromatic Dispersion		EIA/TIA 455-168A/169A/175A
5	Core – Clad Concentricity Error		EIA/TIA 455-/176
6	Cladding diameter		EIA/TIA 455-176
7	Fibre Tensile Proof Testing		EIA/TIA 455-31B
-End of table-			

The test report for the above tests for the fibers carried out by the Fiber Manufacturer and used in the OPGW cables shall be shown to the inspector during OPGW cable FAT and shall be submitted along with the OPGW cable FAT report.

2.2.4 Factory Acceptance Test on OPGW Cable

The factory acceptance tests for OPGW cable specified below in Table follow the requirements set forth in IEEE standard 1138 / IEC 60794. The FAT shall be carried out on 10% of offered drums in each lot as specified in technical specifications and the optical tests shall be carried out in all fibres of the selected sample drums. The Rated Tensile Strength test shall be carried out on one sample in each lot.

Table 2-5
Factory Acceptance Tests on OPGW
Applicable standard: IEEE 1138 / IEC 60794

S. No.	Factory Acceptance Test on Manufactured OPGW
1	Attenuation Co-efficient at 1310 nm and 1550 nm
2	Point discontinuities of attenuation
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Rated Tensile Strength
5	Lay Length Measurements

2.2.5 Factory Acceptance Test on OPGW Fittings

The factory acceptance tests for OPGW Fittings as specified below in Table 2-6. The sampling plan shall be as per relevant standard:

Table 2-6
Factory Acceptance Tests On OPGW Fittings

S. No.	Factory Acceptance Test
Suspension Assembly	
1	UTS/Mechanical Strength of the assembly
2	Clamp Slip Test
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Mechanical strength of each component
5	Galvanising test
Tension Assembly	
6	Clamp Slip Strength test
7	Visual Material verification and dimensional checks as per approved DRS/Drawings
8	Mechanical strength of each component
9	Galvanising Test
Vibration Damper	
10	Galvanising test on damper, masses and messenger wires
11	Damper response (resonant frequencies)
12	Clamp Slip test
13	Strength of messenger wires
14	Attachments of weights to messenger cable

Table 2-6
Factory Acceptance Tests On OPGW Fittings

S. No.	Factory Acceptance Test
15	Attachments of clamps to messenger cable
16	Clamp bolt tightening test
17	Clamp bolt torque test
18	Dynamic characteristic test.
19	Visual Material verification and dimensional checks as per approved DRS/Drawings
Structure Mounting Clamp	
20	Clamp fit test
21	Clamp Strength test
22	Visual Material verification and dimensional checks as per approved DRS/Drawings
End of Table	

2.2.6 Factory Acceptance Test on Approach Cable

The factory acceptance tests for Approach Cable specified below in Table 2-7:

Table 2-7
Factory Acceptance Tests On Approach Cable

S. No.	Factory Acceptance Test
1	Attenuation Co-efficient at 1310 nm and 1550 nm
2	Point discontinuities of attenuation
3	Visual Material verification and dimensional checks as per approved DRS/Drawings

2.2.7 Factory Acceptance Test on Splice Enclosure (Joint Box) /FODP

The factory acceptance tests for Splice Enclosures/FODP as specified below in Table: 2-8

Table 2-8
Factory Acceptance Tests on Splice Enclosures (Joint Box)/FODP

S. No.	Factory Acceptance Test
1	Visual check of Quantities and Specific Component Number for each component

	of Splice Enclosure/FODP and dimensional checks against the approved drawings.

2.2.8 Factory Acceptance Test on Test Equipment & other items

As per technical specification and approved DRS/Documents.

2.3 Site Acceptance Tests

The Contractor shall be responsible for the submission of all material & test equipment supplied in this contract for site tests and inspection as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate.

The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. At a minimum Site Acceptance Testing requirement for FO cable etc. is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s) for FO installation.

During the course of installation, the Employer shall have full access for inspection and verification of the progress of the work and for checking workmanship and accuracy, as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the Employer to demonstrate that it is entirely suitable for commercial operation.

2.3.1 Minimum Site Acceptance Testing Requirement for FO Cabling

Prior to installation, every spooled fibre optic cable segment shall be tested for compliance with the Pre-shipment data previously received from the manufacturer. This requirement will preclude the installation of out of specification cable segments that may have been damaged during shipment.

2.3.1.1 Phases of Site Acceptance Testing

SAT shall be carried out link by link from FODP to FODP. SAT may be performed in parts in case of long links.

The tests, checks, adjustments etc conducted by the Contractor prior to offering the equipment for SAT shall be called Pre-SAT activities. The Pre-SAT activities shall be described in the installation manuals and Field Quality Plan documents.

Sag and tension of OPGW shall generally be as per approved sag-tension chart and during installation, sag and tension of OPGW shall be documented. Upon completion of a continuous cable path, all fibres within the cable path shall be demonstrated for acceptance of the cable path. Fibre Optic cable site testing minimum requirements are provided in Table 2-9(a) through 2-9(c) below:

Table 2-9(a)
Fibre Optic Cable Pre-Installation Testing

Item:	Description:
1.	Physical Inspection of the cable assembly for damage
2.	Optical fibre continuity and fibre attenuation with OTDR at 1550 nm
3.	Fibre Optic Cable length measurement using OTDR

Table 2-9(b)
Fibre Optic Cable Splicing Testing

Item:	Description:
1.	Per splice bi-directional average attenuation with OTDR
2.	Physical inspection of splice box/enclosure for proper fibre / cable routing techniques
3.	Physical inspection of sealing techniques, weatherproofing, etc.

Table 2-9(c)
Fibre Optic Cable Commissioning Testing

Item:	Description:
1.	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by OTDR.
2.	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by Power meter.
3.	Bi-directional average splice loss by OTDR of each splice as well as for all splices in the link (including at FODP also).
4.	Proper termination and labelling of fibres & fibre optic cables at FODP as per approved labelling plan.
-End of Table-	

----------End of this Section----------

Chapter-03

Installation for OPGW Cabling

Table of Content

Section-03
Installation of OPGW Cabling

3.1 Installation requirements

The OPGW cable shall be installed at the top of the tower in place of earthwire (only one of the earthwire peaks in case of 400kV & above lines, if applicable) for under construction transmission lines as envisaged.

The OPGW cable sections shall normally be terminated & spliced only on tension towers. In exceptional circumstances, and on Employer specific approval, cable may be terminated on suspension towers, but in this case tower strength shall be examined to ensure that tower loads are within safe limits and if required, necessary tower strengthening shall be carried out by the Contractor.

For OPGW Cable to be installed on new line transmission line, the stringing shall be carried by the Transmission Line Contractor as per the stringing chart/procedure submitted by them and approved by Employer. The Contractor shall install OPGW as per approved stringing procedure.

The Contractor shall follow precautions including proper location of drum site, installation of stringing blocks/pulleys, proper sagging, proper installation of hardware, proper tension as per Sag-Tension chart, provision of service loops of OPGW in jointing locations etc.

3.1.1 Installation of OPGW cable

The OPGW cable sections shall normally be terminated & spliced only on tension towers. In exceptional circumstances and on Employer specific approval, cable may be terminated on Suspension towers, but in this case tower strength shall be examined to ensure that tower loads are within safe limits and if required, necessary tower strengthening shall be carried out by the Contractor. In such a case, the jointing of OPGW on suspension tower if required, shall be acceptable subject to its suitability.

3.1.2 Installation Hardware Fittings

All required hardware fittings shall be installed alongwith OPGW Cable.

3.2 Installation of Approach Cable

The existing cable trenches/ cable raceways proposed to be used shall be identified in the survey report. The Contractor shall make its best effort to route the cable through the existing available cable trenches. Where suitable existing cable trenches are not available, suitable alternatives shall be provided after Employer approval. However, the approach cable shall be laid in the HDPE pipe in all condition.

Suitable provisions shall be made by the Contractor to ensure adequate safety earthing and insulated protection for the approach cable.

All required fittings, supports, accessories, ducts, inner ducts, conduits, risers and any item not specially mentioned but required for laying and installation of approach cables shall be supplied and installed by the Contractor.

3.3 Optical Fibre Termination and Splicing

Optical fibre terminations shall be installed in Fibre Optic Distribution Panels (FODP) designed to provide protection for fibre splicing of preconnectorized pigtails and to accommodate connectorized termination and coupling of the fibre cables. The Contractor shall provide rack /wall mounted Fibre Optic Distribution Panels (FODPs) sized as indicated in the appendices and shall terminate the fibre optic cabling up to the FODPs. The location of FODP rack shall be fixed by the Contractor, with the Employer's approval.

3.4 Fibre Optic Distribution Panel

At each location requiring the termination of at least one fibre within a cable, all fibres within that cable shall be connectorized and terminated in Fibre Optic Distribution Panels in a manner consistent with the following :

(a) All fibre optic terminations shall be housed using FODPs provisioned with splice organizers and splice trays. All fibres within a cable shall be fusion spliced to pre-connectorized pigtails and fitted to the "Back-side" of the provided fibre optic couplings.

(b) Flexible protection shall be provided to the patch cord bunches going out from FODP to other equipment.

3.5 Methodology for Installation and Termination

All optical fibre cable termination, installation, stringing and handling plans, guides and procedures, and engineering analysis (e.g. tension, sag, vibration etc.) shall be submitted to the Employer for review and approval in the engineering/design phase of the project, prior to establishing the final cable lengths for manufacture. Installation procedures including details of personnel and time required shall be documented in detail and submitted to Employer for approval. All installation practices shall be field proven and ISO accredited.

All cable segments shall include service loops as specified in this specification .The maximum allowable stringing tension, maximum allowable torsional shear stress, crush strength and other physical parameters of the cable shall not be exceeded. The preventative measures to be taken shall be documented in detail and submitted to Employer in advance of installation.

Optical fibre attenuation shall be measured after installation and before splicing. Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable segment failure. In the event of cable damage or any fibre damage, the complete section (tension location to tension location) shall be replaced as mid-span joints are not acceptable.

Any or all additional steel work or modifications required to attach the fibre cabling to the overhead transmission/ distribution line towers shall also be carried out by the Contractor. It shall be the Contractors responsibility to provide adequate communications among all crew members and support

staff to ensure safe and successful installations.

3.6 Cable Raceways

To the extent possible, existing cable raceways shall be utilised. The Contractor is required to provide and install any additional indoor cable raceways which may be required for proper implementation of the fibre optic cabling system. This requirement shall be finalised during survey. The cable raceways shall conform to the following:

(a) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.

(b) Indoor cable raceways shall be fabricated from construction grade aluminium, galvanized iron or anodized sheet metal or any other suitable material approved by the Employer. Suitable anti-corrosion measures shall be provided. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to- paint bond.

(c) Mechanical construction drawings of the cable raceways shall be submitted for Employer's information & review.

…….……..…End of this Section……...

TECHNICAL SPECIFICATION FOR G.I.S

SECTION – GAS INSULATED SWITCHGEAR

Revision 00

Technical Specification: Chapter 19-GIS

1. GENERAL CHARACTERISTICS

1.1. The SF6 gas insulated metal enclosed switchgear shall be totally safe against inadvertent touch of any of it's constituent parts. It should be designed for indoor application with meteorological conditions at site as per Section Project.

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 220kV and three phase enclosed for 132 KV.

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

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

S. No	Technical particulars	220 kV System	132KV system	66KV system
1.	Rated Voltage (RMS)	245 kV	145 kV	72 kV
2.	Rated frequency	50 HZ	50 HZ	50 HZ
	Grounding	Effectively earthed	Effectively earthed	Effectively earthed
3.	Rated power frequency withstand Voltage (1 min) line to earth (rms)	460 kV	275 kV	140 kV
4.	Impulse withstand BIL (1.2/50/mic. Sec) Line to earth	±1050 kVp	±650 kVp	±320 kVp
5.	Rated short time withstand current (1 sec) (As applicable)	40 kA (rms)	31.5kA (rms)	31.5kA (rms)
6.	Rated peak withstand current (as applicable)	125/100 kA (peak)	78.75kA (peak)	78.75kA (peak)
7.	Rated current (at 50 degree C design ambient temperature)	As per BPS		As per BPS

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.

3. DEFINITIONS

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

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

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

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

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

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

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

GENERAL DESIGN AND SAFETY REQUIREMENT

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.

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

3.9. 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.

3.10. 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.

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

The bus enclosure should be sectionalized in a manner that maintenance work on any bus disconnector (when bus and bus disconnector are enclosed in a single enclosure) can be carried out by isolating and evacuating the small effected section and not the entire bus.. The design of 220/132 kV GIS shall be such that in case a circuit breaker module of a feeder is removed for maintenance, both busbars shall remain in service. 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.

Typical drawings indicating gas tight compartments are enclosed at **Annexure-A**.

3.12. 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.

3.13. 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.

3.14. 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.

3.15. 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.

3.16. 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

3.17. 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.

3.18. 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.

3.19. The thermal rating of all current carrying parts shall be minimum for one sec. for the rated symmetrical short-circuit current.

3.20. 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)

3.21. 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.

3.22. 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.

3.23. All the elements shall be accessible without removing support structures for routine inspections. The removal of individual enclosure parts or entire breaker bays shall be possible without disturbing the enclosures of neighboring bays.

3.24. 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.

3.25. 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.

3.26. 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.

3.27. The enclosure shall be of continuous design and shall meet the requirement as specified in clause no. 10 (special considerations for GIS) of IEEE- 80, Year- 2000.

The enclosure shall be sized for carrying induced current equal to the rated current of the Bus. The conductor and the enclosure shall form the concentric pair with effective shielding of the field internal to the enclosure.

3.28. 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.

3.29. 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.

3.30. 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.

3.31. 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.

3.32. The ladders and walkways shall be provided wherever necessary for access to the equipment.

3.33. 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.

3.34. 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.

3.35. The sealing provided between flanges of two modules / enclosures shall be such that long term tightness is achieved.

3.36. 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.

3.37. 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.

3.38. 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

3.39. **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.

3.40. **Indication and verification of switch positions**: Indicators shall be provided on all circuit breakers, isolators and earth-switches, which shall clearly show whether the switches are open or closed. The indicators shall be mechanically coupled directly to the main contact operating drive rod or linkages and shall be mounted in a position where they are clearly visible from the floor or the platform in the vicinity of the equipment.

Inspection windows shall also be provided with all isolators and earth switches so that the switch contact positions can be verified by direct visual inspection.

3.41. **Pressure relief device** : Pressure relief devices shall be provided in the gas sections to protect the gas enclosures from damage or distortion during the occurrence of abnormal pressure increase or shock waves generated by internal electrical fault arcs (preferably in downward direction).

Pressure relief shall be achieved either by means of diaphragms or plugs venting directly into the atmosphere in a controlled direction.

If the pressure relief devices vent directly into the atmosphere, suitable guards and deflectors shall be provided. Contractor shall submit to the owner the detailed criteria/ design regarding location of pressure relief devices/rupture diaphragms.

3.42. **Pressure vessel requirements**: The enclosure shall be designed for the mechanical and thermal loads to which it is subjected in service. The enclosure shall be manufactured and tested according to the pressure vessel code (ASME/CENELEC code for pressure Vessel.)

The bursting strength of Aluminum castings has to be at least 5 times the design pressure. A bursting pressure test shall be carried out at 5 times the design pressure as a type test on each type of enclosure.

Each enclosure has to be tested as a routine test at 1.5 times the design pressure for one minute.

3.43. **Grounding:**

3.43.1. The grounding system shall be designed and provided as per IEEE-80-2000 and CIGRE-44 to protect operating staff against any hazardous touch voltages and electro-magnetic interferences.

3.43.2. The GIS supplier shall define clearly what constitutes the main grounding bus of the GIS. The contractor shall supply the entire material for grounding bus of GIS viz conductor, clamps, joints, operating and safety platforms etc. The contractor is also required to supply all the earthing conductors and associated hardware material for connecting all GIS equipment, bus ducts, enclosures, control cabinets, supporting structure, GIS surge arrestor etc. to the ground bus of GIS.

3.43.3. The enclosure of the GIS may be grounded at several points so that there shall be grounded cage around all the live parts. A minimum of two nos. of grounding connections should be provided for each of circuit breaker, cable terminals, surge arrestors, earth switches and at each end of the bus bars. The grounding continuity between each enclosure shall be effectively interconnected externally with Copper /Aluminum bonds of suitable size to bridge the flanges. Subassembly to subassembly bonding shall be provided to bridge the gap & safe voltage gradients between all intentionally grounded parts of the GIS assembly & between those parts and the main grounding bus of the GIS.

3.43.4. Each marshaling box, local control panel, power and control cable sheaths and other non- current carrying metallic structures shall be connected to the grounding system of GIS via connections that are separated from GIS enclosures.

3.43.5. The grounding connector shall be of sufficient mechanical strength to withstand electromagnetic forces as well as capable of carrying the anticipated maximum fault current without overheating. At least two grounding paths shall be provided to connect each point to the main grounding bus. Necessary precautions should be under taken to prevent excessive currents from being induced into adjacent frames, structures of reinforcing steel and to avoid establishment of current loops via other station equipment.

3.43.6. All flexible bonding leads shall be tinned copper. All connectors, for attaching flexible bonding leads to grounding conductors and grounding conductors to support structures shall be tinned bronze with stainless steel or tinned bronze hardware.

3.43.7. The contractor shall provide suitable measure to mitigate transient enclosure voltage caused by high frequency currents caused by lightning strikes, operation of surge arrestor, phase to earth fault and discharges between contacts during switching operation. The grounding system shall ensure safe touch & step voltages in all the enclosures.

3.44. **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.

3.45. **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 220 kV & 132 kV.

(2) GIS bus ducts of each circuit shall be arranged in preferably horizontal formation and the clearance (outer to outer) between nearest bus ducts of two adjacent circuits shall be minimum one (1) meter.

(3) GIB shall be generally in only one horizontal layer. However in exceptional circumstance two horizontal GIB layers can be provided with the approval of Owner/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 220 kV & 132 kV voltage level.

(5) The minimum vertical ground clearance of GIB at road crossing shall be 5.5 meters

(6) The horizontal clearance between GIB and GIS building /any other building wall shall be minimum three (3) meters.

(7) The GIB route inside the GIS Hall shall not obstruct easy access to GIS and control room buildings and shall not obstruct movement of crane, equipment including HV test equipment for maintenance works.

(8) The GIB height outside the GIS hall in switchyard area shall not obstruct easy access to GIB, movement of crane for maintenance work.

(9) Optimisation 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

3.46. A portable ladder with adjustable height shall be supplied to access the GIS equipment for O&M purpose.

3.47. **Extension of GIS**

3.47.1. The arrangement of gas sections or compartments shall be such as to facilitate future extension of any make without any drilling, cutting or welding on the existing equipment. To add equipment, it shall not be necessary to move or dislocate the existing switchgear bays.

3.47.2. As the GIS is likely to be extended in future, the contractor shall make available during detailed engineering stage, the complete design detail of interface module such as cross section, enclosure material, enclosure dimensions (inner & outer), Flange diameter (inner & outer), conductor connection arrangement, bolt spacing & dimension, rated gas pressure etc. Further GIS manufacturer supplying GIS under present scope shall furnish all the required details in addition to mentioned above necessary for design and successful implementation of an interface module during later stage while extending GIS by any other GIS manufacturer, without any help of GIS manufacturer who has supplied the GIS equipment in present scope.

3.47.3. The Interface module shall be designed to provide Isolating link with access hole on enclosure. The Isolating link shall be provided in such a way so that HV test can be performed on either side of the interface module separately, keeping other side of GIS remain isolated.

3.47.4. Further the contractor who is extending the existing GIS installation shall optimally utilize the space inside the GIS hall (including the extension portion) for accommodating the interface module being supplied under the contract and the space (along the length of the hall) inside the GIS hall for interface module shall preferably be limited to 1 meter for 220/132kV

3.48. **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.

3.48.1. **SF6 gas monitoring devices and alarm circuits:** Dial type temperature compensated gas density monitoring devices with associated pressure gauge will be provided. The devices shall provide continuous & automatic monitoring of gas density & a separate device shall be provided for each gas compartment so that each compartment can be monitored simultaneously as follows:-

Compartment/ 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.

3.48.2. The contractor should furnish temperature v/s pressure curves for each setting of density monitor along with details of the monitoring device.

It shall be possible to test all gas monitoring relays/devices without de-energizing the primary equipment & without reducing pressure in the main section. Plugs & sockets shall be used for test purposes. It shall also damp the pressure pulsation while filling the gas in service, so that flickering of the pressure switch contacts does not take place.

3.48.3. **Gas Supply:** The contractor shall include the supply of all SF6 gas necessary for filling & putting into operation the complete switchgear installation being supplied. The empty gas cylinders shall be returnable to the contractor.

4. CIRCUIT BREAKERS

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.

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.

4.3. The circuit breaker shall be capable of:

1. Interrupting the steady and transient magnetizing current shall be as follows:

Voltage Level	Type of Transformer	Rating in MVA
220kV	**220/132 kV**	**50 to 200**
132kV	**132/11kV**	**10 to 50**

2. Interrupting line/cable charging current as per IEC without re-strikes and without use of opening resistors. The breaker shall be able to interrupt the rated line charging current as per IEC-62271-100 with test voltage immediately before opening equal to the product of U/√3 and 1.4

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

4. Breaking 25% the rated fault current at twice the rated voltage under phase opposition condition.

5. The breaker shall satisfactorily withstand the high stresses imposed on them during fault clearing, load rejection and re-energisation of shunt reactor and/or series capacitor compensated lines with trapped charges.

6. Withstanding all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. shall be designed for 2 p.u. across the breaker continuously, for validation of which a power frequency withstand test conducted for a duration of at least 15 minutes is acceptable).

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.

4.5. **Constructional features :**The features and constructional details of breakers shall be in accordance with requirements stated hereunder:

4.5.1. **Contacts:** All making and breaking contacts shall be sealed and free from atmospheric effects. Contacts shall be designed to have adequate thermal and current carrying capacity for the duty specified and to have a life expectancy so that frequent replacement due to excessive burning will not be necessary. Provision shall be made for rapid dissipation of heat generated by the arc on opening.

4.5.2. Any device provided for voltage grading to damp oscillations or, to prevent re-strike prior to the complete interruption of the circuit or to limit over voltage on closing, shall have a life expectancy comparable of that of the breaker as a whole.

4.5.3. Breakers shall be so designed that when operated within their specified rating, the temperature of each part will be limited to values consistent with a long life for the material used. The temperature rise shall not exceed that indicated in IEC-62271-100 under specified ambient conditions.

4.5.4. The gap between the open contacts shall be such that it can withstand atleast 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 presssure continuously (i.e. 2 pu. power frequency voltage across the breaker continuously)

4.5.5. In the interrupter assembly there shall be an adsorbing product box to minimize the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be such as to be fully compatible with SF6 gas decomposition products.

4.5.6. Provisions shall be made for attaching an operational analyzer to record travel, speed and making measurement of operating timings etc. after installation at site. The contractor shall supply three set of transducer for each substation covered under the scope.

4.5.7. Circuit Breaker shall be supplied with auxiliary switch having additional 8 NO(normally open) and 8 NC (normally closed) contacts for future use over and above those required for switchgear interlocking and other control and protection function. These spare NO and NC contacts shall be wired upto the local control cubicle.

4.6. **Operating mechanism**

4.6.1. 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.

4.6.2. 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.

4.6.3. 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.

4.6.4. 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.

4.7. The technical parameters of Circuit breakers are as per Annexure -1

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.

4.9. **Tests :**

4.9.1. **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

4.9.2. 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.

5. DISCONNECTORS (ISOLATORS)

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.

5.2. **Construction & Design**.

5.2.1. The disconnectors shall be operated by electric motor suitable for use on DC system and shall be equipped with a manual operating mechanism for emergency use. The motor shall be protected against over current and short circuit.

5.2.2. Disconnectors shall be suitable to switch the bus charging currents during their opening and closing and shall confirm to all three test duties viz TD1,TD2 and TD3 as per Annexure –F of IEC: 62271- 102.They shall also be able to make and break rated bus transfer current at rated bus transfer voltage which appears during transfer between bus bars in accordance with Annexure –B of IEC: 62271-102. The contact shielding shall also be designed to prevent restrikes and high local stresses caused by transient recovery voltages when these currents are interrupted.

5.2.3. The disconnecting switches shall be arranged in such a way that all the three phases operate simultaneously. All the parts of the operating mechanism shall be able to withstand starting torque of the motor mechanism without damage until the motor overload protection operates.

5.2.4. It shall be possible to operate the disconnecting switches manually by cranks or hand wheels. The contacts shall be both mechanically and electrically disconnected during the manual operation.

5.2.5. The operating mechanisms shall be complete with all necessary linkages, clamps, couplings, operating rods, support brackets and grounding devices. All the bearings shall be permanently lubricated or shall be of such a type that no lubrication or maintenance is required.

5.2.6. The opening and closing of the disconnectors shall be achieved by either local or remote control. The local operation shall be by means of a two-position control switch located in the Local Control Cabinet (LCC) .

5.2.7. Remote control of the disconnectors from the control room/SAS shall be made by means of remote/ local transfer switch.

5.2.8. The disconnector operations shall be inter-locked electrically with the associated circuit breakers in such a way that the disconnector control is inoperative if the circuit breaker is closed.

5.2.9. Each disconnector shall be supplied with auxiliary switch having additional 4 NO (Normally Open) and 4 NC (Normally Closed) contacts for future use over and above those required for switchgear interlocking and automation purposes. These spare NO and NC contacts shall be wired up to the local control cabinet.

5.2.10. The signaling of the closed position of the disconnector shall not take place unless it is certain that the movable contacts will reach a position in which the rated normal current, peak withstand current and short-time withstand current can be carried safely.

5.2.11. The signaling of the open position of the disconnector shall not take place unless the movable contacts have reached such a position that the clearance between the contacts is at least 80 percent of the rated isolating distance.

5.2.12. The disconnectors and safety grounding switches shall have a mechanical and electrical inter-locks to prevent closing of the grounding switches when isolator switches are in the closed position and to prevent closing of the disconnectors when the grounding switch is in the closed position. Integrally mounted lock when provided shall be equipped with a unique key for such three phase group. Master key is not permitted.

5.2.13. The local control of the Isolator and high-speed grounding switches from the Local Control Cabinet (LCC) should be achieved from the individual control switches with the remote/local transfer switch set to local.

5.2.14. All electrical sequence interlocks will apply in both remote and local control modes.

5.2.15. Each disconnector shall have a clearly identifiable local, positively driven mechanical position indicator, together with position indicator on the local control cubicle (LCC) and provisions for taking the signals to the control room. The details of the inscriptions and colouring for the indicator are given as under :

	INSCRIPTION	COLOUR
Open position	OPEN	GREEN
Closed position	CLOSED	RED

5.2.16. All the disconnecting switches shall have arrangement allowing easy visual inspection of the travel of the switch contacts in both open and close positions, from the outside of the enclosure.

5.2.17. The disconnecting switches shall be provided with rating plates and shall be easily accessible.

5.2.18. The mechanical endurance class shall be M2 as per IEC for 765kV, 400kV and 220kV and it shall be M1 class for 132kV disconnectors

5.2.19. Mechanical position indication shall be provided locally at each disconnector and Electrical indication at each Local Control Cabinet (LCC) / SAS.

5.3. The technical parameters of disconnectors are as per **Annexure-2**

6. SAFETY GROUNDING SWITCHES

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.

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.

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.

6.4. The details of the inscription and colouring for the indicator are given as under :

	INSCRIPTION	COLOUR
Open position	OPEN	GREEN
Closed position	CLOSED	RED

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.

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.

6.7. Provision shall be made for padlocking / suitable locking arrangement for the ground switches in either the open or closed position.

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.

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.

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.

6.11. Combined Disconnectors & Safety grounding switch arrangement shall also be acceptable.

6.12. Mechanical position indication shall be provided locally at each switch and Electrical indication at each Local Control Cabinet (LCC) / SAS.

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.

7. HIGH SPEED MAKE PROOF GROUNDING SWITCHES:

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

7.2. High Speed Grounding switches shall be provided with individual/three pole operating mechanism suitable for operation from DC.

7.3. The switches shall be fitted with a stored energy closing system to provide fault making capacity.

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.

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.

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

7.7. High speed ground switch operation should be possible locally from Local Control Cabinet (LCC)

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.

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.

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.

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.

7.12. The high speed make proof grounding switches shall confirm to the requirements of IEC-62271-102.

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.

8. INSTRUMENT TRANSFORMERS

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.

8.1.1. **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.

8.1.2. **Rating and Diagram Plates: Rating** and diagram plates shall be as specified in the IEC specification incorporating the year of manufacture. The rated extended current rating voltage and rated thermal current shall also be marked on the name plate.

The diagram plates shall show the terminal markings and the relative physical arrangement of the current transformer cores with respect to the primary terminals (P1 & P2).

The position of each primary terminal in the current transformer SF6 gas section shall be clearly marked by two plates fixed to the enclosure at each end of the current transformer.

8.1.3. **Constructional Details**:

a) The current transformers incorporated into the GIS will be used for protective relaying and metering purposes and shall be of metal- enclosed type.

b) Each current transformer shall be equipped with a secondary terminal box with terminals for the secondary circuits, which are connected to the Local Control Cubicle. The star/ delta configuration and the inter connection to the line protection panels will be done at the CT terminal block located in the local control cubicle.

c) Current transformers guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

d) 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.

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.

8.2.1. **Ratios and Characteristics**: The rating, ratio, accuracy class, connection etc. for the voltage transformers shall be in accordance with annexure -4 & Table 4

8.2.2. **Rating and diagram plates** :Rating and diagram plate shall be provided complying with the requirements of the IEC specification incorporating the year of manufacture and including turns ratio, voltage ratio, burden, connection diagram etc.

8.2.3. **Secondary Terminals, Earthing**

The beginning and end of each secondary winding shall be wired to suitable terminals accommodated in a terminal box mounted directly on the voltage transformer section of the SF6 switchgear.

All terminals shall be stamped or otherwise marked to correspond with the marking on the diagram plate. Provision shall be made for earthing of the secondary windings inside the terminal box.

8.2.4. The transformer shall be able to sustain full line to line voltage without saturation of transformer.

8.2.5. Constructional Details of Voltage Transformers :

a) The voltage transformers shall be located as a separate bay module and will be connected phase to ground and shall be used for protection, metering and synchronization.

b) The voltage transformers shall be of inductive type, nonresistant and shall be contained in their own-SF6 compartment, separated from other parts of installation. The voltage transformers shall be effectively shielded against high frequency electromagnetic transients. The supplier shall ensure that there is no risk of Ferro resonance due to the capacitance of the GIS.

c) The voltage transformers shall have three secondary windings.

d) Voltage transformers secondary shall be protected by Miniature Circuit breakers (MCBs) with monitoring contacts for all the windings. The secondary terminals of the VT's shall be terminated to preferably stud type non-disconnecting terminal blocks in the secondary boxes via the fuse.

e) The voltage transformer should be thermally and dielectrically safe when the secondary terminals are loaded with the guaranteed thermal burdens.

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

g) The diagram for the interconnection of the VTs shall be provided inside secondary terminal box.

8.3. **Tests:**

Current and voltage transformers shall conform to type tests and shall be subjected to routine test in accordance with IEC.

9. SURGE ARRESTORS

9.1. The surge arrestors shall confirm in general to latest IEC –60099-4.

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.

9.3. **Duty requirements of GIS Surge Arrestor**

9.3.1. The surge arrester shall be of heavy duty station class and gapless (Metal oxide) type without any series or shunt gaps.

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

9.3.3. 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.\

9.3.4. The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

9.3.5. The surge arresters are being provided to protect the followings whose insulation levels are indicated in the table given below:-

Equipment to be protected	220KV system	132KV system	66KV system
	Lightning impulse (kVp)	Lightning impulse (kVp)	Lightning impulse (kVp)
Power Transformer	± 950	± 550	± 325
Instrument Transformer	± 1050	± 650	± 325
Reactor	-	-	-
CB/Isolator Phase to ground	± 1050	± 650	± 325
CB/Isolator Across open contacts	± 1200	± 750	± 350

9.3.6. Constructional Features

The nonlinear blocks shall be of sintered/infered metal oxide material. These shall be provided in such a way as to obtain robust construction, with excellent mechanical and electrical properties even after repeated operations.

The arrestor enclosure shall be vertically or horizontally mounted to suit the layout of the switchgear as suggested by the supplier and each arrestor shall be fitted with a Online continuous resistive leakage current monitoring system. The system shall be provided with an interface to integrate with the substation automation system.

The main grounding connection from the surge arrestor to the earth shall be provided by the contractor. The size of the connecting conductor shall be such that all the energy is dissipated to the ground without getting overheated.

9.4. **Tests**

9.4.1. In accordance with the requirements stipulated, the surge arrestors shall conform to type tests and shall be subjected to routine and acceptance tests in accordance with IEC document.

9.4.2. Each metal oxide block shall be tested for the guaranteed specific energy capability in addition to the routine/acceptance test as per IEC-60099.

9.4.3. Test on Surge Monitors: The Surge monitors shall also be connected in series with the test specimens during residual voltage and current impulse withstand tests to verify efficacy of the same. Additional routine/functional tests with one 100A and 10 kA current impulse, (8/20 micro sec.) shall also be performed on the surge monitor.

9.5. **Technical Parameters** : Technical parameters are as per annexure 5;

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.

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).

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)

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.

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.

10.5. The technical parameters of Bushing are as per Annexure -6.

11. SF6 GIS TO XLPE CABLE TERMINATION (If Applicable)

11.1. The underground cables shall be connected to GIS by the interfacing of XLPE cable sealing end to GIS Cable termination enclosure.

11.2. The SF6 GIS to XLPE cable termination shall conform to IEC-62271-209.

11.3. The rating of XLPE cables for different voltages are specified in the Section project.

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.

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.

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.

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.

11.8. Type test reports of radio interference voltage (RIV) level shall be submitted for approval

12. TRANSFORMER TERMINATION MODULE (If applicable)

12.1.1. 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.

12.1.2. The oil filled transformers and reactors are as shown in the substation SLD. The oil to air bushings of the transformers and reactors shall be supplied by the respective supplier's and the same shall be connected to the SF6 ducts thru air to SF6 bushings to be provided under present scope.

12.1.3. Terminal connection arrangement to connect GIS duct to bushing and duct mounting arrangement details shall be submitted during detailed engineering for Employer's/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.

12.1.4. 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.

13. LOCAL CONTROL CUBICLE (LCC)

13.1. Functions

13.1.1. Each circuit-breaker bay shall be provided with a local control cubicle containing local control switches and a mimic diagram for the operation and semaphore for status indication of the circuit-breaker and all associated isolators and earth switches together with selector switches to prevent local and remote and supervisory controls being in operation simultaneously

13.1.2. Status indications in the LCC shall be semaphore type or LED type.

13.1.3. Closing of the circuit- breaker from the local control unit shall only be available when the breaker is isolated for maintenance purposes. Circuit-breaker control position selector, operating control switch and electrical emergency trip push button shall be installed in the Local Control Cubicle. Circuit-breaker control from this position will be used under maintenance and emergency conditions only. The emergency trip push buttons shall be properly shrouded.

13.1.4. If Disconnector or earth switch is not in the fully open or closed position a "Control Circuit Faulty" alarm shall be initiated, and electrical operation shall be blocked.

13.1.5. 20% spare terminals shall be provided in each LCC apart from terminals provided for the termination and interconnection of all cabling associated with remote and supervisory control, alarms, indications, protection and main power supply etc .

13.1.6. Where plugs and sockets connect control cabling between the local control cubicle and the switchgear these shall not be interchanged.

13.1.7. Hydraulic/pneumatic and SF6 auxiliary equipment necessary for the correct functioning of the circuit breaker, isolators and earth switches shall be located in a separate cubicle compartment.

13.1.8. LCC shall be suitable for remote operation from substation automation system (SAS) . Each gas tight compartment shall be monitored individually per phase basis through SAS

13.2. **Constructional features**

13.2.1. Local Control cubicle shall be either mounted on the GIS with front access or free standing, floor mounting type. It shall comprise structural frames completely enclosed with specially selected smooth finished, cold rolled sheet steel of thickness not less than 3 mm for weight bearing members of the panels such as base frame, front sheet and door frames, and 2.0mm for sides, door, top and bottom portions. There shall be sufficient reinforcement to provide level transportation and installation.

13.2.2. Access to all compartments shall be provided by doors. All fastenings shall be integral with the panel or door and provision made for locking. Cubicles shall be well ventilated through vermin-proof louvers having anti insect screen. All doors shall be gasketed all around with suitably profiled Neoprene/EPDM gaskets conforming with provision of IS 11149. However, XLPE gaskets can also be used for fixing protective glass doors.

13.2.3. Each LCC panel should have its own separate AC supply source feed from the ACDB. The DC supply shall be from respective relay & protection panel power, control, interlocking, signaling. Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with Fuses. All fuses shall be HRC cartridge type 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'.

13.2.4. Each LCC Panel shall be provided with the following

1. **Plug Point**: 230V, Single phase 50Hz, AC socket with switch suitable to accept 5 Amps and 15 Amps pin round standard Indian plug, shall be provided in the interior of each cubicle with ON-OFF switch.
2. **Interior Lighting**: Each panel shall be provided with a fluorescent lighting fixture rated for 230 Volts, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch. Adequate lighting shall also be provided for the corridor in Duplex panels.
3. **Space Heater**: Each panel shall be provided with a thermostatically connected space heater rated for 230V, single phase, 50 Hz AC supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with switch unit

13.2.5. Operating mechanisms, auxiliary switches and associated relays, control switches, control cable terminations, and other ancillary equipment shall be accommodated in sheet steel vermin proof cubicles.

13.2.6. Local control cubicles shall be provided to be free standing and shall be equipped with anti-condensation heaters. A suitable humidity stat and thermostat shall be included in the heater circuit.

13.2.7. The interior of each cubicle shall be finished with a semi gloss white surface. An interior lamp suitable for the local LVAC supply, controlled by a door-operating switch, shall be fitted at the top of each panel.

13.2.8. The arrangement of equipment within cubicles shall be such that access for maintenance or removal of any item shall be possible with the minimum disturbance of associated apparatus. All the control switches shall be internal i.e. installed behind a lockable glass door.

13.2.9. An interlocking scheme shall be provided that takes into account the following basic requirements.

- To safeguard maintenance personnel who may be working on one section of the equipment with other sections live.
- prevent incorrect switching sequences that could lead to a hazardous situation to plant, equipment and personnel.

13.2.10. Electrical bolt interlocks shall be energized only when the operating handle of the mechanism is brought to the working position. Visible indication shall be provided to show whether the mechanism is locked or free. Means, normally padlocked, shall be provided whereby the bolt can be operated in the emergency of a failure of interlock supplies.

13.2.11. Where key interlocking is employed tripping of the circuit breaker shall not occur if any attempt is made to remove the trapped key from the mechanism. Any local emergency-tripping device shall be kept separate and distinct from the key interlocking.

13.2.12. Disconnecting switches shall be so interlocked that they cannot be operated unless the associated circuit-breaker is open except that where double bus bar arrangements are specified, on-load transfer of feeder circuits from one bus bar to another shall be made possible by interlocks which ensure that the associated bus coupler and its isolators are closed.

13.2.13. Bus coupler circuit breaker shall be interlocked so that it shall not be possible to open a bus coupler circuit breaker while on load change over on that side of the breaker is in progress.

13.2.14. All isolating devices shall be interlocked with associated circuit-breakers and isolators in the same station so that it shall not be possible to make or break current on an isolating device unless a parallel circuit in that station is already closed.

14. GIS BUILDING

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

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.

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.

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.

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.

15. ELECTRIC OVERHEAD CRANE :

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.

15.2. The capacity of the crane shall be sized to lift the heaviest GIS switchgear component crane.

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.

15.4. Crane hook approaches shall be of the minimum possible dimensions to ensure maximum coverage of the plant area.

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.

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

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.

15.8. The platform and walkways shall be designed to support any weight to be imposed upon them during crane overhaul.

15.9. An access platform shall be provided together with a guarded ladder on the crane to allow access to the bridge rails.

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.

15.11. Contractor shall submit the capacity calculation of crane for GIS hall considering a factor of safety of 5.

a) The crane for 220kV GIS/132kV 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.

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.

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. VENTILATION SYSTEM FOR GIS HALL

16.1. Each GIS Hall shall have an independent ventilation system. Each Ventilation system shall consist of two 100% capacity systems, one operating and one stand-by.

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.

17. SEISMIC DESIGN CRITERIA:

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.

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.

18. DESIGN REVIEW

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.

18.2. Employer/consultant may also visit to the supplier's works to inspect design, manufacturing and test facilities.

18.3. The design review will commence after placement of award with the successful contractor and shall be finalised before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the GIS under the scope of this specification. Employer/consultant reserve the right to waive off the design review during detailed engineering.

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.

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.

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.

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.

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.

20. GENERAL

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.

20.2. **Heaters:** Wherever required, heaters shall be provided to prevent moisture condensation. Heaters are not allowed inside the main circuit**.**

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.

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.

22. PACKING, STORAGE AND UNPACKING

23.1. All the equipment shall be carefully packed for transport by sea, rail and road in such a manner that it is protected against the climatic conditions and the variations in such conditions that will be encountered enroute from the manufacturer's works to the site.

23.2. The SF6 metal clad equipment shall be shipped in the largest factory assembled units that the transport and loading limitations and handling facilities on site will allow to reduce the erection and installation work on site to a minimum.

23.3. Where possible all items of equipment or factory assembled units shall be boxed in substantial crates or containers to facilitate handling in a safe and secure manner. Should the units be considered too large for packing in crates, they shall be suitably

lagged and protected to prevent damage to any part, particularly small projections, during transport and handling. Special lugs or protective supports shall be provided for lifting to prevent slings and other lifting equipment from causing damage. Each crate, container or shipping unit shall be marked clearly on the outside to show where the weight is bearing and the correct position for the slings.

23.4. Each individual piece to be shipped, whether crate, container or large unit, shall be marked with a notation of the part or parts contained therein.

23.5. Special precautions shall be taken to protect any parts containing electrical insulation against the ingress of moisture. This applies particularly to the metal clad equipment of which each gas section shall be sealed and pressurized prior to shipping. Either dry nitrogen/air or dry SF6 gas shall be used and the pressure shall be such as to ensure that, allowing for reasonable leakage, it will always be greater than the atmospheric pressure for all variations in ambient temperature and the atmospheric pressure encountered during shipment to site and calculating the pressure to which the sections shall be filled to ensure positive pressure at all times during shipment. The type of gas, the maximum pressure to which sections will be filled prior to shipment and the minimum allowable pressure during shipment shall be advised prior to dispatch.

23.6. All blanking plates, caps, seals, etc., necessary for sealing the gas sections during shipment to site shall be provided as part of the contract and shall remain the property of 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.

23.7. Valves and other gas couplings associated with the switchgear gas systems shall be adequately protected against damage from any bumps or physical blows. They shall also be capped to prevent ingress of dirt or moisture or damage to any coupling, pipes, threads or special fittings. Any explosion vents and other pressure relief devices, shall be suitably sealed and protected to prevent accidental exposure of the sealed sections during shipment to site.

23.8. For bus ducts involving male and female joints of the current carrying conductor, the same shall be transported in disassembled condition to avoid any damage during transit. All bright parts liable to rust shall receive a coat of anti rusting composition and shall be suitably protected.

23.9. The contractor will be able to use the available storage areas at site. The contractor shall ensure that during the period between arrival at site and erection, all materials and parts of the contract works are suitably stored in such approved manner as to prevent damage by weather, corrosion, insects, vermin or fungoral growth. The scope of providing the necessary protection, storing off the ground, as required etc. is included in the works to be performed by the contractor.

23.10. The equipment shall only be unpacked or removed from the containers immediately prior to being installed. They shall not be left lying unnecessarily in open crates or containers. Special precautions shall be taken when gas sections which have been sealed and pressurized for shipping are opened up to reduce the ingress of dirt and atmospheric moisture to a minimum. Whenever possible this shall only be done immediately prior to installation and if any section is to be left outside for any length of time after being opened, it shall be resealed and pressurized with either dry nitrogen/air or SF6 gas until required.

24. INSTALLATION OF GIS

24.1. Civil works of GIS Hall shall be completed in all respects for taking up the installation and it shall be ensured that all dust and dirt in the hall are removed. All openings (including Bus Duct) except entry door should be closed and proper sealed

24.2. The installation area shall be secured against entry of unauthorized personnel. Only certified manufacturer's engineer and supervisor shall supervise critical & important erection works. The help of local technicians can be taken only for material handling and non-critical erection works. Engineers and supervisors of the manufacturer shall submit authorization and competency certificate.

24.3. Assembly drawing for GIS erection for the section under progress shall be available and displayed in GIS hall at the time of work.

24.4. Proper power supply shall be ensured by installing DG Set of proper rating and frequency if required prior to commencement of erection work so that assembly work is not interrupted in the middle which is critical for GIS installation.

24.5. Working personnel shall clean their shoes or apply covers on shoes before entering the immediate working area. The working clothes of authorized personnel shall be made of non fluffy material.

24.6. GIS hall door shall have automatic close facility after entry of personnel to avoid dust and moisture entry. Walls and ceiling shall be in a condition so that neither dirt nor plaster might fall or rub off and formation of condensation water in ceiling shall be prevented under any circumstances.

24.7. Floor in the installation area shall have a firm surface and shall be kept dust free with a vacuum cleaner. Vacuum cleaning to be done at regular interval through out the day with separate team of persons assigned for cleaning work only.

24.8. Only T&P and consumables required for GIS erection shall be kept in GIS during erection.

24.9. In case of outdoor installation of GIS or of GIS components open gas compartments shall be protected from dust and moisture ingress (by tarpaulin covers etc)

24.10. Bus duct exit in the GIS hall wall shall be kept covered by suitable means until permanent cover is provided after installation of bus ducts.

24.11. A separate room shall be identified in consultation with NEA/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

24.12. All assembly work shall be done by qualified personnel only who are to be identified before starting of erection work.

24.13. Erection agency shall submit method statement and make available formats for checking during each stage of hall preparation, assembly process and final checks to be approved before start of erection. Method statement shall include record of shock/ impact recorder at the time of unpacking. Shock recorder down loaded data and analysis shall be submitted before commencement of erection work. In case of violation of shock limits, expert form manufacturer shall visit and do the internal inspection before giving clearance for erection.

24.14. Cleaning is of utmost importance and hence before assembly, all the loose metal parts, subassemblies and all contact& sealing surfaces shall be cleaned before installation. Cleaning shall be e carried out with specified cleaning agents of the manufacturer in no condition water is to be used except for external surfaces. Further, Prior to opening, gas compartment shall be thoroughly cleaned and vacuum

cleaning of the installation area shall also be done specially the immediate vicinity of the flanges to be connected. Dust disturbance in the area to be avoided

Also, before closing a flange connection clean the immediate vicinity and all accessible parts of the components shall be connected with a vacuum cleaner

24.15. Once the transport covers are removed installation of flanges shall be done without any interruptions, if interruptions cannot be avoided open flanges are to be covered with clean plastic foil. Transport covers, O-rings and other packing material shall be taken out of GIS after immediately after removal.

24.16. O Rings shall be properly stored and taken out only before installation. O Rings are also to be cleaned before use with manufacturer authorized cleaning agent.

24.17. At all points of time during installation authorized personnel shall use disposable gloves to avoid contamination.

24.18. Cable termination work shall commence only after completion of GIS equipment as during GIS installation period laying and termination of cables interferes with the GIS erection work and affects cleanliness.

24.19. Approved Field Quality Plan shall be followed strictly during site work.

25. ON SITE TESTING

After the switchgear has been completely installed on site and filled with SF6 gas, the complete assembly shall be subjected to the site tests as per IEC – 62271-203 and with the test voltages specified below :-

25.1. The adequacy of number of UHF sensors and their location shall be verified as per recommendations of CIGRE task force **TF 15/33.03.05** (Task force on **Partial discharge detection system for GIS: Sensitivity verification for the UHF method and the acoustic method**). In case during site testing additional UHF sensors are required, the same shall also be supplied and installed to complete the technical requirement.

25.2. Application of AC voltage equal to 1.2 times the service voltage in order to condition the GIS whilst at the same time permitting measurement of Partial discharge and detection of conductive particles by UHF method.

25.3. In case of a disruptive discharge in the gas as outlined in clause no: C.6.2.2 Procedure b) , annexure – C of IEC : 62271-203 , and a repeat test is performed due to failure during the AC voltage test , then the test shall be carried out at 1.2 times the service voltage .

The analysis of PD measured during High voltage test shall done very carefully and presence of PD measured by any sensor shall be attended and HV test shall be repeated after the rectification work. Calibration of PD sensors shall be completed before start of HV test to establish reference for detection of PD above 5 pc

25.4. Method statement/ procedure of on site high voltage testing and PD measurement shall be submitted by contractor in advance.

26. TESTING & MAINTENACE EQUIPMENT

All testing & maintenance equipment shall be offered, if specified as per relevant schedule of BPS.

26.1. SF6 Gas leakage detector.

The detector shall be portable, battery operated with built in battery charger, hand held type and having a minimum SF6 gas leakage sensitivity of 5gm/year. The sensor shall be connected through a flexible wand for easy accessibility to joints,

seals and couplings in GIS equipment and provided with a protection filter. The equipment shall have on/off switch & suitable indicating lamps/LEDs, variable pitch audible signal for leakage indication, and a head phone jack. The equipment shall have automatic zeroing of background signals suitable for detecting SF6 gas leakage in charged switchyard. The test kit shall be compatible for EMI/EMC environment as per IEC 1000.

26.2. Gas filling and evacuating plant :

26.2.1. The plant necessary for filling and evacuating the SF6 gas in the switchgear shall be supplied to enable any maintenance work to be carried out. **This shall include all the necessary gas cylinders for temporarily storing the evacuated SF6 gas.** The capacity of the temporary storage facilities shall at least be sufficient for storing the maximum quantity of gas that could be removed from at least one phase of one complete bay(switchgear and associated equipment).

26.2.2. Where any item of the filling and evacuating plant is of such a weight that it cannot easily be carried by maintenance personnel, it shall be provided with lifting hooks for lifting and moving with the overhead cranes.

26.2.3. The minimum capacity of evacuation plant will be as under :

Vacuum Pump: 60 M^3/Hour (Nominal suction pressure)
Compressor : 15 M3/Hour(Delivery)

26.2.4. The evacuation equipment shall be provided with all the necessary pipes, couplings, flexible tubes and valves for coupling up to the switchgear for filling or evacuating all the gases.

26.2.5. The gases compartments shall preferably be fitted with permanent non-return valves through which the gas is pumped into or evacuated form the compartments.

Details of the filling and evacuating plant that will be supplied, as well as the description of the filling and evacuating procedures shall be furnished

26.3. **SF6 gas analyzer:**

The SF6 gas analyser should be of portable type and instruments shall have following features:

a. In-built calibration facility.
b. Sensitivity of the equipment shall not be affected by any atmospheric conditions like dust, humidity, heat, wind etc.
c. Equipment shall work on zero gas loss principle i.e. gas should be pumped back to the compartment after measurement without any exposure to the atmosphere.
d. Equipment shall be supplied with suitable regulator which can be used to connect SF6 cylinder if required.
e. Following acidic/impurities products should be detected as per IEC 60480 and IEC 60376
  i) SF6 purity – Range: 0-100 % & Accuracy: +/- 0.5 %
  ii) Dew point - Range : -60 to +20 deg C & Accuracy: +/- 0.5 deg C
  iii) SO2 - Range : 0-150 ppm & Accuracy : +/- 2 %
  iv) CF4 – Range : 0-60% vol & Accuracy : +/- 1 %
  v) HF - Range : 0-200ppm & Accuracy : +/- 5 %
f. Instrument should work on AC source as well as on rechargeable battery
g. Input pressure: upto 10 bar
h. It should be housed in a robust IP67 case with wheels

26.3.1. Portable Partial Discharge(PD) monitoring system

26.3.2. The equipment shall be used for detecting different types of defects in Gas Insulated Stations (GIS) such as Particles, Loose shields and Partial Discharges as well as for detection of Partial discharges in other types of equipment such as Cable Joints, CTs and PTs.

26.3.3. It shall be capable for measuring PD in charged GIS environment as EHV which shall have bandwidth in order of 100 MHz–2GHz with possibility to select a wide range of intermediate bandwidths for best measurement results. The principle of operation shall be based on UHF principle of detection. The instrument should also be able to detect partial discharges in cable joints and terminations.

26.3.4. Detection and measurement of PD and bouncing particles shall be displayed on built in large LCD display and the measurement shall be stored in the instrument and further downloadable to a PC for further analysis to locate actual source of PD such as free conducting particles, floating components, voids in spacers, particle on spacer surfaces etc. Software for display and diagnosis of PD signals and an expert software system for accurate interpretation of cause of PD shall also be supplied and installed by the contractor.

26.3.5. The equipment shall meet the following requirements

1. Measurement shall be possible in noisy environment.
2. Stable reading shall be possible in presence of vibrations within complex GIS assemblies, which can produce signals similar to PD.
3. Equipment should have necessary synchronizing circuits to obtain PD correlation with power cycle and power frequency.
4. The equipment shall be battery operated with built-in-battery charger. It shall also be suitable for 230V AC/50 Hz input.
5. Measurement shall be possible in the charged switchyard in the presence of EMI/EMC. Supplier should have supplied similar detector for GIS application to other utilities. Performance certificate and the list of users shall be supplied along with the offer.
6. Instrument shall be supplied with standard accessories i.e., re-locatable sensors with mounting arrangements, connecting cables (duly screened) to sensors, Lap-top PC, diagnostic and expert interpretation software, carrying case, rechargeable battery pack with charger suitable for 230V AC, 50Hz supply connecting cables (duly screened) to view in storage.
7. The function of software shall be covering the following:
   a) Data recording, storage and retrieval in computer
   b) Data base analysis
   c) Template analysis for easy location of fault inside the GIS
   d) Evaluation of PD measurement i.e, Amplitude, Phase Synchronization etc.
   e) Evaluation of bouncing/loose particles with flight time and estimation on size of particle.
   f) Expert software system for accurate interpretation of cause of PD.
   g) Report generation.
8. To prove the suitability in charged switchyard condition, practical demonstration shall be conducted before acceptance.
9. Supplier shall have “Adequate after sales service” facility.
10. Necessary training may be accorded to personnel to make use of the kit for locating PD sources inside the GIS
11. Instrument shall be robust and conform to relevant standard.

26.3.6. **Calibration:** The UHF Couplers have to be first calibrated as per CIGRE procedure TF 15/330305 as part of factory acceptance tests to guarantee detection sensitivity of 5pC or better. The GIS of same design shall be used as test specimen during the coupler calibration. The pulse injection level determined through above factory calibration tests shall only be used as reference for site

sensitivity checks during commissioning of PDM system. The data sheet/frequency response characteristics shall be submitted for reference.

26.3.7. Pulse generator for UHF sensor sensitivity test shall also be supplied as a standard accessory.

ANNEXURE-1

TECHNICAL PARAMETERS FOR CIRCUIT BREAKER

Sl no	Parameter	220kV system	132 kV system	66 kV system
1.	Rated voltage kV (rms)	245	145	72
2.	Rated frequency (Hz)	50	50	50
3.	No. of poles	3	3	3
4.	Type of circuit breaker	SF6 insulated.	SF6 insulated.	SF6 insulated.
5.	Rated continuous current (A) at an ambient temperature of 50^0C	1600/3000 (as applicable)	1250/2000 (as applicable)	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.	40 kA (As applicable)	31.5 kA (As applicable)	31.5 kA (As applicable)
7.	Symmetrical interrupting capability kA (rms) (As applicable)	40	31.5	31.5
8.	Rated short circuit making current kAp (As applicable)	100	80	80
9.	Short time current carrying capability for one second kA (rms) (As applicable)	50/40	80	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 1.4 as per IEC-62271-100	As per IEC	As per IEC	As per IEC
11.	First pole to clear factor	1.3	As pr IEC	As pr IEC
12.	Rated break time as IEC (ms)	60	60	60
13.	Total break time (ms)	65	65	65
14.	Total closing time (ms)	Not more than 200	Not more than 200	Not more than 200
15.	Rated operating duty cycle	O-0.3s-CO-3 min-CO		
16.	Reclosing	Single phase &Three phase auto reclosing.	Single phase &Three phase auto reclosing.	Single phase &Three phase auto reclosing.
17.	**Rated insulation levels**			

	Full wave impulse withstand (1.2 /50 µs) between line terminals and ground:	±1050 kVp	± 650 kVp	± 325 kVp
	Full wave impulse withstand (1.2 /50 µs) Between terminals with circuit breaker open:	±1050 kVp	± 750kVp	± 350kVp
	Rated switching impulse withstand voltage (250/2500 µs) Dry & wet.	NA	NA	NA
	Rated switching impulse withstand voltage (250/2500 µs) Dry &wet Between terminals with circuit breaker open:	NA	NA	NA
	One minute power frequency withstand voltage between line terminals and ground	460 kV rms.	275 kV rms	140 kV rms
	One minute power frequency withstand voltage between terminals with circuit breaker open	530 kV rms.	315 kV rms	150 kV rms
18.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 266 kV (Micro volts)	1000 µV	500µV	… µV
19.	Max. difference in the instants of closing/opening of contacts (ms) between poles	As per IEC	As per IEC	As per IEC
20.	Trip coil and closing coil voltage with variation as specified in Sec. GTR	220 V DC	220 V DC	110 V DC
21.	Rating of Auxiliary contacts	10A at 220 V DC	10A at 220 V DC	10A at 110 V DC
22.	Breaking capacity of Aux. Contacts less than 20 ms.	10A at 220 V DC	10A at 220 V DC	10A at 110 V DC
23.	System neutral earthing	Solidly Gound		Solidly Gound

ANNEXURE-2

TECHNICAL PARAMETERS FOR DISCONNECTORS/ ISOLATORS

Sl. No	**Particulars**	**220 kV**	**132kV**	**66kV**
1.	Rated voltage (rms) Un	245 kV	145 kV	72 kV
2.	Rated frequency	50 HZ	50 Hz	50 Hz
3.	System earthing	Effectively earthed	Effectively earthed	Effectively earthed
4.	Type	SF6 insulated	SF6 insulated	SF6 insulated

5.	Rated continuous current (A) at 50^0C ambient temp.(as applicable)	1600/3000 (as applicable)	1250 (for line /transformer / bus coupler) (as applicable)	1200/600 (for line /transformer /bus coupler) (as applicable)
6.	Rated short time withstand current of isolator and earth switch(as applicable)	40 kA for 1 Sec.	31.5 kA for 1 second	31.5 kA for 1 second
7.	Rated dynamic short circuit withstand current withstand current of isolator and earth switch(As applicable)	1125/00 kAp.(As applicable)	80 kAp	80 kAp
8.	Rated insulation level:			
	One minute power freq. Withstand voltage: To earth :	460 kV rms.	275 kV rms.	140 kV rms.
	One minute power freq. Withstand voltage: Across isolating distance	530 kV rms.	315 kV rms.	150 kV rms.
	1.2/50 micro sec. Lighting impulse withstand voltage (+ve or –ve polarity) To earth:	±1050 kVp	±650 kVp	±325 kVp
	1.2/50 micro sec. Lighting impulse withstand voltage (+ve or –ve polarity) : Across Isolating distance	±1200 kVp	±750 kVp	±350 kVp
	Rated switching impulse withstand voltage (250/2500 micro-sec.) Dry & wet :between line terminals and ground:	N.A	N.A	N.A
	Rated switching impulse withstand voltage (250/2500 micro-sec.) Dry & wet :Between terminals with Isolator open:	N.A	N.A	N.A
9.	Mechanical Endurance clause as per IEC	M2	M1	M1
10.	No. of spare auxiliary contacts on each isolator	4 NO and 4 NC	4 NO and 4 NC	4 NO and 4 NC
11.	No. of spare auxiliary contacts on each earthing switch	4 NO and 4 NC	4 NO and 4 NC	4 NO and 4 NC

ANNEXURE-3

TECHNICAL PARAMETERS FOR CURRENT TRANSFORMERS

Sl no	Particular	220 kV	132kV	66kV
1.	Rated voltage Un	245 kV (rms)	145 KV (rms)	72 KV (rms)
2.	Rated frequency	50 Hz	50 Hz	50 Hz
3.	System neutral earthing	Effectively Earthed	Effectively Earthed	Effectively Earthed
4.	Rated short time thermal current for 1 second (as applicable)	40 kA	31.5 kA	31.5 kA
5.	Rated dynamic current	100 kAp.	78.75kA	78.75kA
6.	Rated insulation levels			
i.	1.2/50 micro second impulse voltage	±1050 kVp	±650 kVp	±325 kVp
ii.	one minute power frequency withstand voltage	460 kV (rms)	275 kV (rms)	140 kV (rms)
7.	Maximum temperature rise over an ambient temperature of 40^0C	As per IEC 60044-1	As per IEC 60044-1	As per IEC 60044-1
8.	Radio interference voltage at 1.1 Un/√3 and frequency range 0.5 to 2 MHz	1000 µV	500µV	5…µV
9.	One minute power frequency withstand voltage between sec. Terminal & earth	3 kV (rms)	3 kV (rms	3 kV (rms
10.	Partial discharge level	5 pico coulombs	5 pico coulombs	5 pico coulombs

TABLE-3A

REQUIREMENTS FOR 220 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. Resist-ance (ohm)	Max. Excitation current at Vk (in mA)
5	1	BUS DIFF CHE-CK	1600-800/1	-	-	1600/ 800	8/4	25 on 1600/1tap. 50 on 800/1tap.
	2	BUS DIFF MAIN	1600-800/1	-	-	1600/ 800	8/4	25 on 1600/1tap. 50 on 800/1tap.
	3	METE-RING	1600-800/1	20	0.2S	-	-	-
	4	TRAN BACK UP/ LINE PRTN.	1600-800/1	-	-	1600/ 800	8/4	25 on 1600/1tap. 50 on 800/1tap.
	5	TRAN. DIFF/ LINE PRTN.	1600-800/1	-	-	1600/ 800	8/4	25 on 1600/1tap. 50 on 800/1tap.

REQUIREMENTS FOR 220 kV CURRENT TRANSFORMER (TRANSF)

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. Resist-ance	Max. Excitation current at Vk (in mA)

							(ohm)	
/. 5	1	BUS DIFF CHE-CK	1600-800/1	-	-	1600/ 800	8/4	25 on 1600/1tap. 50 on 800/1tap.
	2	BUS DIFF MAIN	1600-800/1	-	-	1600/ 800	8/4	25 on 1600/1tap. 50 on 800/1tap.
	3	METE-RING	300-150/1	20	0.2S	-	-	-
	4	TRAN BACK UP/ LINE PRTN.	300-150/1	-	-	As Required		
	5	TRAN. DIFF/ LINE PRTN.	300-150/1	-	-	As Required		

All relaying CTs shall be of accuracy class PS as per IS: 2705.

Note: The rating and ratio of the current transformer will be finalized during DDE.

TABLE-3B

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

REQUIREMENTS FOR 132 kV CURRENT TRANSFORMER (TRANSF)

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. 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	400-200/1	20	0.2S	-	-	-
	4	TRAN BACK UP/ LINE PRTN.	400-200/1	-	-	400-200	8/ 4	25 on 600/1 50 on 300/1
	5	DIFF/ LINE PRTN.	400-200/1	-	-	400-200	8/ 4	25 on 800/1 50 on 400/1

All relaying CTs shall be of accuracy class PS as per IS: 2705.

Note: The rating and ratio of the current transformer will be finalized during DDE.

Table- 3C

REQUIREMENTS FOR 245 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	3000-1600-800/1	-	PS	3000-1600-800	15/ 8/ 4	13.3 on 3000/1 25 on 1600/1 50on 800/1
2	protection	3000-1600-800/1	-	PS	3000-1600-800	15/ 8/ 4	13.3 on 3000/1 25 on 1600/1 50on 800/1
3	Metering	3000-1600-800/1	20	0.2S	-	-	-
4	protection	3000-1600-800/1	-	PS	3000-1600-800	15/ 8/ 4	13.3 on 3000/1 25 on

							1600/1 50on 800/1
5	protection	3000-1600-800/1	-	PS	3000-1600-800	15/ 8/ 4	13.3 on 3000/1 25 on 1600/1 50on 800/1

TABLE – 3D

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

ANNEXURE-4

TECHNICAL PARAMETERS FOR VOLTAGE TRANSFORMERS

Sl. No.	Particular	220 kV	132kV	66kV
1	Rated system voltage (Un)	245 kV (rms)	145 KV (rms)	72 KV (rms)
2	Rated frequency	50 Hz	50 Hz	50 Hz
3	System neutral earthing	Effectively earthed	Effectively earthed	Effectively earthed
4	System fault level	50/40 kAp. (As applicable) for 1 Second.	31.5 kA	31.5 kA
5	Rated insulation levels			

Sl. No.	Particular	220 kV	132kV	66kV
i.	1.2/50 micro second impulse voltage	±1050 kVp	±650 kVp	±325 kVp
ii.	one minute power frequency withstand voltage	460 kV (rms)	275 kV (rms)	140 kV (rms)
iii.	250/2500 micro second switching impulse voltage (dry & wet)	NA	NA	NA
6	One minute power frequency withstand voltage for secondary winding	3 kV (rms)	3 kV(rms)	3 kV(rms)
7	Radio interference voltage at 1.1 Un/√3 and frequency range 0.5 to 2 MHz	1000 µV	500µV	….µV
8	Rated total thermal burden	400 VA		
9	Partial discharge level	10 Pico coulombs.	10 pico coloumbs	10 pico coloumbs

TABLE -4A

REQUIREMENT OF VOLTAGE TRANSFORMERS

Sl. No	PARTICULARS	220 kV			132kV /66		
1	Rated primary voltage	220/√3 kV			132//√3 kV 66//√3 kV		
2	Type	Electromagnetic			Electromagnetic		
3	No. of secondaries	3			3		
4	Rated voltage factor	1.2 continuous			1.2 continuous		
		1.5 for 30 seconds			1.5 for 30 seconds		
5	Phase angle error	±10 minutes (for metering core)			±10 minutes (for metering core)		
		Sec I	Sec II	Sec III	Sec I	Sec II	Sec III
6.	Rated secondary voltage (V)	110/ √3	110/ √3	110/ √3	110/ √3	110/ √3	110/√3
7.	Application	Prote ction	Prote ction	Meterin g	Prot ecti on	Prot ecti on	Metering
8.	Accuracy	3P	3P	0.2	3P	3P	0.2
9.	Output burden (VA) (minimum)	50	50	50	50	50	50

ANNEXURE-5

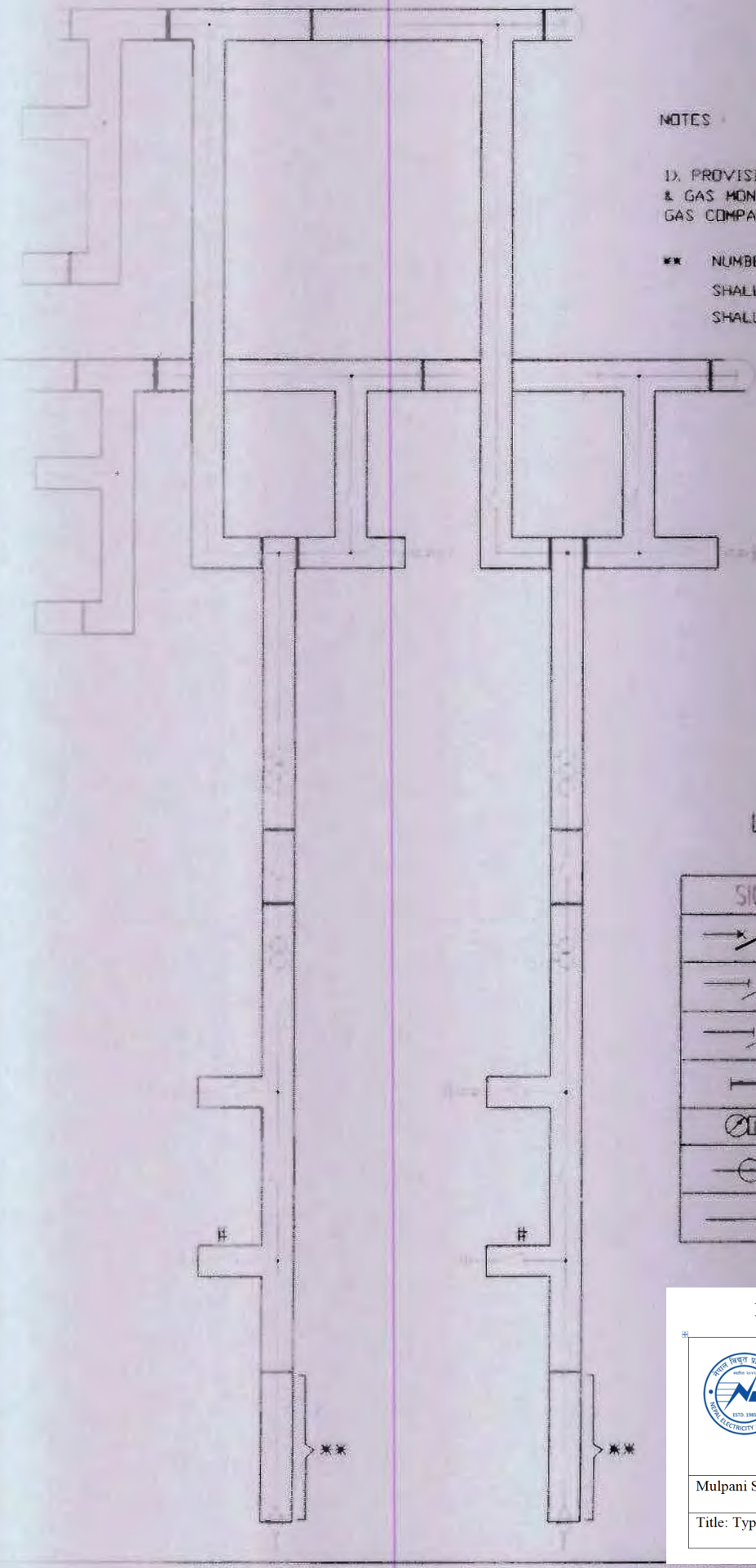
TECHNICAL PARAMETERS OF GIS SURGE ARRESTOR

Sl. No.	Particulars	220 kV	132 kV	66 kV
1	Rated system voltage	245 kV	132kV	66kV
2	System neutral earthing	Effectively earthed	Effectively earthed	Effectively earthed
3	Rated arrestor voltage	216 kV	120 kV	60 kV
4	Nominal discharge current	10 kA of 8/20 µs wave	10 kA of 8/20 µs wave	10 kA of 8/20 µs wave
5	Rated frequency	50 Hz	50 Hz	50 Hz
6	Minimum discharge capability voltage corresponding to minimum discharge characteristics	5 KJ/kV (referred to rated arrestor)	5 KJ/kV (referred to rated arrestor)	5 KJ/kV (referred to rated arrestor)
7	Continuous operating voltage at 50^0C	168 kV	102 kV	
8	Min. switching surge residual voltage	-		
	Max. switching surge residual voltage	500 kVp	280kVp	
9	Max. residual voltage at 5 kA	560 kVp	310kVp	
11	Max. residual voltage at 10 kA nominal discharge current	600 kVp	330 kVp	
12	Max. residual voltage at 20 kA nominal discharge current	-		
13	Steep fronted wave residual voltage	650kVp 10kA		
14	Long duration discharge class	3	3	3
15	High current short duration test value (4/10 micro second wave)	100 kAp	100 kAp	100 kAp
16	Current for pressure relief test	50kA/50kA (as applicable)	31.5 kA	31.5 kA
17	Prospective symmetrical fault current	40 kA rms for 0.2 Sec	As per IEC	As per IEC
18	Pressure relief class:	A	A	A
19	RIV at 1.1 $U_n/\sqrt{3}$ kV rms(micro volts)	Less than 500	Less than 500	Less than 500
20	Partial discharge at 1.05 COV (pC)	Not more than 5	Not more than 5	Not more than 5
21	Reference ambient temp.	50 ^{0}C	50 ^{0}C	50 ^{0}C

ANNEXURE-6

TECHNICAL PARAMETERS FOR SF6/AIR BUSHING

Sl. No.	Particular	220 kV	132kV
1	Rated Voltage (kV)	245 kV (rms)	145 kV (rms)
2	Rated Current (Amp)	1600	600
3	1.2/50 micro second impulse voltage (Lightning impulse withstand voltage)	1050 kVp	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	6125	3625
7	Minimum Cantilever strength (kN)	8	5



NOTES :

1). PROVISION OF RUPTURE DISC,ABSORBER,GAS FILLING & GAS MONITORING ARRANGEMENT TO BE KEPT IN EACH GAS COMPARTMENT.

** NUMBER OF GAS COMPARTMENTS IN THIS SECTION SHALL BE AS PER THE ACTUAL LAYOUT & SHALL BE FINALISED DURING DETAILED ENGG.

LEGENDS

SIGN	NAME	DESCRIPTION
	CB	CIRCUIT BREAKER
	DS	DISCONNECTING SWITCH
	ES/FES#	EARTHING SWITCH
		BARRIER INSULATOR
P		SF6 GAS DENSITY MONITOR
	CT	CURRENT TRANSFORMER
	BSG	SF6/AIR BUSHING

Reference drawing only for tender proposes

Nepal electricity authority
(GoN Undertaking)
Project Management Directorate
Electricity Grid Modernization Project

Mulpani Substation Construction Project

Title: Typical Gas Schematic Diagram (Double Main Scheme)

CHAPTER 20 – TECHNICAL SPECIFICATIONS FOR TRANSFORMERS

(Transformer up to 220 kV class)

Table of Content

1.0 General

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

1.2 Transportation

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

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

2.0 Performance

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

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

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

2.4 The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10 per cent continuous over voltage condition it does not exceed 1.9 Tesla at any tap position.

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

2.6 Radio Interference and Noise Level

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

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

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

2.8 The transformer and all its accessories including CTs etc. shall be designed to withstand without injury, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for a period of 3 secs. The short circuit level of the HV & LV System to which the subject transformers will be connected is 40 kA for 1 sec (sym, rms, 3 phase fault) on 220kV, 31.5 kA (sym, rms,3 phase fault on 132 kV) & 25kA (sym rms 3 phase fault on 11kV).

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

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

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

2.11 Dynamic Short Circuit Test requirement

(i) For 220 kV Class Transformer:

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on any rating of 220 kV or above voltage class transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report / Certificate along with bid.. Further design review of offered 220 kV class transformers shall be carried out based on design of short circuit tested 220 kV or above voltage class transformer.

(ii) For 132 kV Class Transformer:

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on any rating of 132 kV or above voltage class transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report / Certificate along with bid. Further design review of offered 132 kV class transformers shall be carried out based on design of short circuit tested 132 kV or above voltage class transformer.

2.12 **Design review**

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

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

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

The design review will commence after placement of award with successful bidder and shall be finalised before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the transformer under scope of this specification.

The design review shall be conducted generally following the “Guidelines for conducting design reviews for transformers 100 MVA and 123kV and above” prepared by Cigre SC 12 Working Group 12.22.

The manufacturer shall provide all necessary information and calculations during design review to demonstrate that the transformer meets the requirements for short circuit strength and durability. The latest recommendations of IEC and Cigre SC 12 shall be applied for short circuit withstand evaluation.

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

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

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

3.0 Construction Details

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

3.1 Tank and Tank Accessories

3.1.1 Tank

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

3.1.1.2 All seams and those joints not required to be opened at site shall be factory welded, and wherever possible they shall be double welded. After completion of tank and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. The requirement of post weld heat treatment of tank/stress relieving shall be based on recommendation of BS-5500 table 4.4.3.1.

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

3.1.1.4 The transformer shall have conventional type tank. In case the joint is welded it shall be provided with flanges suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld splatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise of the joint.

3.1.1.5 Each tank shall be provided with:

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

(b) A minimum of four jacking pads in accessible position to enable the transformer complete with oil to be raised or lowered using hydraulic jacks. Each jacking pad shall be designed to support with an adequate factor of safety for at least half of the total mass of the transformer filled with oil allowing in addition for maximum possible misalignment of the jacking force to the centre of the working surface.

(c) Suitable haulage holes shall be provided.

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

3.1.1.7 The base of each tank shall be so designed that it shall be possible to move the complete transformer unit by skidding in any direction without injury when using plates or rails.

3.1.1.8 Paint system and procedures

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

	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thick-ness (DFT)	Colour shade
Main tank, pipes, conservator tank, oil storage tank etc. (external surfaces)	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40μm)	Epoxy high build Micaceous iron oxide (HB MIO) (75μm)	Aliphatic polyurethane (PU) (Minimum 50μm)	Minimum 155μm	RAL 7035
Main tank, pipes (above 80 NB), conservator tank, oil storage tank etc. (Internal surfaces)	Shot Blast cleaning Sa 2 ½*	Hot oil resistant, non-corrosive varnish or paint or epoxy	--	--	Minimum 30μm	Glossy white for paint
Radiator (external surfaces)**	Chemical / Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40μm)	Epoxy base Zinc primer (30-40μm)	PU paint (Minimum 50μm)	Minimum 100μm	Matching shade of tank/ different shade aesthetically matching to tank
Radiator and pipes up to 80 NB (Internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish	--	--	--	--
Control cabinet / marshalling box/RTCC	Seven tank process as per IEC	Zinc chromate primer (two coats)	--	EPOXY paint with PU top coat	Minimum 80μm	RAL 7035 shade for exterior and interior

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

3.1.2 **Tank Cover**

3.1.2.1 The tank cover shall be designed to prevent retention of rain water and shall not distort when lifted. The internal surface of the top cover shall be shaped to ensure efficient collection and direction of free gas to the buchholz relay.

3.1.2.2 At least one adequately sized inspection openings shall be provided in the transformers for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 kg. Handles shall be provided on the inspection cover to facilitate lifting.

3.1.2.3 The tank covers shall be fitted with pockets at the position of maximum oil temperature at maximum continuous rating for bulbs of oil and winding temperature indicators. It

shall be possible to remove these bulbs without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.

3.1.2.4 Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

3.1.2.5 All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression. All gasketed joints shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. Groove provided to accommodate round nitrile rubber cord for rectangular openings shall be milled.

3.1.2.6 Tank hotspot

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

3.1.2.7 Currents flowing in tank cover and bushing turrets

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

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

3.1.3 **Axles and Wheels**

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

3.1.3.2 The roller mounted transformers are to be provided with flanged bi-directional wheels and axles. This set of wheels and axles shall be suitable for fixing to the under carriage of transformer to facilitate its movement on rail track. Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of transformer.

3.1.3.3 The rail track gauge shall be 1676 mm.

3.1.4 **Foundation and Anti Earthquake Clamping Device**

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

3.1.5 **Conservator & Oil Preservation System**

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

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

3.1.5.3 **Conservator tank and pipe work**

3.1.5.3.1 Conservator tank shall have adequate capacity with highest and lowest visible-levels to meet the requirements of expansion of total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to 100degC. The capacity of

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

3.1.5.3.2 The conservator shall be fitted with integral lifting lugs in such a position so that it can be removed for cleaning purposes. Suitable provision shall be kept to replace air cell and cleaning of the conservator wherever applicable.

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

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

3.1.5.3.5 The feed pipe to the transformer tank shall enter the transformer cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the transformer side of the Buchholz relay, and straight for not less than three times that diameter on the conservator side of the relay.

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

3.1.5.4 **Oil Preservation Equipment**

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

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

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

3.1.5.4.3 Air cell of conservator shall be able to withstand the vacuum during installation /maintenance periods. Otherwise provision shall be kept to isolate the conservator from the main tank when the latter is under vacuum by providing a vacuum sealing valve or other suitable means in the pipe connecting main tank with the conservator. The transformer manual shall give full and clear instructions on the operation, maintenance, testing and replacement of the air cell. It shall also indicate shelf life, life expectancy in operation, the recommended replacement intervals and the supplier.

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

3.1.5.5 **Maintenance-free Dehydrating Breather**

Conservator of Main Tank and OLTC each shall be fitted with a maintenance-free dehydrating breather in which only pure silica gel has been filled as dehydrating agent. Connection shall be made to a point in the oil conservator not less than 50 mm above the maximum working oil level by means of a pipe with a minimum diameter of 25 mm. Breathers and connecting pipes shall be securely clamped and supported to the transformer, or other structure supplied by the contractor, in such a manner so as to eliminate undesirable vibration and noise. The design shall be such that:

a) Incoming air is directed toward the desiccant (silica gel) and dried.
b) The desiccant is regenerated/de-humidified by an installed heating element that shall be sensor-controlled and self-regulating.
c) Silica gel is isolated from atmosphere by an oil seal.
c) Moisture absorption indicated by a change in color of the crystals.
d) Breather is mounted approximately1200mm above rail top level.
e) The maintenance free dehydrating breathers shall have a humidity and temperature sensor and must have 3 LED for status indication and a data logger to log all important events. The maintenance free breather shall be equipped with a self learning algorithm alpha control for the OLTC conservator and beta control for main tank conservator. Moving parts such as solenoid valves or fans are not accepted. Additionally an Anti-Condensation heater shall be installed in the control box and test button is required for auto-diagnosis and testing functions

3.1.5.6 Pressure Relief Device

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

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

3.1.5.7 Buchholz Relay

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

3.1.5.8 Temperature Indicators

3.1.5.8.1 Oil Temperature Indicator (OTI)

All transformers shall be provided with a 150 mm (approx.) dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically

independent ungrounded alarm and trip contacts, maximum reading pointer and resetting device shall be provided in the OTI. A temperature sensing element suitably located in a pocket on top oil shall be furnished. This shall be connected to the OTI by means of capillary tubing. Temperature indicator dials shall have linear gradations to clearly read atleast every 2 deg C. Accuracy of OTI shall be ± 3.0 deg C or better. The setting of alarm and tripping contacts shall be adjustable at site.

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

a) Signal transmitter

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

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

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

3.1.5.8.2 **Winding Temperature Indicator (WTI)**

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

i) Temperature sensing element.
ii) Image coil.

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

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

v) Calibration device.

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

Alarm – 110degC
Trip - 120degC

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

a) Signal transmitter for each winding

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

b) Remote winding temperature indicator

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

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

3.1.9 **Earthing Terminals**

3.1.9.1 Two (2) earthing pads (each complete with two (2) nos. holes, M 10 bolts, plain and spring washers) suitable for connection to 75 x 6 mm galvanised steel grounding flat shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

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

3.2 **Core**

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

3.2.2 The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations which may cause local heating. The temperature of any part of the core or its support structure in contact with oil shall not exceed 120 deg C under normal operating condition and 130 deg C under most extreme operating condition. Adequate temperature margin shall be provided to maintain longer life expectancy for this material.

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

3.2.4 Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

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

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

3.2.7 The supporting frame work of the core shall be so designed as to avoid presence of pockets which would prevent complete emptying of tank through drain valve or cause trapping of air during oil filling.

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

3.2.9 The core shall be earthed to the core clamping structure at one point only, through a removable external link suitably located and protected to facilitate testing after installation of the transformer.

In case core laminations are divided into sections by insulating barriers or cooling ducts parallel to the plane of the lamination, tinned copper bridging strips shall be inserted to maintain electrical continuity between sections.

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

3.3 **Windings**

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

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

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

3.3.4 Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.

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

3.3.6 The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalise the distribution of currents and temperature along the winding.

3.4 **Unused inhibited Insulating Oil**

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

Sl. No.	Property	Test Method	Limits
A1.	Function		
1a.	Viscosity at 100degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.) 3 mm2/s

1b.	Viscosity at 40degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.)12 mm2/s
1c.	Viscosity at -30degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.)1800 mm2/s
2.	Appearance	A representative sample of the oil shall be examined in a 100 mm thick layer, at ambient temperature	The oil shall be clear and bright, transparent and free from suspended matter or sediment
3.	Pour point	ISO 3016 or ASTM D97	(Max.)- 40degC
4.	Water content a) for bulk supply b) for delivery in drums	IEC 60814 or ASTM D1533	(Max.) 30 mg/kg 40 mg/kg
5.	Electric strength (breakdown voltage)	IEC 60156 or ASTM D1298	(Min.) 50 kV(new unfiltered oil) / 70 kV (after treatment)
6.	Density at 20 deg C	ISO 3675 or ISO 12185 or ASTM D 4052	0.820 - 0.895 g/ml
7.	Dielectric dissipation factor (tan delta) at 90 deg C	IEC 60247 or IEC 61620 Or ASTM D924	(Max) 0.0025
8.	Resistivity at 90 deg C	IEC 60247	150 X 10^12 Ohm –cm, (Min.) for records only.
9.	Negative impulse testing KVp @ 25 deg C	ASTM D-3300	145 (Min.)
10.	Carbon type composition (% of Aromatic, Paraffins and Naphthenic compounds.)	IEC 60590 or ASTM D 2140	Max.Aromatic : 4 to12 % Paraffins : <50% & balance shall be Naphthenic compounds.
B1.	Refining / Stability		
1.	Acidity	IEC 62021-1 or ASTM D974	(Max) 0.01 mg KOH/g
2.	Interfacial tension at 27degC	ISO 6295 or ASTM D971	(Min) 0.04 N/m
3.	Total sulfur content	BS 2000 part 373 or ISO 14596	0.15 % (Max.)
4.	Corrosive sulphur	IEC 62535	Non-Corrosive on copper and paper
		ASTM D1275B	Non-Corrosive
5.	Presence of oxidation inhibitor	IEC 60666 or ASTM D2668 or D4768	0.08% (Min.) to 0.4% (Max.) Oil should contain no other additives .Supplier should declare presence of additives, if any.
6.	2-Furfural content	IEC 61198 or ASTM D5837	25 Microgram/litre (Max.)
C1.	Performance		
1	Oxidation stability -Total acidity -Sludge - Dielectric dissipation factor (tan delta) at 90degC	IEC 61125 (method c) Test duration 500 hour IEC 60247	 Max 0.3 mg KOH/g Max 0.05 % Max 0.05
2.	Gassing	IEC 60628A or ASTM D2300	No general requirement
3.	Oxidation stability (Rotating Bomb test)	IEC : 61125(Method B) / ASTM D2112 (e)	220 Minutes (Min.)
D1.	Health, safety and environment (HSE)		

1.	Flash point	ISO 2719	(Min.)135degC
2.	PCA content	BS 2000 Part 346	Max 3%
3.	PCB content	IEC 61619 or ASTM D4059	Not detectable (Less than 2 mg/kg)

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

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

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

1. Break Down voltage (BDV) : 70 kV (min.)
2. Moisture content : 10 ppm (max.)
3. Tan-delta at 90 °C : 0.01 (max.)
4. Resistivity at 90 °C : 6 X 10 ^12 ohm-cm (min.)
5. Interfacial tension : 0.035 N/m (min.)
6. *Oxidation Stability (Test method as per IEC 61125 method C,Test duration: 500hour for inhibited oil)
   a) Acidity : 0.3 (mg KOH /g) (max.)
   b) Sludge : 0.05 % (max.)
   c) Tan delta at 90 °C : 0.05 (max.)
7. * Total PCB content : Not detectable (2 mg/kg total)

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

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

Oil sample shall be drawn before and after heat run test and shall be tested for dissolved gas analysis. Oil sampling to be done 2 hours prior to commencement of temperature rise test. For ONAN/ONAF cooled transformers, sample shall not be taken earlier than 2 hours after shutdown. The acceptance norms with reference to various gas generation rates shall be as per IEC 61181.

3.5 Terminal Arrangements

3.5.1 Bushings

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

3.5.1.2 Bushing for various voltage rating shall be as follows

52 kV and above	Hermetically sealed Oil filled condenser type/ RIP bushing with porcelain or composite insulator.
36 kV and below	Solid porcelain or oil communicating type. Dimensions of 11 kV bushing shall conform to IEC

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

(a) Oil level gauge.

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

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

3.5.1.5 Bushings of identical rating shall be interchangeable.

3.5.1.6 Porcelain used in bushing manufacture shall be homogenous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

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

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

3.5.1.9 No arcing horns shall be provided on the bushings.

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

3.5.2 **Terminal Marking**

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

3.5.3 **Neutral Earthing Arrangement**

i) For 3-Phase Unit

The neutral of the transformer shall be brought out through bushing. The neutral terminal of 3-phase transformer shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to two (2) 75 x 12 mm galvanised steel flats connected to Employer's grounding mat.

ii) For 1-Phase Unit

The neutral of the transformer shall be brought out through bushing. The contractor shall connect the neutrals of 1-phase transformers by overhead connection using an overhead common brass/tinned copper/Aluminum pipe /ACSR conductor grounding bus, supported from the tank and fire walls by using porcelain insulators. All material like Bus post insulator, Aluminium tube, conductor, clamps & connectors, earthing materials, support structure, hardware etc required for neutral formation and connection with neutral CT and earthing of neutral shall be provided by contractor. The neutral formation shall be such that neutral winding of single-phase spare transformer can be disconnected or connected to either of the three phase banks.

i) Spare Unit connection arrangement (as applicable for 1-Phase Transformer)

Connection arrangement of spare unit of transformer with other units shall be made by isolator switching (Isolators are not part of this specification). Nutral formation for spare unit of transformer shall be done by manual connection. The contractor shall make connection arrangement as well as control scheme of OLTC and Cooler in such a way that spare unit of transformer can be connected in place of faulty unit without physically shifting it from its location. For this purpose, HV , LV and Neutral Connections of spare unit are to be extended upto the other unit by forming auxiliary buses and shall be supported by structure mounted bus post insulators at suitable intervals to enable spare unit connection through flexible/rigid conductor and suitable connector in place of existing unit to be replaced. The detail configuration and actual sizes of various items shall be finalised during detailed engineering and shall be subject to Employer's approval. All associated materials like Bus post insulators, Aluminium tube, conductors, clamps & connectors, insulator strings, hardware, cables, support structures, required for the above-mentioned arrangement shall be provided by the contractor.

3.6 **Cooling Equipment and its Control**

3.6.1 **Cooling Equipment**

3.6.1.1 The cooler shall be designed using sufficient number of tank mounted radiators. Design of cooling system shall satisfy the performance requirements.

3.6.1.2 Tank mounted radiators shall have its cooling fans , shut off valves at the top and bottom of suitable size, lifting lugs, top and bottom oil filling valves, air release plug at the top, a drain and sampling valve and thermometer pocket fitted with captive screw cap on the inlet and outlet.

3.6.1.3 Required number of standby fans of approximately 20% capacity shall also be provided with radiators.

3.6.1.4 Cooling fans shall be directly mounted on radiator. Each fan shall be suitably protected by galvanised wire guard. The exhaust air flow from cooling fan shall not be directed towards the main tank in any case.

3.6.1.5 Cooling fans motors shall be suitable for operation from 400 volts, three phase 50 Hz power supply and shall conform to IEC. Each cooling fan motors shall be provided with starter thermal overload and short circuit protection. The motor winding insulation shall be conventional class 'B' type. Motors shall have hose proof enclosure equivalent to IP: 55.

3.6.1.6 The cooler and its accessories shall preferably be hot dip galvanized or corrosion resistant paint (as per clause 3.1.1.8) should be applied to it.

3.6.1.7 Air release device and oil plug shall be provided on oil pipe connections. Drain valves shall be provided in order that each section can be drained independently.

3.6.2 Cooling Equipment Control (ONAN/ONAF COOLING)

3.6.2.1 Automatic operation control of fans shall be provided (with temperature change) from contacts of winding temperature indicator. The Contractor shall recommend the setting of WTI for automatic changeover of cooler control from ONAN to ONAF. The setting shall be such that hunting i.e. frequent start-up operations for small temperature differential do not occur.

3.6.2.2 Suitable manual control facility for cooler fans shall be provided.

3.6.2.3 Selector switches and push buttons shall also be provided in the cooler control cabinet to disconnect the automatic control and start/stop the fans manually.

3.6.2.4 Indicating Devices

Following lamp indications shall be provided in cooler control cabinet:

a) Control Supply failure.
b) Cooling fan failure.
c) Common thermal overload trip

One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of cooler control cabinet for further wiring to Common Marshalling Box (CMB).

3.6.2.5 Two auxiliary power supplies, 400 volt, three phase four (4) wire shall be provided at common marshalling box. All loads shall be fed by one of the two sources through an electrically interlocked automatic transfer scheme housed in the CMB. Power supply to individual phase unit shall be extended from the CMB. Power supply to spare unit shall be extended from nearest CMB only. Suitably rated power contactors, separate MCBs/MCCBs shall be provided in the Common Marshalling Box for each circuit.

3.6.2.6 Control and power supplies are to be given for Cooler circuits after suitable selection at Common Marshalling Box. Necessary isolating switches and protective devices shall be provided at suitable points as per Purchaser's approved scheme. The Contractor shall derive AC power for Cooler Control Circuitry from the AC feeder as mentioned above. In case auxiliary power supply requirement for Cooler Control Mechanism is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor.

3.6.2.7 For each circuit, suitably rated MCBs/MCCBs as required for further distribution of auxiliary power supply to DM boxes, Online Gases and moisture monitoring system, Online drying system and Fibre optic sensor Box etc. (as applicable), shall be provided by contractor, in individual marshalling boxes /cooler control boxes.

3.6.3 Auxiliary power supply distribution scheme shall be submitted for approval. Supply and laying of Power, Control and special cables from common marshalling box to individual MB/Cooler Control Cubicle (including spare unit) & further distribution from IMB/CCC to all accessories is in the scope of the contractor. Further any special cable (if required) from CMB to Owner's Control Panels/RTCC panels are also in the scope of the contractor.

3.6.4 The cooler control cabinet / Individual Marshalling box shall have all necessary devices meant for cooler control and local temperature indicators. All the contacts of various protective devices mounted on the transformer and all the secondary terminals of the bushing CTs shall also be wired upto the terminal board in the cooler control cabinet/Individual Marshalling box. All the CT secondary terminals in the cooler control cabinet shall have provision for shorting to avoid CT open circuit while it is not in use. All the necessary terminations for remote connection to Purchaser's panel shall be wired upto the Common Marshalling box.

3.6.5 Connection arrangement for spare unit shall be in such a way that spare unit of transformer can be connected in place of faulty unit without physically shifting and all the control, protection, indication signals of spare unit shall also be brought in common marshalling box

of all the banks. Necessary arrangement in schematic of Common marshalling box is required to facilitate change-over of all the signals of faulty units to spare unit of Transformer, to ensure flow of control, protection and indication signals between Purchaser's Control panels / Digital RTCC Panel / SCADA and individual units under operation (i.e. any designated unit for bank or spare unit, if it replace any designated unit). To facilitate change-over of spare unit signals with faulty unit in CMB, male-female plug-in connector or better arrangement shall be provided to reduce the outage time

3.6.6 **Valves**

3.6.6.1 All valves shall be of gun metal or of cast steel/cast iron. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel.

3.6.6.2 Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.

3.6.6.3 Each valve shall be provided with the indicator to show clearly the position of the valve.

3.6.6.4 All valves flanges shall have machined faces.

3.6.6.5 All valves in oil line shall be suitable for continuous operation with transformer oil at 115 deg C.

3.6.6.6 The oil sampling point for main tank shall have two identical valves to be put in series .Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.

3.6.6.7 A valve or other suitable means shall be provided to fix (in future) on line dissolved gas monitoring system to facilitate continuous dissolved gas analysis. The location & size of the same shall be finalised during detail engineering stage

3.6.6.8 After testing, inside surface of all cast iron valves coming in contact with oil shall be applied with one coat of oil resisting paint/varnish with two coats of red oxide zinc chromate primer followed by two coats of fully glossy finishing paint conforming to international standards. Outside surface except gasket setting surface of butterfly valves shall be painted with two coats of red oxide zinc chromate conforming to International Standards followed by two coats of fully glossy finishing paint.

3.6.6.9 All hardware used shall be cadmium plated/electro galvanised steel.

3.6.6.10 For estimation purpose of spares one set of valves would mean one valve of each type used in Transformer.

3.7 Tap Changing Equipment

Each transformer shall be provided with Off load tap / On Load Tap changing equipment as specified elsewhere.

3.7.1 Off load tap Changer equipment (if applicable)

The off load / Off Circuit tap changer (OCTC) equipment shall be handle operated with a locking arrangement along with tap position indicator. The external handle shall be

situated in an unobstructed position. The contacts are positively self-locating in each tapping position without constraint from the operating mechanism. The rating of the contacts shall be suitable to carry maximum current of the transformer. For three phase transformer the tap change switch shall simultaneous switch the similar taps on the three phases. A warning plate indicating that OCTC shall be operated only when the transformer is de-energized, shall be fitted.

3.7.2 ON Load Tap Changing (OLTC) Equipment

The On Load Tap Changer (OLTC) shall be of high speed resistor type with vacuum technology include the following:

3.7.2.1 Main OLTC Gear Mechanism

3.7.2.1.1 Each single / three phase transformer shall be provided with voltage control equipment of the tap changing type for varying its effective transformation ratio whilst the transformers are on load.

3.7.2.1.2 OLTC shall be motor operated suitable for local as well as remote operation. The diverter switch or arcing switch shall be designed so as to ensure that its operation once commenced shall be completed independently of the control relays or switches, failure of auxiliary supplies etc. To meet any contingency which may result in incomplete operation of the diverter switch, adequate means shall be provided to safeguard the transformer and its ancillary equipment. The current diverting contacts shall be housed in a separate vacuum interrupter chamber not communicating with the oil in main tank of the transformer. The contacts shall be accessible for inspection without lowering oil level in the main tank and the contacts shall be replaceable. Electrical arcing took place in a vacuum interrupter only.

3.7.2.1.3 Necessary safeguards shall be provided to avoid harmful arcing at the current diverting contacts in the event of operation of the OLTC gear under overload conditions of the transformer.

3.7.2.1.4 Tap changer shall be so mounted that bell cover of transformer can be lifted without removing connections between windings and tap changer

3.7.2.2 Local OLTC Control Cabinet (Drive Mechanism Box)

Each transformer unit of OLTC gear shall have following features:

3.7.2.2.1 OLTC shall be suitable for manually handle operated and electrically motor operated. For local manual operation from Local OLTC Control cabinet (Drive Mechanism Box), an external handle shall be provided.

3.7.2.2.2 OLTC's Local control cabinet shall be mounted on the tank in accessible position. The cranking device/handle for manual operation for OLTC gear shall be removable and suitable for operation by a man standing at ground level. The mechanism shall be complete with the following:

- Mechanical tap position indicator which shall be clearly visible from near the transformer.
- A mechanical operation counter of at least five digits shall be fitted to indicate the number of operations completed and shall have no provision for resetting. Mechanical stops to prevent over- cranking of the mechanism beyond the extreme tap positions.

- The manual control considered as backup to the motor operated on load tap changer control shall be interlocked with the motor to block motor start-up during manual operation.
- The manual operating mechanism shall be labeled to show the direction of operation for raising the voltage and vice-versa.
- An electrical interlock to cut-off a counter impulse for reverse step change being initiated during a progressing tap change and until the mechanism comes to rest and resets circuits for a fresh position.

3.7.2.2.3 For electrical operation from local as well as remote, motor operated mechanism shall be provided. It shall not be possible to operate the electric drive when the manual operating gear is in use. It shall not be possible for any two controls to be in operation at the same time. Transfer of source in the event of failure of one AC supply shall not affect the tap changer. Thermal device or other means shall be provided to protect the motor and control circuit.

3.7.2.2.4 The Local OLTC Drive Mechanism Box shall house all necessary devices meant for OLTC control and indication. It shall be complete with the followings:

i. A circuit breaker/contactor with thermal overload devices for controlling the AC Auxiliary supply to the OLTC motor
ii. Emergency Push Button to stop OLTC operation
iii. Cubicle light with door switch
iv. Provided with anti-condensation metal clad heaters to prevent condensation of moisture
v. Padlocking arrangement for hinged door of cabinet
vi. All contactors relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.
vii. The cabinet shall be tested at least IP55 protection class.

3.7.2.2.5 All relays and operating devices shall operate correctly at any voltage within the limits specified in Chapter-GTR. Incase auxiliary power supply requirement for OLTC DM Box is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor.

3.7.2.2.6 Operating mechanism for on load tap changer shall be designed to go through one step of tap change per command only, until the control switch is returned to the off position between successive operations/repeat commands.

3.7.2.2.7 Limit switches shall be provided to prevent over running of the mechanism and shall be directly connected in the control circuit of the operating motor provided that a mechanical de-clutching mechanism is incorporated. In addition, a mechanical stop shall be provided to prevent over-running of the mechanism under any condition. An interlock to cut-out electrical control when it tends to operate the gear beyond either of the extreme tap positions.

3.7.2.2.8 OLTC local control cabinet shall be provided with tap position indication for the transformer. Drive Mechanism shall be equipped with a fixed resistor network capable of providing discrete voltage steps or provide 4-20mA transducer outputs for tap position indication in CMB (for single phase unit) and input to Digital RTCC/SCADA

system.

3.7.2.2.9 'Local-remote' selector switch shall be provided in the local OLTC control cabinet. In Local mode, all electrical commands from remote (i.e. from CMB, Digital RTCC, SCADA etc.) shall be cut-off/blocked. Electrical operations to change tap positions shall be possible by using raise/lower push buttons under local mode from DM Box. In remote mode electrical commands from CMB/Digital RTCC/SCADA etc. shall be executed. The remote-local selector switch shall be having at-least two spare contacts per position.

3.7.2.2.10 Following minimum contacts shall be available in DM Box, which shall be wired to CMB for single phase unit. Further these contacts shall be wired to Digital RTCC panel:

a. INCOMPLETE STEP which shall not operate for momentary loss of auxiliary power.
b. OLTC motor overload protection
c. Supply to DM Motor fail
d. OLTC INPROGRESS
e. Local / Remote Selector switch position
f. OLTC upper/lower limits reached

3.7.2.2.11 All relays, switches, fuses etc. shall be mounted in the OLTC local control cabinet and shall be clearly marked/labeled for the purpose of identification.

3.7.2.2.12 A permanently legible lubrication chart if required shall befitted within the OLTC local control cabinet.

3.7.2.3 OLTC Control from Common Marshalling Box (CMB)

3.7.2.3.1 It shall be possible to monitor, control/operate, the OLTC of all the three 1- phase transformers of a transformer bank from Common Marshalling Box. The control and monitoring terminations of a spare transformer unit shall be brought to CMB. The necessary switching arrangement through male-female plug-in TB assembly shall be provided for replacing spare unit with any one of the faulty phase unit for monitoring & control from CMB.

3.7.2.3.2 'Independent-combined-remote selector switch, raise/lower switch and emergency stop Push Button shall be provided in the common marshalling box for OLTC control.

3.7.2.3.3 When the selector switch is in independent position, the OLTC control shall be possible from individual Local OLTC Control Cabinet (DM Box) only.

3.7.2.3.4 In '**combined position'**, raise-lower switch (provided in the CMB), shall be used to operate for bank of three single phase transformers from CMB.

3.7.2.3.5 In **'remote position'** control of OLTC shall be possible from Digital RTCC/SCADA etc.

3.7.2.3.6 From CMB, the operation of OLTC shall be for 3-phases of transformer units without producing phase displacement. Independent operation of each single phase

transformer from CMB/Digital RTCC/SCADA will be prevented.

3.7.2.3.7 Following minimum **LED indications** shall be provided in CMB:

a. INCOMPLETESTEP
b. OLTC motor overload protection
c. Supply to DM Motor fail
d. OLTC IN PROGRESS
e. Local / Remote Selector switch positions of DM
f. OLTC upper/lower limits reached
g. 400V Main AC supply ON
h. 400V Standby AC supply ON

Following **contacts** shall be wired to TBs in CMB for further wiring to C & R Panels.

i. 400V Main AC supply Fail
j. 400V Standby AC supply Fail

Following **contacts** shall be wired to TBs in CMB for further wiring to digital RTCC Panel:

a. INCOMPLETESTEP
b. OLTC motor overload protection
c. Supply to DM Motorfail
d. OLTC INPROGRESS
e. Local / Remote Selector switch positions of DM
f. OLTC upper/lower limits reached
g. 'Independent-combined-remote' selector switch positions of CMB

Further, OLTC Tap position Digital indications for all three 1-PhTransformer units either separately or through selector switch shall be provided in CMB. The same shall also be wired to Digital RTCC Panel to display tap positions for all three 1-ph unit separately.

3.7.3 Digital RTCC Panel

3.7.3.1 The digital RTCC panel shall have Automatic Tap Changer control and monitoring relay with Automatic Voltage Regulating features (referred as **Digital RTCC relay**) to remotely control and monitor OLTC. The relay shall be offered from the manufacturer who has already supplied Digital RTCC relay, which is in operation for at-least 2 years for transformer OLTC application.

3.7.3.2 Digital RTCC relay shall be microprocessor based adopting the latest state of the art design & technology within-built large display for ease of programming and viewing. The unit supplied shall be field programmable so that in the event of change in transformer / location, it could be customized to site conditions without sending back to works. The programming shall be menu driven and easily configurable. If it is designed with draw out type modules, it should take care of shorting all CT inputs automatically while drawing out. The CT/VT ratio shall be field programmable and Relay shall display the actual HV Voltage and current considering suitable multiplying factors. The system shall be self-sufficient and shall not require any additional devices like parallel balancing module etc. All Digital RTCC Relays shall be of same make for smooth integration of these relays for parallel operations of all transformers in the substation.

3.7.3.3 The digital RTCC Panel shall be provided with digital RTCC relay having Raise/Lower push buttons, Manual/ Automatic mode selection features, Master / Follower/ Independent/ off mode selection features and emergency stop Push Button for control of OLTC. Touch screen option in the relay, instead of electrical push button/switch is also acceptable.

3.7.3.4 **In Manual Mode**: In this mode, power system voltage based automatic control from digital RTCC relay shall be blocked and commands shall be executed manually by raise/lower push buttons.

3.7.3.5 **In Auto Mode:** In Auto mode, digital RTCC relay shall automatically control OLTC taps based on power system voltage and voltage set points. An interlock shall be provided to cut off electrical control automatically upon recourse being taken to the manual control in emergency.

3.7.3.6 Master/Follower/Independent/Off mode

Master Position: If the selector switch is in master position, it shall be possible to control the OLTC units of other parallel operating transformers in the follower mode by operation from the master unit.

Follower Position: If the selector switch is in Follower position control of OLTC shall be possible only from panel where master mode is selected.

Independent Position: In independent position of selector switch, control of OLTC shall be possible only from the panel where independent mode is selected. Suitable interlock arrangement shall be provided to avoid unwanted/ in consistent operation of OLTC of the transformer

3.7.3.7 **Raise/Lower control:** The remote OLTC scheme offered shall have provision to raise or lower taps for the complete bank of three 1-phase transformers/3-Phase Transformers. Individual 1-phase OLTC operation shall not be possible from the remote control panel.

3.7.3.8 Digital RTCC relays shall communicate with SCADA using IEC 61850 protocols to monitor, parameterize & control the OLTC. Any software required for this purpose shall be supplied. The supplied software shall not have restriction in loading on multiple computers for downloading and analyzing the data. Software shall indicate the current overview of all measured parameters of the connected transformer in real time. The digital RTCC Relay shall have multiple selectable set point voltages and it shall be possible to select the set points from SCADA, with a facility to have the possibility of additional set points command from SCADA. Communication between the Digital RTCC relays to execute the commands for parallel operation shall be implemented using required communication protocol. IEC-61850 GOOSE messaging between Digital RTCC relays for OLTC parallel operation is not permitted. Suitable communication hardware shall be provided to communicate upto distance of 1km between digital RTCC relays. Scope shall also include communication cables between digital RTCC relays. Cables as required for parallel operation of OLTCs of all transformers (including existing transformers wherever required) from Digital RTCC relays shall be considered included in the scope of bidder.

3.7.3.9 The Digital RTCC relay shall have programmable Binary Inputs (minimum 7 Nos.) and Binary outputs (minimum 7 Nos.) for Employer's future use. It shall be possible to have

additional module for Binary Input/output as well as Analogue input module depending upon requirement.

3.7.3.10 The relays shall ensure positive completion of lowering/raising of the OLTC tap, once the command is issued from the relay."Step-by-Step" operation shall be ensured so that only one tap change from each tap changing pulse shall be effected. If the command remains in the "operate" position, lock-out of the mechanism is to be ensured.

3.7.3.11 Following minimum indications/alarms shall be provided in Digital RTCC relay either through relay display panel or through relay LEDs:

a. INCOMPLETE STEP alarm
b. OLTC motor overload protection alarm
c. Supply to DM Motor fail alarm
d. OLTC IN PROGRESS alarm
e. Local/Remote Selector switch positions in DM Box
f. OLTC upper/lower limits reached alarm
g. OLTC Tap position indications for transformer units
h. 'Independent-combined-remote selector switch positions of CMB

3.7.3.12 In case of parallel operation or 1-PhaseTransformer unit banks OLTC out of step alarm shall be generated in the digital RTCC panel for discrepancy in the tap positions.

3.8 Auxiliary Power Supply of OLTC, Cooler Control and Power Circuit

3.8.1 Two auxiliary power supplies, 400 volt, three phase four (4) wire shall be provided by the Employer at cooler control cabinet for OLTC and cooler control and power circuit.

3.8.2 All loads shall be fed by one of the two feeders through an electrically interlocked automatic transfer switch housed in the cooler control cabinet for on load tap changer control and cooler circuits.

Design features of the transfer switch shall include the following:

a) Provision for the selection of one of the feeder as normal source and other as standby.

b) Upon failure of the normal source, the loads shall be automatically transferred after an adjustable time delay to standby sources.

c) Indication to be provided at cooler control cabinet for failure of normal source and for transfer to standby source and also for failure to transfer.

d) Automatic re-transfer to normal source without any intentional time delay following re-energization of the normal source.

e) Both the transfer and the re-transfers shall be dead transfers and AC feeders shall not be paralleled at any time.

3.8.3 Power Supply for OLTC Circuits

a) AC feeder shall be brought to the local OLTC control cabinet by the Contractor after suitable selection at cooler control cabinet for which description is given in 3.10.2 above, for control power circuit of OLTC.

b) The Contractor shall derive AC power for OLTC control circuitry from the AC feeder as mentioned above by using appropriately rated dry type transformers. If the control circuit is operated by DC supply, then suitable main and standby converters shall be provided by the Contractor to be operated from AC power source.

3.8.4 Power Supply for Cooler Circuits

3.8.4.1 Control and power supplies are to be given for Cooler circuits after the selection as mentioned above.

3.8.4.2 The Contractor shall derive AC power for Cooler Control Circuitry by using appropriately rated dry type transformer in case of using supply voltage different from the Employer's auxiliary supply. If the control circuit is operated by DC supply then suitable main and standby convertors shall be provided by the Contractor, to be operated from AC power source.

3.8.5 Necessary isolating switches and MCBs/MCCBs shall be provided at suitable points as per Employer's approved scheme**.**

3.9 Constructional features of Cooler Control Cabinet/ Individual Marshalling Box/Common Marshalling Box and Digital RTCC Panel

3.9.1 Each transformer unit shall be provided with local OLTC Drive Mechanism Box, cooler control cabinet/individual marshalling box. Digital RTCC panel and common marshalling (for a bank of three 1-phase units) shall be provided.

3.9.2 The cooler control cabinet, Individual Marshalling Box, Common Marshalling Box, shall be made of stainless steel sheet of at least 1.6mm thick. Digital RTCC panel shall be CRCA sheet of minimum thickness of 2.5mm and shall be painted suitably as per **Annexure–E**.

3.9.3 The degree of protection shall be IP: 55 for outdoor and IP: 43 for indoor in accordance with IS: 13947/IEC: 60947.

3.9.4 All doors, removable covers and plates shall be gasketed all around with suitably profiled. All gasketed surfaces shall be smooth straight and reinforced if necessary to minimize distortion to make a tight seal. For Control cubicle / Marshalling Boxes etc. which are outdoor type, all the sealing gaskets shall be of EPDM rubber or any better approved quality, whereas for all indoor control cabinets /Digital RTCC panel, the sealing gaskets shall be of neoprene rubber or any better approved quality. The gaskets shall be tested in accordance with approved quality plan, IS: 1149 and IS: 3400.

3.9.5 Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh of brass. All the control cabinets shall be provided with suitable lifting arrangement. Thermostat controlled space heater and cubicle lighting with ON-OFF switch shall be provided in each panel.

3.9.6 The size of Common marshalling box shall not be less than 1600mm (front) X 650mm (depth) X 1800mm (height). All the cabinets except common marshalling box & Digital RTCC shall be tank mounted. All the separately mounted cabinets and panels shall be free standing floor mounted type and have domed or sloping roof for outdoor application.

4 **Fittings**

4.1 The following fittings shall be provided with each three phase transformer covered in this specification.

4.1.1 Conservator for main tank with oil filling hole and cap, air cell, isolating valves, drain valve, magnetic oil level gauge with low level alarm contacts and dehydrating silicagel breather.

4.1.2 Pressure relief devices with alarm/trip contacts.

4.1.3 Buchholz relay double float/reed type with isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm and trip contacts.

4.1.4 Air release plug.

4.1.5 Inspection openings and covers.

4.1.6 Bushing with metal parts and gaskets to suit the termination arrangement.

4.1.7 Winding temperature indicators for local and remote mounting. One remote winding temperature indicator with a four point selector switch shall be provided for the three windings for three phase unit to have selection of any of the three windings.

4.1.8 Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs.

4.1.9 Protected type mercury or alcohol in glass thermometer.

4.1.10 Bottom and top filter valves with threaded male adaptors, bottom sampling valve and drain valve.

4.1.11 Rating and diagram plates on transformers and auxiliary apparatus.

4.1.12 Flanged bi-directional wheels/Trolley for movement

4.1.13 Cooler cabinet.

4.1.14 Off load / On load tap changing gear.

4.1.15 Cooling equipment

4.1.16 Bushing current transformers.

4.1.17 Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently.

4.1.18 Terminal marking plates.

4.1.19 Valves schedule plates.

4.1.20 Oil temperature indicator for local and remote mounting

.

4.1.21 Oil flow indicator

4.1.22 Marshalling box/Common Marshalling box

4.1.23 Suitable galvanized iron or stainless steel tray for cabling on main tank for better aesthetics.

4.1.24 Terminal clamp & connector

4.1.25 The fittings listed above are only indicative and other fittings which generally are required for satisfactory operation of the transformer are deemed to be included.

4.1.26 One set of hand tools of reputed make packed in a carry bag/box broadly comprising of double ended spanners (open jaws, cranked ring, tubular with Tommy bar each of sizes 9mm to 24mm, one set each), adjustable wrenches (8 &12 inch one set), gasket punches (of different sizes as used in the reactor one set), pliers (flat nose, round nose & side cutting one of each type), hammer with handle (one), files with handle (two), knife with handle (one), adjustable hacksaw (one), and cold chisel (one) shall be supplied per Substation.

5 Inspection and Testing

The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the equipment. An indication of inspection envisaged by the Employer is given under Clause 5.1. This is however not intended to form a comprehensive programme as it is Contractor's responsibility to draw up and carry out such a programme in the form of detailed quality plan duly approved by Employer for necessary implementation.

5.1 Inspection

5.1.1 Tank and Conservator

5.1.1.1 Certification of chemical analysis and material tests of plates.

5.1.1.2 Check for flatness.

5.1.1.3 Electrical interconnection of top and bottom by braided tinned copper flexibles.

5.1.1.4 Welder's qualification and weld procedure.

5.1.1.5 Testing of electrodes for quality of base materials and coatings.

5.1.1.6 Inspection of major weld preparation.

5.1.1.7 Crack detection of major strength weld seams by dye penetration test.

5.1.1.8 Measurement of film thickness of :

i) Oil insoluble varnish.

ii) Zinc chromate paint.

iii) Finished coat.

5.1.1.9 Check correct dimensions between wheels, demonstrate turning of wheels through 90 deg C and further dimensional check.

5.1.1.10 Check for physical properties of materials for lifting lugs, jacking pads, etc. All load bearing welds including lifting lug welds shall be subjected to NDT.

5.1.1.11 Leakage test of the conservator.

5.1.1.12 Certification of all test results.

5.1.2 **Core**

5.1.2.1 Sample testing of core materials for checking specific loss, bend properties, nameled tion characteristics and thickness.

5.1.2.2 Check on the quality of varnish if used on the stampings :

i) Measurement of thickness and hardness of varnish on stampings.

ii) Solvent resistance test to check that varnish does not react in hot oil.

iii) Check over all quality of varnish by sampling to ensure uniform shining colour, no bare spots, no over burnt varnish layer and no bubbles on varnished surface.

5.1.2.3 Check on the amount of burrs.

5.1.2.4 Bow check on stampings.

5.1.2.5 Check for the overlapping of stampings. Corners of the sheet are to be part.

5.1.2.6 Visual and dimensional check during assembly stage.

5.1.2.7 Check for interlaminar insulation between core sectors before and after pressing.

5.1.2.8 Visual and dimensional checks for straightness and roundness of core, thickness of limbs and suitability of clamps.

5.1.2.9 High voltage test (2 kV for one minute) between core and clamps.

5.1.2.10 Certification of all test results.

5.1.3 **Insulation Material**

5.1.3.1. Sample check for physical properties of materials.

5.1.3.2 Check for dielectric strength.

5.1.3.3 Visual and dimensional checks.

5.1.3.4 Check for the reaction of hot oil on insulating materials.

5.1.3.5 Dimension stability test at high temperature for insulating material.

5.1.3.6 Tracking resistance test on insulating material

5.1.3.7 Certification of all test results.

5.1.4 **Winding**

5.1.4.1 Sample check on winding conductor for mechanical properties and electrical conductivity.

5.1.4.2 Visual and dimensional checks on conductor for scratches, dent marks etc.

5.1.4.3 Sample check on insulating paper for pH value, bursting strength and electric strength.

5.1.4.4 Check for the reaction of hot oil on insulating paper.

5.1.4.5 Check for the bonding of the insulating paper with conductor.

5.1.4.6 Check and ensure that physical condition of all materials taken for windings is satisfactory and free of dust.

5.1.4.7 Check for absence of short circuit between parallel strands.

5.1.4.8 Check for brazed joints wherever applicable.

5.1.4.9 Measurement of voltage ratio to be carried out when core/yoke is completely restacked and all connections are ready.

5.1.4.10 Conductor enamel test for checking of cracks, leakage and pin holes.

5.1.4.11 Conductor flexibility test

5.1.4.12 Heat shrink test for anameled wire.

5.1.4.13 Certification of all test results.

5.1.5 **Checks Before Drying Process**

5.1.5.1 Check condition of insulation on the conductor and between the windings.

5.1.5.2 Check insulation distance between high voltage connections, cables and earth and other live parts.

5.1.5.3 Check insulating distances between low voltage connections and earth and other parts.

5.1.5.4 Insulation of core shall be tested at 2 kV/minute between core to bolts and core to clamp plates.

5.1.5.5 Check for proper cleanliness and absence of dust etc.

5.1.5.6 Certification of all test results.

5.1.6 **Checks During Drying Process**

5.1.6.1 Measurement and recording of temperature, vacuum and drying time during vacuum treatment.

5.1.6.2 Check for completeness of drying by periodic monitoring of IR and Tan delta.

5.1.6.3 Certification of all test results.

5.1.7 **Assembled Transformer**

5.1.7.1 Check completed transformer against approved outline drawings, provision for all fittings, finish level etc.

5.1.7.2 Test to check effective shielding of the tank.

5.1.7.3 Jacking test with oil on all the assembled transformers.

5.1.7.4 Dye penetration test shall be carried out after the jacking test.

5.1.8 **Bought Out Items**

5.1.8.1 The makes of all major bought out items shall be subject to Employer's approval.

5.1.8.2 The Contractor shall also prepare a comprehensive inspection and testing programme for all bought out/sub-contracted items and shall submit the same to the Employer for approval. Such programme shall include the following components:

a) Buchholz Relay.

b) Axles and wheels.

c) Winding temperature indicators for local and remote mounting.

d) Oil temperature indicators.

e) Bushings.

f) Bushing current transformers.

g) Cooler cabinet.

h) ON Load / Off Load Tap change gear.

i) Oil pumps.

j) Terminal connectors.

k) Pressure relief device relay

l) Cables used for interconnecting Turret CT, equipment relays (exposed), with marshalling box.

The above list is not exhaustive and the Contractor shall also include other bought out items in his programme.

5.1.9 **Pre-Shipment Checks at Manufacturer's Works**

5.1.9.1 Check for interchangeability of components of similar transformers for mounting dimensions.

5.1.9.2 Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

5.1.9.3 Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

5.1.9.4 Gas tightness test to confirm tightness and record of dew point of gas inside the tank.

5.1.9.5 Derivation of leakage rate and ensure the adequate reserve gas capacity.

5.1.9.6 Measure and record the dew point of dry air /Nitrogen at the time of filling and after 24 hours in the transformer tank. Dew point of dry air / nitrogen at the time of transformer dispatch should be better than (-) 30 deg C. Also the dew point of dry air / nitrogen cylinders attached for make up during transportation should of the order of (-) 50 deg C.

5.1.9.7 Functioning of impact recorder(s) at their works before installing on the tank.

5.2 Factory Tests

The manufacturer shall be fully equipped to perform all the required tests as specified. Bidder shall confirm the capabilities of the proposed manufacturing plant in this regard when submitting the bid. Any limitations shall be clearly stated in. The contractor shall bear all additional costs related to tests which are not possible to carry out at his own works. Procedure for some of tests is given at annexure-I.

The contractor shall submit an Inspection and test plan (ITP) for approval. A typical test plan is indicated below.

No.	Item	Test Category
1.	Measurement of winding resistance	Routine
2.	Voltage ratio measurement	Routine
3.	Polarity & Vector group test	Routine
4.	No-load loss and current measurement	Routine
5.	Impedance voltage and load loss measurement	Routine
6.	Measurement of insulation resistance & Polarization Index	Routine
7.	Measurement of insulation power factor and capacitance between winding and earth	Routine
8.	Measurement of insulation power factor and capacitance of bushings	Routine
9.	Lightning impulse test	Routine
10a	Short duration induced AC withstand Test (ACSD) with PD measurement	Routine
11.	Separate source voltage withstand test	Routine
12.	On-load tap changer test (Ten complete cycle before LV test)	Routine
13.	Gas-in-oil analysis	Routine
14.	Core assembly dielectric and earthing continuity test	Routine
15.	Oil leakage test on transformer tank	Routine
16.	Appearance, construction and dimension check	Routine
17.	Magnetic balance test	Routine
18.	Measurement of no load current & Short circuit impedance with 400 V, 50 Hz AC.	Routine
19.	High voltage with stand test on auxiliary equipment and wiring after assembly	Routine
20.	Tank vacuum test	Routine
21.	Tank pressure test	Routine
22.	Frequency response analysis (Soft copy of test report in sfra format to be submitted to site along with O & M manual)	Routine
23.	Temperature rise test	*Type

24.	Measurement of harmonic level in no load current	*Type
25.	Measurement of acoustic noise level	*Type
26.	Measurement of Zero seq. reactance	*Type
27.	Measurement of power taken by fans and oil pumps	*Type

All tests shall be done in line with IEC: 60076 and as per "Annexure-A". Complete test report shall be submitted to purchaser after proper scrutiny and signing on each page by the test engineer of the manufacturer. * Type test shall be carried out at first unit manufactured against the LOA at each manufacturing plant.

5.2.1 Measurement of capacitance and tan delta to determine capacitance between winding and earth. Tan delta value shall not be more than 0.5% at ambient temperature.

5.2.2 Measurement of capacitance and tan delta of OIP bushings. Tan delta value shall not be more than 0.4% at ambient temperature.

5.2.3 Type Tests on fittings:

All the following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with the drawings of equipment/ fittings as per the clause no. 9.0 of the Chapter2 – GTR. The list of fittings and the type test requirement is:

1. Bushing (Type Test as per IEC: 60137, including snap back/seismic test)

2. Buchholz relay (Type Test as per IEC and IP-55 Test on terminal box)

3. OLTC (Temperature Rise of contact, Short circuit current test, Mechanical test and Dielectric Test as per IEC: 60214 and IP-55 test on driving mechanism box).

4. Cooling fan and motor assembly – Free air delivery, Temperature rise, sound level, running at reduced voltage, IP-55 degree of protection for terminal box.

5. Air Cell (Flexible air separator) – Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per BS: 903.

6. Cooler Control cabinet (IP-55 test)

7. Pressure Relief device Test

   The pressure Relief Device of each size shall be subjected to increase in oil pressure. It shall operate before reaching the test pressure specified in transformer tank pressure test above.. The operating pressure shall be recorded. The device shall seal off after excess pressure has been released.

   The terminal box / boxes of PRD should conform to degree of protection as per IP-55.

8. Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.

9. OTI & WTI – Switch setting & operation, switch differential, switch rating.

5.2.4 **Pre-Shipment Checks at Manufacturer's Works**

5.2.5 Check for interchangeability of components of similar transformers for mounting dimensions.

5.2.6 Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

5.2.7 Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

5.2.8 Gas tightness test to confirm tightness and record of dew point of gas inside the tank.

5.2.9 Derivation of leakage rate and ensure the adequate reserve gas capacity.

5.2.10 Measure and record the dew point of dry air /Nitrogen at the time of filling and after 24 hours in the transformer tank. Dew point of dry air / nitrogen at the time of transformer despatch should be better than (-) 30 deg C. Also the dew point of dry air / nitrogen cylinders attached for make up during transportation should of the order of (-) 50 deg C.

5.3 **Inspection and Testing at Site**

The Contractor/Manufacturer shall carry out a detailed inspection and testing programme for field activities covering areas right from the receipt of material stage upto commissioning stage. An indicative programme of inspection as envisaged by the Employer is given below. Pre commissioning Procedures and Formats for equipments shall be contractor's responsibility to draw up and carry out such a programme.

5.3.1 **Receipt and Storage Checks**

5.3.1.1 Check and record condition of each package, visible parts of the transformer etc. for any damage.

5.3.1.2 Check and record the gas pressure in the transformer tank as well as in the gas cylinder. Measure and record the dew point of dry air /nitrogen in the transformer tank.

5.3.1.3 Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.

5.3.2 **Installation Checks**

5.3.2.1 Inspection and performance testing of accessories like tap changers etc.

5.3.2.2 (i) Check the direction of rotation of fans .

(ii) Check the bearing lubrication.

5.3.2.3 Check whole assembly for tightness, general appearance etc.

5.3.2.4 Oil leakage test

5.3.2.5 Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.

5.3.2.6 Leakage test on bushing before erection.

5.3.2.7 Measure and record the dew point of nitrogen/dry air in the main tank before assembly. Manufacturer shall submit dew point acceptable limits along with temperature correction factor and shall form part of instruction manual. In case dew point values are not within permissible limit suitable drying out process shall be applied for dry out of active part in consultation with the Manufacturer.

5.3.2.8 **Oil filling.**

5.3.2.8.1 Oil impregnation or drying under vacuum at site shall be done with the transformer and oil at a temperature not exceeding 70 deg C.

5.3.2.8.2 The duration of the vacuum treatment shall be demonstrated as adequate by means of water measurement with a cold trap or other suitable method. The vacuum shall be measured on the top of the transformer tank and should be less than 1mbar.

5.3.2.8.3 Vacuum shall not be broken until the transformer is oil filled up to the Buchholz relay. Whenever the active insulation or any paper insulated HV connections, especially those from the windings to the bushings are exposed, these shall be re-impregnated under vacuum along with the complete transformer. For this purpose the transformer shall first be drained to expose all insulation material.

5.3.2.8.4 The minimum safe level of oil filling (if different from the Buchholz level) to which the transformer shall be oil filled under vacuum, shall be indicated in the manual.

5.3.2.8.5 Procedures for site drying, oil purification, oil filling etc shall be submitted for approval and complete instructions shall form part of the manual.

5.3.3 **Commissioning Checks**

5.3.3.1 Check the colour of silicagel in silicagel breather.

5.3.3.2 Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.

5.3.3.3 Check the bushing for conformity of connection to the lines etc,

5.3.3.4 Check for correct operation of all protection devices and alarms :

(i) Buchholz relay.

(ii) Excessive winding temperature.

(iii) Excessive oil temperature.

(iv) Low oil flow.

(v) Low oil level indication.

(vi) Fan and pump failure protection.

5.3.3.5 Check for the adequate protection on the electric circuit supplying the accessories.

5.3.3.6 Check resistance of all windings on all steps of the tap changer. Insulation resistance measurement for the following:

(i) Control wiring.

(ii) Main windings.

5.3.3.7 Check for cleanliness of the transformer and the surroundings.

5.3.3.8 Continuously observe the transformer operation at no load for 24 hours.

Gradually put the transformer on load, check and measure increase in temperature in relation to the load and check the operation with respect to temperature rise and noise level etc.

5.3.3.9 Phase out and vector group test.

5.3.3.10 Ratio test on all taps.

5.3.3.11 Magnetising current test.

5.3.3.12 Capacitance and Tan delta measurement of winding and bushing.

5.3.3.13 DGA of oil just before commissioning and after 24 hours energisation at site.

5.3.3.14 Frequency response analysis (FRA) at site by the equipment to be provided by the bidder.

5.3.3.15 Contractor shall prepare a comprehensive commissioning report including all commissioning test results and forward to Employer for future record.

6.0 Technical Parameters

Technical Particulars / Parameters of Transformers
(132/22(11) kV, 3-Phase Transformer)

Cl. No.	Description	Unit	TECHNICAL PARAMETERS
1.1	**Rated Capacity**		
	HV	MVA	31.5/45
	LV	MVA	31.5/45
1.2	Rated Voltage ratio (HV/LV) (Line to line)	kV	132/11
1.3	Single / Three Phase Design		Three
1.4	Applicable Standard		IEC 60076
1.5	Frequency	Hz	50
1.6	Cooling		ONAN / ONAF
1.7	Rating at different cooling	%	70/100
1.8	Type of Transformer		Constant Ohmic impedance type (Refer Note1)
1.9	**HV-LV Impedance at 75 Deg C at**		
i)	Max. Voltage tap	%	
ii)	Principal tap	%	> 11
iii)	Min. Voltage tap	%	
1.10	Service		OUTDOOR
1.11	Duty		Continuous
1.12	Overload Capacity		IEC 60076-7
1.13	**Temperature rise over 50 deg C Ambient Temp**		
i)	Top oil measured by thermometer	Deg C	50
ii)	Average winding measured by resistance method	Deg C	55
1.14	**Windings**		
i)	System Fault level		

	HV	kA	31.5
	LV	kA	25
ii)	Lightning Impulse withstand Voltage		
	HV	kVp	550
	LV	kVp	75
	HV Neutral	kVp	95
	LV Neutral	kVp	75
iii)	Switching Impulse withstand Voltage		
	HV	kVp	460
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	230
	LV	kVrms	28
	HV Neutral	kVrms	38
	LV Neutral	kVrms	28
v)	Neutral (HV & LV)		Solidly grounded
vi)	Insulation		
	HV		GRADED
	LV		UNIFORM
vii)	Tan delta of winding at ambient Temperature	%	<0.5%
1.15	Vector Group (unless specified differently elsewhere)		YNyn0
1.16	**Tap Changer**		OLTC vacuum
i)	Tap range & No. of steps		–10% to +10% in the step of 1.25% for HV variation, 16 steps
ii)	Location of Tap Winding		Neutral end of HV winding
iii)	Design		Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I
iv)	Tap control		Full capacity on load tap changer suitable for group/independent, remote /local electrical and local manual operation and bi-directional power flow.
1.17	**Bushings**		
i)	Rated voltage		
	HV	kV	145
	LV	kV	12
	Neutral (HV)	kV	36
	Neutral (12 LV)		12
ii)	Rated current (Min.)		
	HV	A	800
	LV	A	3150
	Neutral (HV & LV)	A	3150
iii)	Lightning Impulse withstand Voltage		
	HV	kVp	650
	LV	kVp	75
	Neutral (HV)	kVp	170
	Neutral (LV)		75
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	305
	LV	kVrms	28
	Neutral (HV)	kVrms	77
	Neutral (LV)	kVrms	28
v)	Minimum total creepage distances		
	HV	mm	3625
	LV	mm	25 mm / kV
	Neutral (HV)	mm	900

	Neutral (LV)	mm	25 mm / kV
vi)	Tan delta of bushing at ambient Temperature		
	HV	%	<0.4%
vii)	Max Partial discharge level at U_m		
	HV	pC	10
1.18	Max Partial discharge level at 1.5Um/√3	pC	100
1.19	Max Noise level at rated voltage and at principal tap on full load and all cooling active	dB	70
2.20	Bushing Current Transformer		
2.20.1	HV / HV N	A	200/1A
2.20.2	LV / LV N	A	2400-1200/1A

Notes:

1. For parallel operation with existing transformer, percentage impedance, OLTC connection & range, vector group and the winding configuration (if necessary) is to be matched.

2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/LV impedances.

3. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.

4. The criteria for Transformer losses shall be "**Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)".**

Notes:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/LV impedances.
3. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. The criteria for Transformer losses shall be "**Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)".**
5. **Cooler Loss (Auxiliary Loss)".**

7.0 Bushing Current Transformer

7.1 Current transformers shall comply with IEC-60185.

7.2 It shall be possible to remove the turret mounted current transformers from the tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.

7.3 Current transformer secondary leads shall be brought out to a weather proof terminal box near each bushing. These terminals shall be wired out to cooler control cabinet/ marshalling box using separate cables for each core.

7.4 Bushing Current transformer parameters indicated in this specification are tentative and liable to change within reasonable limits. The Contractor shall obtain Employer's approval before proceeding with the design of bushing current transformers.

7.5 Technical Parameters for Bushing CT

7.5.1 Technical Parameters of Current Transformers (for 45 MVA, 132/11kV 3-Ph Transformers)

Description	Current Transformer Parameters (Transformer)			
	HV Side	HV Neutral Side	LV Side	LV Neutral Side
(a) Ratio				
CORE 1	200/1	200/1	2400/1	1600/1
CORE 2	200/1	-	2400/1	-
(b) Minimum knee point voltage or burden and accuracy class				
CORE 1	200V, TPS	200V, TPS	2400V, TPS	2400V, TPS
CORE 2	0.2 Class 10VA ISF ≤ 5	-	0.2 Class 10VA ISF ≤ 5	-
(c) Maximum CT Secondary Resistance				
CORE 1	1.5 Ohm	1.5 Ohm	1.5 Ohm	1.5 Ohm
CORE 2		-	-	-
(d) Application				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Metering	Restricted Earth Fault
CORE 2	Metering			-
(e) Maximum magnetization current (at knee point voltage)				
CORE 1	100mA	100 mA	100 mA	100 mA
CORE 2		-	-	-

NOTE: The CT ratio and ratings will be finalized during detail engineering.

NOTE:

i) For TPS class CT's, Dimensioning parameter "K", Secondary VA shall be considered 1.5 and 20 respectively. Class (for the relevant protection and duties) as per IEC 60185.

ii) Rated continuous thermal current rating shall be 200% of rated primary current.

iii) Parameters of WTI CT for each winding shall be provided by the contractor.

iv) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.

v) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

vi)

8.0 Oil Storage Tank

8.1 General

This specification is for oil storage tank. Oil Storage tank shall be supplied if specified in Bid Price schedule.

8.2 Standard

The oil storage tank shall be designed and fabricated as per relevant standards.

8.3 Specifications

Transformer oil storage tanks shall be towable on pneumatic tyres and rested on manual screw jacks of adequate quantity & size. The tank shall be cylindrical in shape and mounted horizontally and made of mild steel plate of adequate thickness. Size of the storage tank shall be as follows:

Diameter	:	1.5 meter (For 10 cubic meter capacity) 2.0 meter (For 20 cubic meter capacity)
Minimum Capacity	:	As mentioned in BPS

The tank shall be designed for storage of oil at a temperature of 100°C.

8.3.1 The Bidder may further note that maximum height of any part of the complete assembly of the storage tank shall not exceed 4.0 metres above road top.

8.3.2 The tank shall have adequate number of jacking pad so that it can be kept on jack while completely filled with oil. The tank shall be provided with suitable saddles so that tank can be rested on ground after removing the pneumatic tyres.

8.3.3 The tank shall also fitted with manhole, outside & inside access ladder, silicagel breather assembly, inlet & outlet valve, oil sampling valve with suitable adopter, oil drainage valve, air vent etc. Pulling hook on both ends of the tank shall be provided so that the tank can be pulled from either end while completely filled with oil. Bidder shall indicate the engine capacity in horse power to pull one tank completely fitted with oil. Oil level indicator shall be provided with calibration in terms of litre so that at any time operator can have an idea of oil in the tank. Suitable arrangement shall also be provided to prevent overflow in the tank. Solenoid valve (Electro-mechanically operated) with centrifugal pump shall be provided at bottom inlet so that pump shall be utilized both ways during oil fill up and draining. Suitable arrangement shall also be provided to prevent overflow and drain from the tank/

8.3.4 The following accessories shall form part of supply along with each Oil storage tank.

i) Four numbers of suitable nominal bore rubber hoses for transformer oil application upto temperature of 100°C, full vacuum and pressure up to 2.5 Kg/ cm2 with couplers and unions each not less than 10 metre long shall be provided.

ii) Two numbers of suitable nominal bore vacuum hoses, suitable for full vacuum without collapsing and kinking, with couplers and unions each not less than 10 metre long shall also be provided.

(iii) One number of digital vacuum gauge with sensor capable of reading up to 0.001 torr, operating on 230V 50Hz AC supply shall be supplied. Couplers and unions for sensor

should block oil flow in the sensor. Sensor shall be provided with atleast 8 meter cable so as to suitably place the Vacuum gauge at ground level.

8.3.5 The painting of oil storage tank and its control panel shall be as per clause no 3.1.1.8.

8.3.6 The tank shall contain a self mounted centrifugal oil pump with inlet and outlet valves, with couplers -suitable for flexible rubber hoses and necessary switchgear for its control. There shall be no rigid connection to the pump. The pump shall be electric motor driven, and shall have a discharge of not less than 3.0 (For 10 cubic meter capacity) / 6.0 kl/hr (For 20 cubic meter capacity) with a discharge head of 8.0m. The pump motor and the control cabinet shall be enclosed in a cubical with IP-55 enclosure.

9.0 OIL SAMPLING BOTTLE

9.1 Oil sampling bottles shall be suitable for collecting oil samples from transformers and shunt reactors, for Dissolved Gas Analysis. Bottles shall be robust enough, so that no damage occurs during frequent transportation of samples from site to laboratory.

9.2 Oil sampling bottles shall be made of stainless steel having a capacity of one litre.

9.3 Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

9.4 The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.

9.5 An impermeable oil-proof, transparent plastic or rubber tube of about 5 mm diameter, and of sufficient length shall also be provided with each bottle along with suitable connectors to fit the tube on to the oil sampling valve of the equipment and the oil collecting bottles respectively.

Annexure -A

All tests shall be carried out as per IEC: 60076 on transformer.

1) Magnetic Circuit Test

After assembly each core shall be tested for 1 minute at 2000 Volts between all bolts, side plates and structural steel work.

2) Tank Tests

(i) Oil Leakage Test

All tanks and oil filled compartments shall be tested for oil tightness by being completely filled with air or oil of a viscosity not greater than that of insulating oil conforming to IEC-60296 at the ambient temperature and applying a pressure equal to the normal pressure plus 35 KN/Sq.m (5 psi) measured at the base of the tank. The pressure shall be maintained for a period of not less than 12 hours for oil and one hour for air during which time no leak shall occur.

(ii) Vacuum Test

All transformer tank of each size shall be subjected to the specified vacuum. The tank designed for full vacuum shall be tested at an internal pressure of 3.33 KN/Sq.m absolute (25 torr) for one hour. The permanent deflection of flat plate after the vacuum has been released shall not exceed the values specified below:

Horizontal Length of flat plate (in mm)	**Permanent deflection (in mm)**
Upto and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.5
2501 to 3000	16.0
Above 3000	19.0

(iii) Pressure Test

All transformer tank of each size, its radiator, conservator vessel and other fittings together or separately shall be subjected to an air pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 KN/m2 whichever is lower measured at the base of the tank and maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified above for vacuum test.

3) Measurement of capacitance and tan delta to determine capacitance between winding and earth. Tan delta value shall not be more than 0.5% corrected at 20deg C. Temperature correction factor table shall be given by the Contractor and shall form the part of test results.

4) Temp. Rise Test (as per IEC 60076)

Gas chromatographic analysis on oil shall also be conducted before and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC 60567. For the evaluation of the gas analysis in temperature rise test the procedure shall be as IEC: 60567 and results will be interpreted as per IEC -61181. The DGA results shall generally conform to IEC/IEEE guidelines.

The temperature rise test shall be conducted at a tap for the worst combination of loading on the three windings of the transformer. The Contractor before carrying out such test shall submit detailed calculations showing alternatives possible, on various taps of the transformer and shall recommend the combination that results in highest temperature rise for the test.

6) Type Tests on fittings:

All the following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with the drawings of equipment/ fittings. The list of fittings and the type test requirement is:

a. Bushing (Type Test as per IEC: 60137)
b. Buchholz relay (Type Test and IP-55 Test on terminal box)
c. Marshalling box (IP-55 test)
d. Pressure Relief device Test

The pressure Relief Device of each size shall be subjected to increase in oil pressure. It shall operate before reaching the test pressure specified in transformer tank pressure test. The operating pressure shall be recorded. The device shall seal off after excess pressure has been released. The terminal box / boxes of PRD should conform to degree of protection as per IP-55.

e. Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.
f. Air Cell (Flexible air separator) –Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per BS: 903.
g. OTI & WTI – Switch setting & operation, switch differential, switch rating.

7) Inspection and Testing at Site

The Contractor/Manufacturer shall supervise testing & commissioning at site. Testing & commissioning shall be carried out by the owner (MOEP-2). Contractor shall submit a detailed procedure for Testing & Commissioning at site including receipt, storage & installation checks as mentioned below.

a) Receipt and Storage Checks

- Check and record condition of each package, visible parts of the transformer etc. for any damage.
- Check and record the gas pressure in the transformer tank as well as in the gas cylinder.
- Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.
- Check and record reading of impact recorder at receipt and verify the allowable limits as per manufacturer's recommendations.

b) Installation Checks

- Check whole assembly for tightness, general appearance etc.
- Oil leakage test
- Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.
- Leakage check on bushing before erection.
- Measure and record the dew point of nitrogen/dry air in the main tank before assembly. Manufacturer shall submit dew point acceptable limits along with temperature correction factor and shall form part of instruction manual. In case dew point values are not within permissible limit suitable drying out process shall be applied for dry out of active part in consultation with the Manufacturer.

c) Oil filling

Oil impregnation or drying under vacuum at site shall be done with the transformer and oil at a temperature not exceeding 70°C.

The duration of the vacuum treatment shall be demonstrated as adequate by means of water measurement with a cold trap or other suitable method but shall generally not be less than 72 hours. The vacuum shall be measured on the top of the transformer tank and should be less than 1mbar.

Vacuum shall not be broken until the transformer is oil filled up to the Buchholz relay. Whenever the active insulation or any paper insulated HV connections, especially those from the windings to the bushings are exposed, these shall be re-impregnated under vacuum along with the complete transformer. For this purpose the transformer shall first be drained to expose all insulation material.

The minimum safe level of oil filling (if different from the Buchholz level) to which the transformer shall be oil filled under vacuum, shall be indicated in the manual.

Procedures for site drying, oil purification, oil filling etc shall be submitted for approval and complete instructions shall form part of the manual.

d) Commissioning Checks

- Check the colour of silicagel in silicagel breather.
- Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.
- Check the bushing for conformity of connection to the lines etc,
- Check for correct operation of all protection devices and alarms:
  - (i) Buchholz relay.
  - (ii) Excessive winding temperature.
  - (iii) Excessive oil temperature.
  - (iv) Low oil level indication.
- Check for the adequate protection on the electric circuit supplying the accessories.
- Check resistance of all windings on all steps of the tap changer. Insulation resistance measurement for the following:
  - (i) Control wiring.
  - (ii) Main windings.
- Check for cleanliness of the transformer and the surroundings.
- Continuously observe the transformer operation at no load for 24 hours.

- Gradually put the transformer on load, check and measure increase in temperature in relation to the load and check the operation with respect to temperature rise and noise level etc.
- Phase out and vector group test.
- Ratio test on all taps.
- Magnetising current test.
- Capacitance and Tan delta measurement of winding and bushing.
- DGA of oil just before commissioning and after 24 hours energisation at site.

CHAPTER 3-GENERAL TECHNICAL REQUIREMENT (GTR)-TRANSFORMER & REACTOR

Table of Content

1.0 FOREWORD

1.1 The provisions under this Chapter are intended to supplement general requirements for the materials, equipments and services covered under other Chapters of tender documents and is not exclusive. However in case of conflict between the requirements specified in this Chapter and requirements specified under other Chapters, the requirements specified under respective Chapters shall prevail.

2.0 GENERAL REQUIREMENT

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

2.2 The bidders shall furnish catalogues, engineering data, technical information, design documents, drawings etc., fully in conformity with the technical specification. An indicative list of such drawings and documents for transformer and reactor are enclosed in Annexure-A.

2.3 It is recognised that the Contractor may have standardised on the use of certain components, materials, processes or procedures different from those specified herein. Alternate proposals offering similar equipment based on the manufacturer's standard practice will also be considered provided such proposals meet the specified designs, standard and performance requirements and are acceptable to the Employer. Unless brought out clearly, the Bidder shall be deemed to conform to this specification scrupulously. All deviations from the specification shall be clearly brought out in the respective schedule of deviations. Any discrepancy between the specification and the catalogues or the bid, if not clearly brought out in the specific requisite schedule, will not be considered as valid deviation.

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

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

3.0 STANDARDS

3.1 The works covered by the specification shall be designed, engineered, manufactured, built, tested and commissioned in accordance with the Acts, Rules, Laws and Regulations of Nepal.

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

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

3.4 The Contractor shall also note that list of standards presented in this specification is not complete. Whenever necessary the list of standards shall be considered in conjunction with specific IEC/CIGRE/IEEE/NEMA.

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

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

3.7 The bidder shall clearly indicate in his bid the specific standards in accordance with which the works will be carried out.

4.0 SERVICES TO BE PERFORMED BY THE EQUIPMENT BEING FURNISHED

4.1 All equipment shall perform satisfactorily under various electrical, electromechanical and meteorological conditions of the site of installation.

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

4.3 The equipment shall also comply to the following:

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

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

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

4.4.1 System Parameter

Sl. No.	Description of parameters	220 KV System	132 KV System	33 KV System	22 KV System	11 KV System
1.	System operating voltage	220KV	132KV	33KV	22KV	11KV
2.	Maximum system operating voltage (rms),Um	245KV	145KV	36KV	25KV	12KV
3.	Rated frequency	50Hz	50Hz	50Hz	50Hz	50Hz
4.	No. of phase	3	3	3	3	3
5.	Rated Insulation levels					
i)	Full wave impulse withstand voltage(1.2/50 micro sec.)	1050KVp	650KVp	170KVp	150KVp	75KVp
ii)		-	-	-	-	-

iii)	Switching impulse withstand voltage (250/2500 micro sec.) dry and wet One minute power frequency dry and wet withstand voltage (rms)	460KV	275KV	70KV	50KV	28KV
6.	Corona extinction voltage	156KV	105KV	-		
7.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 508kV rms for 765kV, 320KV rms for 400KV system and 156KV rms for 220KV system & 92 KV rms for 132KV system	1000 micro-volt	500 micro-volt	-	-	-
8.	Minimum creepage distance	25 mm/KV (6125 mm)	25 mm/KV (3625 mm)	25 mm/KV (900 mm)	25 mm/KV (625 mm)	25 mm/KV (300 mm)
9.a	Min. clearances in air for Transformer & Reactor					
i.	Phase to phase	2300 mm (for BIL-950 kVp)	1220 mm (for BIL-550 kVp)	350 mm (for BIL-170 kVp)	280 mm (for BIL-150 kVp)	110 mm (for BIL-75 kVp)
ii.	Phase to earth	1800 mm (for BIL-950 kVp)	1050 mm (for BIL-550 kVp)	320mm (for BIL-170 kVp)	280mm (for BIL-150 kVp)	110mm (for BIL-75 kVp)
9.b	Min. clearances in air for other switchyard equipments					
i)	Phase to phase	2100 mm	1300 mm	320 mm	280 mm	110 mm
ii)	Phase to earth	2100 mm	1300 mm	320 mm	280 mm	110 mm
iii)	Sectional clearances	5000 mm	4000 mm	3000 mm	2800 mm	2500 mm
10.	Rated short circuit current for 1 sec. duration	40 kA	31.5 kA	25 kA	25 kA	25 kA
11.	System neutral earthing	Effectively earthed	Effectively earthed	Effectively earthed	Effectively earthed	Effectively earthed

Note : The insulation and RIV levels of the equipments shall be as per values given in the respective chapter of the equipments.

5.0 ENGINEERING DATA AND DRAWINGS

5.1 The engineering data shall be furnished by the Contractor in accordance with the Schedule for each set of equipment as specified in the Technical Specifications.

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

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

5.3 Drawings

5.3.1 All drawings submitted by the Contractor including those submitted at the time of bid shall be in sufficient detail to indicate the type, size, arrangement, material

description, Bill of Materials, weight of each component, break-up for packing and shipment, dimensions, internal & the external connections, fixing arrangement required and any other information specifically requested in the specifications.

5.3.2 Each drawing submitted by the Contractor shall be clearly marked with the name of the Employer, the unit designation, the specifications title, the specification number and the name of the Project. If standard catalogue pages are submitted, the applicable items shall be indicated therein. All titles, noting, markings and writings on the drawing shall be in English. All the dimensions should be in metric units.

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

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

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

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

5.7 Approval Procedure

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

i)	Approval/comments/ by Employer on initial submission	As per agreed schedule
ii)	Resubmission (whenever required) time).	Within 4 (four) weeks from date of comments including both ways postal
iii)	Approval or comments of resubmission.	Within 4 weeks of receipt
iv)	Furnishing of distribution copies in bound volume (5 copies per substation and one copy for Corporate office of Employer)	3 weeks from the date of final approval

v)	Furnishing of distribution copies of test reports	
	(a) Type test reports (one copy per substation plus one copy for corporate office of Employer)	3 weeks from the date of final approval
	(b) Routine Test Reports (one copy for each substation)	-do-
vi)	Furnishing of instruction/ operation manuals (4 copies per substation and two copies for corporate office of Employer)	As per agreed schedule
(vii)	Visual Compact Disk (VCD) highlighting installation and maintenance techniques/ requirements of transformer & reactor (one per substation plus one for corporate office of Employer)	-do-
(viii)	As built drawings on CD/optical Disc (Two sets per substation plus one set for corporate office of Employer)	On completion of entire works

NOTE :

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

(2) The drawings which are required to be referred frequently during execution should be submitted on cloth lined paper or Laminated Sheets. The list of such drawings shall be finalised with the Contractor at the time of Award.

(3) All major drawings should be submitted in Auto Cad Version 2000 or better.

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

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

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

6.0 MATERIAL/ WORKMANSHIP

6.1 General Requirement

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

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

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

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

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

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

6.1.7 All oil, grease and other consumables used in the Works/ Equipment shall be purchased in Nepal unless the Contractor has any special requirement for the

specific application of a type of oil or grease not available in Nepal. In such is the case he shall declare in the proposal, where such oil or grease is available. He shall help Employer in establishing equivalent Nepal make and Nepal Contractor. The same shall be applicable to other consumables too.

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

6.2 **Provisions for Exposure to Hot and Humid climate**

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

6.2.1 **Space Heaters**

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

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

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

6.2.2 FUNGI STATIC VARNISH

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

6.2.3 Ventilation opening

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

6.2.4 Degree of Protection

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

a) Installed out door: IP- 55

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

c) Installed in covered area: IP-52

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

The degree of protection shall be in accordance with IEC-947 (Part-I)/ IEC 529. Type test report for degree of protection test, on each type of the box shall be submitted for approval.

6.3 RATING PLATES, NAME PLATES AND LABELS

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

6.3.2 All such nameplates, instruction plates, rating plates of transformers & reactors shall be bilingual with Hindi inscription first followed by English. Alternatively two separate plates one with Hindi and the other with English inscriptions may be provided.

6.4 FIRST FILL OF CONSUMABLES, OIL AND LUBRICANTS

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

7.0 DESIGN IMPROVEMENTS / COORDINATION

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

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

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

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

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

8.0 QUALITY ASSURANCE PROGRAMME

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

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

(b) Documentation control system;

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

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

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

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

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

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

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

(j) System for quality audits;

(k) System for authorising release of manufactured product to the 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 measures and procedures adopted for controlling the quality characteristics relevant to each item of equipment furnished and/or services rendered.

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

8.2 Quality Assurance Documents

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

9.0 TYPE TESTING, INSPECTION, TESTING & INSPECTION CERTIFICATE

9.1 All equipment being supplied shall conform to type tests including additional type tests as per technical specification and shall be subject to routine tests in accordance with requirements stipulated under respective Chapters. Employer reserves the right to witness any or all the tests. The Contractor shall intimate the Employer the detailed program about the tests atleast three (3) weeks in advance in case of domestic supplies & six (6) weeks in advance in case of foreign supplies.

9.2 The reports for all type tests and additional type tests as per technical specification shall be furnished by the Contractor alongwith equipment / material drawings. The type tests conducted earlier should have either been conducted in accredited laboratory (accredited based on ISO / IEC Guide 25 / 17025 or EN 45001 by the national accredition body of the country where laboratory is located) or witnessed by the representative(s) of EMPLOYER or Utility/third party.

In the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design / manufacturing changes (including substitution of components) or due to non-compliance with the requirement stipulated in the Technical Specification or any/all additional type tests not carried out, same shall be carried out without any additional cost implication to the Employer.

9.3 The Employer intends to repeat the type tests and additional type tests on transformers & reactor for which test charges shall be payable as per provision of contract. The price of conducting type tests and additional type tests shall be included in Bid price and break up of these shall be given in the relevant schedule of Bid Proposal Sheets. These Type test charges would be considered in bid evaluation. In case Bidder does not indicate charges for any of the type tests or does not mention the name of any test in the price schedules, it will be presumed that the particular test has been offered free of charge. Further, in case any Bidder indicates that he shall not carry out a particular test, his offer shall be considered incomplete and shall be liable to be rejected.

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

9.5 The Contractor shall give the Employer /Inspector thirty (30) days written notice of any material being ready for joint testing including contractor and Employer. Such tests shall be to the Contractor's account except for the expenses of the Inspector. The Employer /inspector, unless witnessing of the tests is virtually waived, will attend such tests within thirty (30) days of the date of which the equipment is notified as being ready for test/inspection, failing which the Contractor may proceed alone with the test which shall be deemed to have been made in the Inspector's presence and he shall forthwith forward to the Inspector duly certified copies of tests in triplicate.

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

9.7 When the factory tests have been completed at the Contractor's or Sub-Contractor's works, the Employer/inspector shall issue a certificate to this effect within fifteen (15) days after completion of tests but if the tests are not witnessed by the Employer /Inspector, the certificate shall be issued within fifteen (15) days of receipt of the

Contractor's Test certificate by the Engineer/Inspector. Failure of the Employer /Inspector to issue such a certificate shall not prevent the Contractor from proceeding with the Works. The completion of these tests or the issue of the certificate shall not bind the Employer to accept the equipment should, it, on further tests after erection, be found not to comply with the Contract. The equipment shall be dispatched to site only after approval of test reports and issuance of CIP by the Employer.

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

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

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

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

10. TESTS

10.1 Pre-commissioning Tests

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

10.2 Commissioning Tests

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

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

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

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

11.0 PACKAGING & PROTECTION

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

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

12.0 FINISHING OF METAL SURFACES

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

13.0 HANDLING, STORING AND INSTALLATION

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

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

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

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

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

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

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

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

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

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

13.11 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life. If at any stage during the execution of the Contract, it is observed that the erected equipment(s) do not meet the above minimum clearances as given in clause 4.4.1 the Contractor shall immediately proceed to correct the discrepancy at his risks and cost.

13.12 Equipment Bases

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

14.0 SPECIAL TOOLS AND TACKLES

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

15.0 AUXILIARY SUPPLY

15.1 The sub-station auxiliary supply is normally met through a system having the following parameters. The auxiliary power for station supply, including the equipment drive, cooling system of any equipment, air-conditioning, lighting etc shall be designed for the specified Parameters as under.

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

400V	+/- 10%	50 +/- 5%	3/	Solidly 4 WireEarthed.
230V	+/- 10%	50 +/- 5%	1/	Solidly 2 WireEarthed.

Combined variation of voltage and frequency shall be limited to +/- 10%.

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

16.1 All types of boxes, cabinets etc. shall generally conform to & be tested in accordance with IEC-439 and the clauses given below:

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

16.3 Cabinet/boxes shall be free standing floor mounting type, wall mounting type or pedestal mounting type as per requirements. A canopy and sealing arrangements for operating rods shall be provided in marshalling boxes / Control cabinets to prevent ingress of rain water.

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

16.5 All doors, removable covers and plates shall be gasketed all around with suitably profiled EPDM gaskets. The gasket shall be tested in accordance with approved quality plan. The quality of gasket shall be such that it does not get damaged/ cracked during the ten years of operation of the equipment or its major overhaul whichever is earlier. All gasketed surfaces shall be smooth straight and reinforced if necessary to minimize distortion and to make a tight seal. Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh made of brass.

16.6 All boxes/cabinets shall be designed for the entry of cables from bottom by means of weather proof and dust-proof connections. Boxes and cabinets shall be designed with generous clearances to avoid interference between the wiring entering from below and any terminal blocks or accessories mounted within the box or cabinet. Suitable cable gland plate projecting at least 150 mm above the base of the marshalling kiosk/box shall be provided for this purpose along with the proper blanking plates. Necessary number of cable glands shall be supplied and fitted on this gland plate. The gland shall project at least 25mm above gland plate to prevent entry of moisture in cable crutch. Gland plate shall have provision for some future glands to be provided later, if required. The Nickel plated glands shall be dust proof, screw on & double compression type and made of brass. The gland shall have provision for securing armour of the cable separately and shall be provided with earthing tag. The glands shall conform to BS:6121.

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

16.8 For illumination of a 20 Watts fluorescent tube or 15 watts CFL shall be provided. The switching of the fittings shall be controlled by the door switch.

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

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

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

16.12 a) The following routine tests alongwith the routine tests shall also be conducted:

i) Check for wiring

ii) Visual and dimension check

b) The enclosure of bay marshalling kiosk, junction box, terminal box shall conform to IP-55 including application of, 2.5 KV rms for 1 (one) minute, insulation resistance and functional test after IP-55 test.

17.0 SUPPORT STRUCTURE

17.1 The support structures to be supplied by the contractor for the tertiary arrangement should be hot dip galvanised with minimum 610 gram/sq.m net of zinc.

17.2 Support structure shall meet the following mandatory requirements:

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

18.0 TERMINAL BLOCKS AND WIRING

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

18.2 Terminal blocks shall be 650 V grade and have continuous rating to carry the maximum expected current on the terminals. These shall be of moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Screw clamp, overall insulated, insertion type, rail mounted terminals can be used in place of stud type terminals. The terminal blocks shall be non-disconnecting stud type equivalent to Elmex type CATM4, Phoenix (cage clamp type), Wago or equivalent.

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

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

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

18.6 The terminal blocks shall be of extensible design.

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

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

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

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

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

18.11 The Contractor shall furnish all wire, conduits and terminals for the necessary interphase electrical connections (where applicable) as well as between phases and common terminal boxes or control cabinets. For equipments rated for 400 kV and above the wiring required in these items shall be run in metallic ducts or shielded cables in order to avoid surge overvoltges either transferred through the equipment or due to transients induced from the EHV circuits.

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

19.0 LAMPS AND SOCKETS

19.1 Lamps

All incandescent lamps shall use a socket base as per IEC, except in the case of signal lamps.

19.2 Sockets

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

19.3 Hand Lamp:

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

19.4 Switches and Fuses:

19.4.1 Each panel shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of DC and AC supplies for various control, signalling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with switchfuse units. Selection of the main and Sub-circuit fuse ratings shall be such as to ensure selective clearance of sub-circuit faults. Potential circuits for relaying and metering shall be protected by HRC fuses.

19.4.2 All fuses shall be of HRC cartridge type mounted on plug-in type fuse bases. Miniature circuit breakers with thermal protection and alarm contacts will also be accepted. All accessible live connection to fuse bases shall be adequately

shrouded. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage.

20.0 Bushings, Hollow Column Insulators, Support Insulators:

20.1 Bushings shall be manufactured and tested in accordance with IEC: 60137 while hollow column insulators shall be manufactured and tested in accordance with IEC 233. The support insulators shall be manufactured and tested as per IEC 168 and IEC 273. The insulators shall also conform to IEC 815 as applicable.

The bidder may also offer composite silicon rubber insulator, conforming to IEC-1109.

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

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

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

20.5 When operating at normal rated voltage there shall be no electric discharge between the conductors and bushing which would cause corrosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action. No radio interference shall be caused by the insulators/bushings when operating at the normal rated voltage.

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

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

20.8 Tests

In bushing, hollow column insulators and support insulators shall conform to type tests and shall be subjected to routine tests in accordance with International Standards. The type test reports shall be submitted for approval.

Annexure –A

INDICATIVE LIST OF DRAWINGS FOR TRANSFORMER & REACTOR

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

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

2. Foundation Plan showing reaction at points of support, clamping arrangement & location of jacking pads.
3. Technical Data requirement sheet of transformer & reactor
4. Over fluxing withstand duration curve
5. Schematic wiring and diagram of cooling arrangement along with write up on scheme
6. Schematic wiring and diagram of OLTC along with write up on scheme
7. Mounting Arrangement and wiring diagram of remote WTI along with write up
8. Bushing Drawing showing electrical and mechanical characteristics
   a) HV Bushing
   b) LV Bushing
   c) Neutral bushing
9. Outline and General Arrangement of Cooler Control Cabinet
10. Cooler Control cabinet schematic and wiring diagram
11. Magnetisation Characteristics of bushing CTs
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LIST OF SPECIFICATIONS

GENERAL STANDARDS AND CODES

IEC-60 (Part 1 to P4)	-	High Voltage Test Techniques
IEC 66	-	Environmental Test
IEC-117	-	Graphical Symbols
IEC-156,	-	Method for the Determination of the Electrical Strength of Insulation Oils.
IEC-270,	-	Partial Discharge Measurements.
IEC-376 Hexafluoride	-	Specification and Acceptance of New Sulphur
IEC-437	-	Radio Interference Test on High Voltage Insulators.
IEC-506,	-	Switching Impulse Tests on High Voltage Insulators.
IEC-507	-	Artificial Pollution Tests on High Voltage Insulators to be used on AC Systems.
IEC-6094	-	Common Specification for High Voltage Switchgear & Control gear Standards.
IEC-815	-	Guide for the Selection of Insulators in respect of Polluted Conditions.
IEC-865 (P1 & P2)	-	Short Circuit Current - Calculation of effects.
ANSI-C.1/NFPA.70	-	National Electrical Code
ANSI-C37.90A	-	Guide for Surge Withstand Capability (SWC) Tests
ANSI-C63.21,	-	Specification for Electromagnetic Noise and
C63.3	-	Field Strength Instrumentation 10 KHz to 1 GHZ
C36.4ANSI-C68.1	-	Techniques for Dielectric Tests
ANSI-C76.1/EEE21	-	Standard General Requirements and Test Procedure for Outdoor Apparatus Bushings.
ANSI-SI-4	-	Specification for Sound Level Meters
ANSI-Y32-2/C337.2	-	Drawing Symbols
ANSI-Z55.11	-	Gray Finishes for Industrial Apparatus and Equipment No. 61 Light Gray
NEMA-107T	-	Methods of Measurements of RIV of High Voltage Apparatus
NEMA-ICS-II	-	General Standards for Industrial Control and Systems Part ICSI-109
CISPR-1	-	Specification for CISPR Radio Interference Measuring Apparatus for the frequency range 0.15 MHz to 30 MHz
CSA-Z299.1-1978h	-	Quality Assurance Program Requirements
CSA-Z299.2-1979h	-	Quality Control Program Requirements
CSA-Z299.3-1979h	-	Quality Verification Program Requirements
CSA-Z299.4-1979h	-	Inspection Program Requirements

TRANSFORMERS & REACTORS

IEC 60076	Power transformers
IEC 60076-1	Part 1: General
IEC 60076-2	Part 2: Temperature rise
IEC 60076-3	Part 3: Insulation levels, dielectric tests and external clearances in air
IEC 60076-4	Part 4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors
IEC 60076-3-1	Part 3-1: Insulation Levels and Dielectric Tests – External Clearances in Air
IEC 60076-5	Part 5: Ability to withstand short circuit
IEC 60076-6	Part 6: Reactors
IEC 60076-7	Part 7: Loading guide for oil-immersed power transformers
IEC 60076-8	Part 8: Application guide
IEC 60076-10	Part 10: Determination of sound levels
IEC 60076-10-1	Part 10-1: Determination of sound levels - Application guide
IEC 60076-11	Part 11: Dry-type transformers
IEC 60076-12	Part 12: Loading guide for dry-type power transformers
IEC 60076-13	Part 13: Self-protected liquid-filled transformers
IEC 60076-14	Part 14: Design and application of liquid-immersed power transformers using high-temperature insulation materials
IEC 60076-15	Part 15: Gas-filled power transformers
IEC 60076-16	Part 16: Transformers for wind turbine applications
IEC 60076-18	Part 18: Measurement of frequency response
IEC 60076-19	Part 19: Rules for the determination of uncertainties in the measurement of losses in power transformers and reactors
IEC 60076-21	Part 21: Standard requirements, terminology, and test code for step-voltage regulators
IEC 60044	Current transformers
IEC 60050	International Electrotechnical Vocabulary
IEC 60050(421)	International Electrotechnical vocabulary- Chapter 421 : Power Transformers and Reactors
IEC 60060	High Voltage test techniques
IEC 60060-1	General definitions and test requirements
IEC 60060-2	Measuring systems
IEC 60071	Insulation co-ordination
IEC 60071-1	Part 1: Definitions, principles and rules
IEC 60071-2	Part 2 : Application guide
IEC 60137	Bushing for alternating voltage above 1000V
IEC 60214	On-Load Tap changers
IEC 255-21-3	Relays vibration
IEC 60270	Partial discharge measurements
IEC 60296	Specification for Unused Mineral Oil for Transformers and Switchgear
IEC 60422	Supervision and Maintenance guide for Mineral Insulating Oil in Electrical Equipment
IEC 60475	Method of Sampling Liquid dielectrics
IEC 60529	Classification of Degrees of Protection provided by Enclosures

IEC 60542	Application Guide for On-Load Tap-Changers
IEC 60567	Guide for the Sampling of Gases and of Oil from Oil-filled Electrical Equipment for the Analysis of Free and Dissolved Gases
IEC 60651	Sound Level Meters
IEC 61083	Digital Recorders and Software for High Voltage Impulse testing
IEC 61083-1	Part 1: Requirements for digital recorders in high voltage impulse tests
IEC 61083-2	Part 2: Evaluation of software used for the determination of the parameters of impulse waveforms
CISPR 16	Specification for radio disturbance and immunity measuring apparatus
CISPR 16-1	Radio disturbance and immunity measuring apparatus
CISPR-18	Radio Interference Characteristics of Power Lines and High Voltage Equipment
ISO 9001	Quality system-Model for Quality Assurance in Design /development
Cigre Publication 202	Guidelines for conducting design reviews for transformers 100 MVA and 123 kV and above. August 2002-Cigre Working Group 12.22
WG 12-15	Guide for Customers Specifications for Transformers 100 MVA and 123 kV and above
WG 12 19	Short Circuit Performance of Transformers.
BS-4360	Specification for weldable structural steel
BS-5135	Specification for arc welding of carbon and carbon manganese steels
BS-5500	Specification for unfired fusion welded pressure vessels
ISO-8501	Preparation of steel surface before application of Paints and related product
IEC-60599	Mineral oil impregnated electrical equipment in service – guide to the interpretation of dissolved and free gases analysis
IEC-60034-5	Degrees of protection provided by integral design of rotating electrical machines(IP Code) classification
IEC-62271-203	Gas insulated metal enclosed switchgear for rated voltage above 52kV
IEC-61639	Direct connection between power transformers and gas-insulated metal enclosed switchgear for rated voltages of 52.5 kV and above.
IEC 60529 / IP : 55	Degree of protection for cooler control cabinet , MOLG ,Cooling fan , oil pump, Buchholz Relay
IEC 60529 / IP : 56	Degree of protection for Pressure Relief Device
IEC 60529 / IP : 43	Degree of protection for Remote tap Changer cubicle (RTCC)

Clamps & connectors

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

Wires and cables

ASTMD-2863	-	Measuring the minimum oxygen concentration to support candle like combustion of plastics (oxygen index)
IEC-96 (part 0 to p4)	-	Radio Frequency cables.
IEC-183	-	Guide to the Selection of High Voltage Cables.
IEC-189 (P1 to P7)	-	Low frequency cables and wires with PVC insulation and PVC sheath.
IEC-227 (P1 to P7)	-	Polyvinyl Chloride insulated cables of rated voltages up to and including 450/750V.
IEC-228	-	Conductors of insulated cables
IEC-230	-	Impulse tests on cables and their accessories.
IEC-287 (P1 to P3)	-	Calculation of the continuous current rating of cables (100% load factor).
IEC-304	-	Standard colours for insulation for low-frequency cables and wires.
IEC-331	-	Fire resisting characteristics of Electric cables.
IEC-332 (P1 to P3)	-	Tests on electric cables under fire conditions.
IEC-502	-	Extruded solid dielectric insulated power cables for rated voltages from 1 kV upto to 30 kV
IEC-754 (P1 and P2)	-	Tests on gases evolved during combustion of electric cables.
Galvanizing		
ASTM-A-123	-	Specification for zinc (Hot Galvanizing) Coatings, on products Fabricated from rolled, pressed and forged steel shapes, plates, bars and strips.
ASTM-A-121-77	-	Zinc-coated (Galvanized) steel barbed wire
Painting		
ANSI-Z551	-	Gray finishes for industrial apparatus and equipment
SSPEC	-	Steel structure painting council
HORIZONTAL CENTRIFUGAL PUMPS		
API-610	-	Centrifugal pumps for general services
	-	Hydraulic Institutes Standards
BS:599	-	Methods of testing pumps
PTC-8.2	-	Power Test Codes - Centrifugal pumps

TECHNICAL SPECIFICATION FOR
Indoor Switchgear (VCB Type)

1.00 TECHNICAL REQUIREMENT OF EQUIPMENT

1.01 The manufacturer, whose Indoor switch gear panels are offered should have designed, manufactured, type tested as per relevant IEC, supplied and commissioned the Panels of similar voltage rating.

1.02 In addition to the requirements above, the Vacuum circuit breaker, CT, PT and relays should have been designed, manufactured and type tested as per relevant IEC and should have been in satisfactory operation.

2.00 GENERAL REQUIREMENTS

2.01 The equipment offered by the Bidder shall be complete in all respects. Any material and component not specifically stated in this specification but which are necessary for trouble free operation of the equipment and accessories specified in this specification shall be deemed to be included unless specifically excluded. All such equipment / accessories shall be supplied without any extra cost. Also all similar components shall be interchangeable and shall be of same type and rating for easy maintenance and low spare inventory.

2.02 Equipment shall be installed in a neat workman-like-manner so that it is leveled, plumbed, squared and properly aligned and oriented. Tolerances shall be as established on Contractor's drawings or as stipulated by Employer. No equipment shall be permanently bolted down / tag welded to foundation until the alignment has been checked and found acceptable by the Engineer. Contractor shall furnish all supervision labor, tools, equipment rigging materials, bolts, wedges, anchors, concrete inserts etc. in proper time, required to completely install, test and commission the equipment.

2.03 Manufacturer's and Employer's instructions and recommendations shall be correctly followed in handling, erection, testing and commissioning of all equipment.

2.04 Contractor shall move all equipment into the respective rooms through the regular door or openings specifically provided for this purpose. No parts of structure shall be utilized to lift or erect any equipment without prior permission of Engineer.

2.05 Switchgear shall be installed on finished surfaces, concrete or steel sills. Contractor shall be required to install and align any channel sills which form part of foundations. Minor modifications to foundations shall be carried out by the Contractor at no extra cost. Power bus enclosure, ground and control splices of conventional nature shall be cleaned and bolted together with torque wrench of proper size or by other approved means. Tape or compound shall be applied where called for in drawings. Contractor shall take utmost care in handling instruments, relays and other delicate mechanisms. Wherever the instruments and relays are supplied loose along with switchgear, they shall be mounted only after the associated switchgear panels have been erected and aligned. The blocking materials, employed for safe transit of instrument and relays shall be removed after ensuring that panels have been completely installed and no further movement of the same would be necessary. Any damage shall be immediately reported to Engineer.

3.00 CODES AND STANDARDS

3.01 All work shall be carried out as per the relevant standards, specification and codes of practices, referred to herein & in Section GTR, shall be the latest editions including all applicable official amendments and revisions as on the date of opening of bid.

3.02 Equipment conforming to any other internationally accepted standards will also be considered if they ensure performance and constructional features equivalent or superior to the standards listed above.

4.00 EQUIPMENT SPECIFICATION

4.01 Switchgear Panel

a) The switchgear boards shall have a single front, single tier, fully compartmentalized, metal enclosed construction complying with clause No. 3.102 of IEC 62271-200, comprising of a row of free standing floor mounted panels. Each circuit shall have a separate vertical panel with distinct compartments for circuit breaker truck, cable termination, main bus-bars and auxiliary control devices. The adjacent panels shall be completely separated by steel sheets except in bus-bar compartments where insulated barriers shall be provided to segregate adjacent panels. The Service Class Continuity of Switchgears shall be LSC 2B-PM (as per IS/IEC 622771-200). However, manufacturer's standard switchgear designs without inter panel barriers in bus-bar compartment may also be considered.

b) The circuit breakers shall be mounted on withdrawable trucks which shall roll out horizontally from service position to isolated position. For complete withdrawal from the panel, the truck shall rollout on the floor or shall roll out on telescopic rails. In case the later arrangement is offered, suitable trolley shall be provided by the Bidder for withdrawal and insertion of the truck from and into the panel. Testing of the breaker shall be possible in Isolated position by keeping the control plug connected.

c) The trucks shall have distinct SERVICE and ISOLATED positions. It shall be possible to close the breaker compartment door in isolated position also, so that the switchgear retains its specified degree of protection. While switchboard designs with doors for breaker compartments would be preferred, standard designs of reputed switchgear manufacturers where the truck front serves as the compartment cover may also be considered provided the breaker compartment is completely sealed from all other compartments and retains the IP-4X degree of protection in the Isolated position. In case the later arrangement is offered, the Bidder shall ensure that proper sealing is achieved and shall include blanking covers one for each size of panel per switchboard in his offer.

d) The switchgear assembly shall be dust, moisture, rodent and vermin proof, with the truck in any position SERVICE, ISOLATED or removed, and all doors and covers closed. All doors, removable covers and glass windows shall have gaskets all round with synthetic rubber or neoprene gaskets. **However, Panels which are type tested for IP-4X as per IEC/IS, without any gasket arrangement are also acceptable.**

e) All louvers, if provided, shall have very fine brass or GI mesh screen. Tight fitting gourmet / gaskets are to be provided at all openings in relay compartment. Numerical Relays shall be fully flush mounted on the switchgear panels at a suitable height.

f) **11kV indoor** Switchgear shall have an Internal Arc Classification of IAC FLR **25 KA**, 1 sec. The switchgear construction shall be such that the operating personnel are not endangered by breaker operation and internal explosions, and the front of the panels shall be specially designed to withstand these. Pressure relief device shall be provided in each high voltage compartment of a panel, so that in case of a fault in a compartment, the gases produced are safely vented out, thereby minimizing the possibility of its spreading to other compartments and panels. The pressure relief device shall not however reduce the degree of protection of panels under normal working conditions. Contractor shall submit the type test report for satisfactory operation of pressure relief device in line with IEC 62271-200 Annexure – A.

g) Enclosure shall be constructed with rolled steel sections. The doors and covers shall be constructed from cold rolled steel sheets of 2.0 mm or higher thickness. Gland plates shall be 2.5 mm thick made out of hot rolled or cold rolled steel sheets and for non magnetic material it shall be 3.0 mm.Thickness of explosion vent shall be as per manufacturer's standard design.

h) The switchgear shall be cooled by natural air flow.

i) Total height of the switchgear panels **shall be finalized during detail engineering in line with building design**. The height of switches, pushbuttons and other hand operated devices shall not exceed 1800 mm and shall not be generally less than 700 mm.

j) Necessary guide channels shall be provided in the breaker compartments for proper alignment of plug and socket contacts when truck is being moved to SERVICE position. A crank or lever arrangement shall preferably be provided for smooth and positive movement of truck between Service and Isolated positions. **Suitable locking arrangement should be provided for the racking mechanism.**

k) Safety shutters complying with IEC 62271-200 shall be provided to cover up the fixed high voltage contacts on busbar and cable sides when the truck is moved to ISOLATED position. The shutters shall move automatically, through a linkage with the movement of the truck. Preferably it shall however, be possible to open the shutters of busbar side and cable side individually against spring pressure for testing purpose after defeating the interlock with truck movement deliberately. In case, insulating shutters are provided, these shall meet the requirements of IEC 62271-200 and necessary test report shall be submitted as per IEC 62271-200 Clause 5.103.3.3. A clearly visible warning label "Isolate elsewhere before earthing" shall be provided on the shutters of incoming and tie connections which could be energized from other end.

l) Switchgear construction shall have a bushing or other sealing arrangement between the circuit breaker compartment and the busbar/ cable compartments, so that there is no air communication around the isolating contacts in the shutter area with the truck in service position.

m) The breaker and the auxiliary compartments provided on the front side shall have strong hinged doors. Busbar and cabling compartments provided on the rear side shall have separate bolted covers with self retaining bolts for easy maintenance and safety. Breaker compartment doors shall have locking facility. Suitable interlock shall be provided, which will ensure that breaker is OFF before opening the back doors. For Incomer/ Bus-coupler/ Bus-Section panels, suitable interlock

shall be provided to prevent opening of any compartment doors which has any of the MV (11kV) equipment, in case the incoming supply is ON.

n) In the Service position, the truck shall be so secured that it is not displaced by short circuit forces. Busbars, jumpers and other components of the switchgear shall also be properly supported to withstand all possible short circuit forces corresponding to the short circuit rating specified.

o) Suitable base frames made out of steel channels shall be supplied along with necessary anchor bolts and other hardware, for mounting of the switchgear panels. These shall be dispatched in advance so that they may be installed and leveled when the flooring is being done, welding of base frame to the insert plates shall be in Bidder's scope. The bidder may offer panels with built in base frame ready for dispatch and suitable for installation on indoor cable trenches.

p) The switchboard shall have the facility of extension on both sides. Any adopter panels and dummy panels as required to meet the various busbar arrangements, cable / bus duct termination and layouts shall be included in Bidder's scope of work.

q) Thermostatically controlled space heater for each chamber (CB, Bus bar, cable, PT/CT chamber etc as applicable) along with common MCB shall be provided.

r) **Cassette type design for VCB Panels shall also be acceptable.**

4.02 Circuit Breakers (VCB Type)

a) The circuit breakers shall be of Vacuum type. They shall comprise of three separate, identical single pole interrupting units, operated through a common shaft by a sturdy operating mechanism.

b) Outgoing breakers shall be suitable for switching transformers at any load.

c) Circuit breaker shall be re-strike free, stored energy operated and trip free type. Motor wound closing spring charging shall only be acceptable. An anti-pumping relay shall be provided for each breaker, even if it has built-in mechanical anti-pumping features. An arrangement of two breakers in parallel to meet a specified current rating shall not be acceptable.

d) During closing, main poles shall not rebound objectionably and mechanism shall not require adjustments. Necessary dampers shall be provided to withstand the impact at the end of opening stroke.

e) Plug and socket isolating Contacts for main power circuit shall be silver plated, of self aligning type, of robust design and capable of withstanding the specified short circuit currents. They shall preferably be shrouded with an insulating material. Plug and socket contacts for auxiliary circuits shall also be silver plated, sturdy and of self aligning type having a high degree of reliability. Thickness of silver plating shall not be less than 10 microns.

f) All working part of the mechanism shall be of corrosion resisting material. Bearings which require greasing shall be equipped with pressure type grease fittings. Bearing pins, bolts, nuts and other parts shall be adequately secured and locked to prevent loosening or change in adjustment due to repeated operation of the breaker and the

mechanism.

g) The operating mechanism shall be such that failure of any auxiliary spring shall not prevent tripping and shall not lead to closing or tripping of circuit breaker. Failure of any auxiliary spring shall also not cause damage to the circuit breaker or endanger the operator.

h) Mechanical indicators shall be provided on the breaker trucks / **front** to indicate OPEN / CLOSED conditions of the circuit breaker, and CHARGED / DISCHARGED conditions of the closing spring. An operation counter shall also be provided. These shall be visible without opening the breaker compartment door.

i) The rated control supply voltage shall be as mentioned elsewhere under Technical parameters. The closing coil and spring charging motor shall operate satisfactorily at all values of control supply voltage between **85-110% of the rated voltage**. The shunt trip coil shall operate satisfactorily under all operating conditions of the circuit breaker upto its rated short circuit breaking current at all values of control supply voltage **between 70-110% of the rated voltage.** The trip coil shall be so designed that it does not get energized when its healthiness is monitored by indicating lamps (Red) and trip coil supervision relay.

j) The time taken for charging of closing spring shall not exceed 30 seconds. The spring charging shall take place automatically preferably after a closing operation. Breaker operation shall be independent of the spring charging motor which shall only charge the closing spring. Opening spring shall get charged automatically during closing operation. As long as power supply is available to the charging motor, a continuous sequence of closing and opening operations shall be possible. One open-close- open operation of the circuit breaker shall be possible after failure of power supply to the motor. Spring charging motors shall be capable of starting and charging the closing spring twice in quick succession without exceeding acceptable winding temperature when the control supply voltage is anywhere between **85-110% of rated voltage**. The initial temperature shall be as prevalent in the switchgear panel during full load operation with 50 deg. C ambient air temperature. The motor shall be provided with Over load protection.

k) Motor windings shall be provided with class E insulation or better. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in a hot, humid and tropical climate.

l) Circuit breaker shall be provided with inter pole barriers of insulating materials. The use of inflammable materials like Hylam shall not be acceptable.

m) **Circuit breaker pole shall be with epoxy encasing / epoxy encapsulation to** safe guard against mechanical impact and climatic condition such as moisture, humidity and dust.

4.03 **Control and Interlocks**

a) The circuit breaker will normally be controlled remotely from SAS/SCADA system through closing and shunt trip coils. However, it shall also be designed to locally control from Indoor Switchgear panel. Suitable mimic on Panel shall be provided.

b) Facilities shall be provided for mechanical tripping of the breaker and for manual charging of the stored energy mechanism for a complete duty cycle, in an emergency. These facilities shall be accessible only after opening the compartment door.

c) Each panel shall have two separate limit switches, one for the Service position and the other for isolated position. Each of these limit switches shall have at least four (4) contacts which shall close in the respective positions.

d) Auxiliary Contacts of breaker may be mounted in the fixed portion or in the withdrawable truck as per the standard practice of the manufacturer, and shall be directly operated by the breaker operating mechanism.

e) Auxiliary contacts mounted in the fixed portion shall not be operable by the operating mechanism, once the truck is withdrawn from the service position, but remain in the position corresponding to breaker open position. Auxiliary contacts mounted on the truck portion, and dedicated for Employer's use shall be wired out in series with a contact denoting breaker service position. With truck withdrawn, the auxiliary contacts shall be operable by hand for testing. There shall be at lease Six (2) NO and Six (2) NC breaker auxiliary contacts made available for Employer's future use.

f) The contacts of all limit switches and all breaker auxiliary contacts located on truck portion and fixed portion shall be rated to make, carry and break 1.0A, 240V DC (Inductive) / 10A, 240V AC. Contacts of control plug and socket shall be capable of carrying the above current continuously.

g) Movement of truck between SERVICE and ISOLATED positions shall be mechanically prevented when the breaker is closed. An attempt to withdraw a closed breaker shall not trip it.

h) Closing of the breaker shall be possible only when truck is either in ISOLATED or in SERVICE position and shall not be possible when truck is in between. Further, closing shall be possible only when the auxiliary circuits to breaker truck have been connected up, and closing spring is fully charged.

i) It shall be possible to easily insert breaker of one typical rating into any one of the panels meant for same rating but at the same time shall be prevented from inserting it into panels meant for a different type or rating.

j) Indications shall be provided in display unit of the relay flush mounted on the panel front as brought out in the specification elsewhere. It shall be possible to easily make out whether the truck in SERVICE OR ISOLATED POSITION even when the compartment door is closed.

4.04 **Busbars and Insulators**

a) All busbar and jumper connections shall be of high conductivity aluminium alloy / Copper of adequate size and bus bar size calculation / **supporting type test report** shall be submitted for approval. They shall be adequately supported on insulators to withstand electrical and mechanical stresses due to specified short circuit currents.

b) Busbar cross-section shall be uniform throughout the length of switchgear. Busbars and other high voltage connection shall be sufficiently corona free at maximum working voltage.

c) Contact surfaces at all joints shall be silver plated or properly cleaned and non-oxide grease applied to ensure an efficient and trouble free connection. All bolted

joints shall have necessary plain and spring washers. All connection hardware shall have high corrosion resistance. Bimetallic connectors or any other technically proven method shall be used for aluminum to copper connections.

d) Busbar insulators shall be of arc and track resistant, high strength, non-hygroscopic, non-combustible type and shall be suitable to withstand stresses due to over-voltages, and short circuit current. Busbar shall be supported on the insulators such that the conductor expansion and contraction are allowed without straining the insulators. In case of organic insulator partial discharge shall be limited to 100pico coulomb at rated Voltage X 1.1/$\sqrt{3}$. Use of insulators and barriers of in-flammable material such as Hylam shall not be accepted.

e) All busbars shall be color coded for phase identification.

f) The temperature of the busbar and all other equipment, when carrying the rated current continuously shall be limited as per the stipulations of relevant Indian Standards, duly considering the specified ambient temperature (50 deg. C). The temperature rise of the horizontal and vertical busbars when carrying the rated current shall be in line with IEC at 50 deg. C ambient.

4.05 **Earthing and Earthing Devices**

a) A copper / galvanized steel earthing bus shall be provided at the bottom and shall extend throughout the length of each switch board. It shall be bolted/ welded to the framework of each panel and each breaker earthing contact bar.

b) The earth bus shall have sufficient cross section to carry the momentary short-circuit and short time fault currents to earth as indicated under switchgear parameters without exceeding the allowable temperature rise.

c) Suitable arrangement shall be provided at each end of the earth bus for bolting to Employer's earthing conductors. All joint splices to the earth bus shall be made through at least two bolts and taps by proper lug and bolt connection.

d) All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. Electrical continuity of the whole switchgear enclosure frame work and the truck shall be maintained even after painting.

e) The truck and breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker frame shall be maintained in all positions i.e. SERVICE and ISOLATED as well as throughout the intermediate travel. The truck shall also get and remain earthed when the control plug is connected irrespective of its position.

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

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

h) Separate earthing trucks shall be provided by the Contractor for maintenance work. These trucks shall be suitable for earthing the switchgear busbars as well as outgoing / incoming cables or bus ducts. The trucks shall have a voltage transformer / **Voltage Presence Indicator (VPI)** and an interlock to prevent earthing of any live connection. The earthing trucks shall in addition have a visual/ audible annunciation to warn the operator against earthing of live connections.

As an alternative to separate earthing trucks the Bidder may also offer built-in earthing facilities for the busbars and outgoing / incoming feeders, in case such facilities are available in their standard proven switchgear design. The inbuilt earthing switches shall have provision for short circuiting and earthing a circuit intended to be earthed. These switches shall be quick make type, independent of the action of the operator and shall be operable from the front of the switchgear panel. These switches shall have suitable facility for locking in the earthed condition.

i) The earthing device (truck / switch) shall have the short circuit withstand capability equal to that of associated switchgear panel. 4 NO + 4 NC of auxiliary contacts of the earthing device shall be provided for interlocking purpose.

j) All hinged doors shall be earthed through flexible earthing braid.

k) Interlocks shall be provided to prevent :

1) Closing of the earthing switch if the associated circuit breaker truck is in Service position.

2) Insertion of the breaker truck to Service position if earthing switch is in closed position.

4.06 Painting

All sheet steel work shall be pretreated, in tanks, in accordance with IS: 6005. Degreasing shall be done by alkaline cleaning. Rust and scales shall be removed by pickling with acid. After pickling, the parts shall be washed in running water. Then these shall be rinsed in slightly alkaline hot water and dried. The phosphate coating shall be "Class-C" as specified in IS: 6005. The phosphated surfaces shall be rinsed and passivated. After passivation, Electrostatic Powder Coating shall be used. Powder should meet requirements of IS 13871 (Powder coating specification). Finishing paint shade for complete panels shall be RAL7032 for all boards, unless required otherwise by the Employer. The paint thickness shall not be less than 50 microns. Finished parts shall be suitably packed and wrapped with protective covering to protect the finished surfaces from scratches, grease, dirt and oil spots during testing, transportation, handling and erection.

4.07 Instrument Transformers

a) All current and voltage transformers shall be completely encapsulated cast resin insulated type, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated load and the outside ambient temperature is 50 deg. C. The class of insulation shall be E or better.

b) All instrument transformers shall withstand the power frequency and impulse test voltage specified for the switchgear assembly. The current transformer shall further have the dynamic and short time ratings at least equal to those specified for the associated switchgear and shall safely withstand the thermal and mechanical stress produced by maximum fault currents specified when mounted inside the switchgear for circuit breaker modules.

c) The parameters of instrument transformers specified in this specification are tentative and shall be finalized by the Employer in due course duly considering the actual burden of various relays and other devices finally selected. In case the Bidder finds that the specified ratings are not adequate for the relays and other devices offered by him, he shall offer instrument transformer of adequate ratings.

d) All instrument transformers shall have clear indelible polarity markings. All secondary terminals shall be wired to separate terminals on an accessible terminal block.

e) Current transformers shall be located in the cable termination compartment. All CT/VT shall be single phase type. VT mounting shall be fixed/ withdrawable type.

f) All voltage transformers shall have suitable HRC current limiting fuses on both primary and secondary sides. Primary fuses shall be mounted suitably on the fixed / withdrawable portion.

4.08 Numerical Protection Relays (IEDs)

4.08.01 Indoor switchgear panels shall have communicable numerical protection relays (IEDs) complying with IEC-61850 on all feeders which shall be networked on Ethernet to communicate with substation SAS/SCADA system on IEC-61850. These IEDs shall also be used for control & monitoring the switchgear from SAS. In addition to status of devices (CBs/Isolators) and equipment alarms, Metering data shall also be made available to SAS/SCADA station from protection IEDs. Further, multifunction meters with Modbus protocol are also envisaged, which will be connected in daisy-chain-link to communicate to station SAS. Modbus to IEC 61850 converter shall be provided for integration with SAS.

The Bidder's scope shall include the followings:

a) Communicable Numerical Protection Relays (with IEC 61850) in each of the feeders & Bus-section

b) IED's / Numerical Relays shall have Graphical Display to facilitate settings, relay operations and to view measurement, event and alarm etc.

c) Relays shall have built in Local/Remote Switch.

d) Cat5e Ethernet cable for connection of Numerical Relays (IEDs) to Ethernet switches. Optical cable shall be used between Ethernet switch (for indoor switch gear IEDs) and ring/ redundant network of Substation LAN switch.

e) Required number of Ethernet switches mounted in Indoor Switchgear panels for communication with IEDs on IEC 61850 protocol.

f) The SAS/SCADA system has been envisaged as part of main substation. Bidder shall facilitate in successful Integration of Numerical Relays to the SAS/SCADA system through Ethernet switches.

4.08.02 All Numerical relays shall be of types, proven for the application satisfying requirements specified elsewhere and shall be subject to Employer's approval.

Numerical Relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity to the satisfaction of the Employer.

4.08.03 All numerical relays shall be rated for control supply voltage as mentioned elsewhere under system parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Making, carrying and breaking current ratings of their contacts shall be adequate for the circuits in which they are used. Contacts for breaker close and trip commands shall be so rated as to be used directly used in the closing and tripping circuits of breaker without the need of any interposing / master trip relays. Threshold voltage for binary inputs shall be suitably selected to ensure avoidance of mal operation due to stray voltages and typically shall be more than 70% of the rated control supply voltage.

4.08.04 All IEDs shall have freely programmable optically isolated binary inputs (BI) and potential free binary output (BO) contacts as per approved scheme. These I/O points shall be used for wiring of status of devices (CBs/Isolators) and equipment alarms etc. Heavy duty binary output contacts of IEDs shall be suitable for CB closing / tripping directly and no separate master trip relay shall be used.

4.08.05 Failure of a control supply and de-energization of a relay shall not initiate any circuit breaker operation.

4.08.06 Relays shall have event recording feature, recording of abnormalities and operating parameters with time stamping. Event records & alarms shall be stored in Non-volatile memory and failure of control supply shall not result in deletion of any of these data.

4.08.07 All Numerical relays shall have features for electrical measurements including voltage, current, power (active & reactive), frequency, power-factor and energy parameters.

4.08.08 All numerical relays shall have provision of both current (CT) and voltage (VT) inputs as required for protection & measurement purposes using protection cores.

4.08.09 All numerical relays shall have key pad / keys to allow relay setting from relay front. Relay to be self or hand reset type which shall be software selectable. Manual resetting shall be possible from remote.

4.08.10 Relays shall have suitable output contact for circuit breaker failure protection (LBB) logic.

4.08.11 Relays shall have self diagnostic feature with continuous self check for power failure, program routines, memory and main CPU failures and a separate output contact for indication of any failure.

4.08.12 Contractor shall submit applicable Type Test reports for Numerical relays as per IEC including report for IEC 61850 protocol from accredited lab.

4.09 Control & Protection System

All numerical relays shall communicate to station SCADA / SAS on IEC-61850 communication protocol. It is envisaged that these protection IEDs shall be used for CB control & monitoring of bay equipments.

4.09.01 Numerical Transformer Protection Relay

a) The relay shall have instantaneous as well as time delayed three over current (50) and one earth fault (50N) protections.

b) The over current element should have the minimum setting adjustable between 20-200% of CT secondary rated current and high set setting 500-2000%.

c) The relay shall have selectable directional & non-directional feature

d) The earth fault element of relay shall be suitable for detection of earth fault currents in the range of 5% to 80% of the CT rated current (IDMT) and high set 100-1000%.

e) For transformers of rating 5MVA and above, definite time delayed Stand by earth fault protection shall be provided having a pick up setting range of 10% to 40% with a timer delay of 0.3 sec to 3 sec.

f) The relay shall allow higher setting during transformer charging (inrush) and lower setting during normal operating condition.

g) Transformer troubles like Buchholz, Winding temperature, Oil temperature & Pressure Relief Device trips (as applicable) shall be wired to separate binary inputs of the relay and shall be configured to issue trip command to the breaker.

h) Trip circuit supervision shall be provided to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions.

4.09.02 **Numerical Line Protection Relay**

a) The relay shall have instantaneous as well as time delayed three over current (50) and one earth fault (50N) protections.

b) The over current element should have the minimum setting adjustable between **20**-200% of CT secondary rated current.

c) The relay shall have selectable directional & non-directional feature

d) The earth fault element of relay shall be suitable for detection of earth fault currents in the range of 5% to 80% of the CT rated current.

e) Trip circuit supervision shall be provided to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions.

4.09.03 **Numerical Bus Coupler/Bus-Section Protection Relay**

a) The relay shall have instantaneous as well as time delayed three over current (50) and one earth fault (50N) protections.

b) The over current element should have the minimum setting adjustable between **20**-200% of CT secondary rated current.

c) The earth fault element of relay shall be suitable for detection of earth fault currents in the range of 5% to 80% of the CT rated current.

d) Bus no volt signal shall be configured in the relay for use in control logics and other Protections and Control functions in the Relays.

e) Trip circuit supervision shall be provided to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions.

4.09.04 Other Control and Protections features

a) Control of breakers shall be carried out from the station HMI of SAS/SCADA system through the LAN and the numerical relays.

b) The HMI shall have a graphical dynamic Plant Key Single Line Diagram to view the complete system status. This shall include the status of the switchgears, measurement values, operation counters, graphical alarm representation, etc. Spontaneous changes of a state, typically opening of a circuit breaker from a protection, shall have a specific colour code. All the Breakers with the status shall be clearly displayed along with values of currents, voltages, and frequency, active and reactive powers etc.

c) Separate Master trip (86) relay with self-reset type for Line protection and Electrical reset type for Transformer shall be provided. Electrical reset shall be possible through IED & Substation SAS.

d) Schematics requiring auxiliary relays / timers for protection function shall be a part of numerical relay. The number of auxiliary relay and timer functions shall be as required for the application. Timer functions shall be configurable for on & off delays as per requirement.

e) The numerical relay shall be capable of measuring and storing values of a wide range of quantities, all events, faults and disturbance recordings with a time stamping using the internal real time clock. Battery backup for real time clock in the event of power supply failure shall be provided.

f) At least 250 time tagged events / records shall be stored with time stamping. Details of at least 5 previous faults including the type of protection operated, operating time, all currents & voltages and time of fault.

g) Diagnostics Automatic testing, power on diagnostics with continuous monitoring to ensure high degree of reliability shall be shall be provided. The results of the self reset functions shall be stored in battery back memory. Test features such as examination of input quantities, status of digital inputs and relay outputs shall be shall be available on the user interface

h) The alarm/status of each individual protection function and trip operation shall be communicated to the SAS/SCADA system.

i) Sequence of events shall have 1ms resolution at device level.

j) Measurement accuracy shall be 1% for rated RMS Current and voltage (20-120% of Rated primary).

k) It shall be possible to carryout open / close operation of breakers from a laptop by interfacing from the relay front port during initial commissioning.

5.00 ETHERNET SWITCH

a) Ethernet switches shall be ‘substation hardened‘, and shall comply with IEC61850 for communications with IEDs. The Ethernet switches shall be of managed type with two (2) No. of Fiber optic cable ports and at least Sixteen (16) Copper ports to achieve the LAN configuration. More no. of switches or higher ports switch can also be supplied to meet all IEDs requirements for the LAN. The Ethernet switches shall have features to support the redundant rings. These switches shall be mounted in the switchgear Panels. The FO ports shall be Single-mode 1000Mbps ports. Copper ports shall be 10/100Mbps ports.

b) Necessary software for configuration and real-time network monitoring shall be provided along with the Ethernet switches.

6.00 POWER CABLE TERMINATION

a) Cable termination compartment shall receive the stranded Aluminium /copper conductor, XLPE insulated, shielded, armored, PVC jacketed, single core / three core, unearthed / earthed grade power cable(s).

b) Adequate clearance shall be kept between the cable lug bottom ends and gland plates for stress cone formation for XLPE cables. Inter-phase clearance in the cable termination compartment shall be adequate to meet electrical and mechanical requirement besides facilitating easy connections and disconnection of cables. Dimensional drawing of cable connection compartment showing the location of lug, glands, CTs, gland plates etc. and the electrical clearances available shall be submitted for Employer's approval during detail engineering.

c) Cable termination compartment shall have provision for termination of power cables of sizes indicated in the bidding documents with removable undrilled gland plates. For all single core cables gland plates shall be of non-magnetic material. Cable entry shall generally be from the bottom; however, this shall be finalized during detail engineering.

7.00 CONFIGURATION OF INDOOR VCB PANELS

Sl. No.	Equipment	IP1 I/C	IP2 O/G	IP3 LT TR	IP4 B/S
1.	VCB as per spec	1	1	1	1
2.	CB Spring charge indicator (Mechanical)	1	1	1	1
3.	Mechanical ON/OFF indicator for CB	1	1	1	1
4.	Operation counter for CB	1	1	1	1
5.	CT (1-Phase)	3	3	3	3
6.	VT (1-Phase)	-	-	-	6
7.	Multi Function Meter	1	1	1	1
8.	Control switch for breaker(T-N-C)	1	1	1	1
9.	Green Indicating lamp for CB Open	1	1	1	1
10.	Red indicating lamp for CB Close	1	1	1	1
11.	DC healthy lamp (white)	1	1	1	1
12.	Trip circuit healthy lamp	1	1	1	1
13.	Mimic to represent SLD	1	1	1	1
14.	Voltmeter with selector switch	-	-	-	2
15.	Numerical protection relay (IED)	1	1	1	1
16.	Master Trip Relay (86)	1	1	1	1
17.	Semaphore Indicator for Line Isolator & Line Earth Switch	-	2	-	-
18.	LAN Switches and LAN/FO Cables	AS per requirement			

Notes:

1. IP1: Panel for Transformer Incomer feeder (I/C)
2. IP2: Panel for outgoing Line Feeder (O/G)
3. IP3: Panel for LT Transformer feeder (LT TR)
4. IP4: Panel for Bus Sectionaliser (B/S)
5. Location of VT (I/C or B/S Module) shall be decided during detail engineering.
6. Numerical protection relay (IED) for all type of VCB module shall preferably be interchangeable to optimize mandatory spares.

8.00 TESTS

8.01 Type Tests

The contractor shall submit the reports for the following type tests on the equipment to be supplied under the contract:

A. Switchgear Panel (with Circuit Breaker installed)
   a. Short circuit duty test
   b. Short time and peak withstand current test
   c. Power frequency withstand test
   d. Lightning impulse withstand test
   e. Temperature rise test
   f. Internal Arc Test as per IEC 62271-200 (for 1 second)
   g. Measurement of resistance of main circuit
   h. Test to verify pressure relief operation of the panel **(During internal arc test)**
   i. Cable charging test
   j. Short circuit withstand test of earthing device (truck / switch).

B. Circuit Breaker

   a. Mechanical Endurance Test

C. Current Transformer
   a. Short time current test
   b. Temperature rise test
   c. Lighting Impulse voltage withstand test

D. Potential Transformer
   a. Temperature rise test
   b. Lighting Impulse voltage withstand test

E. Switchgear Panel
   a. IP 4X test

8.02 Routine Tests

All acceptance and routine tests as per the specification and relevant standards IEC 62271-200 & IEC 62271-100 shall be carried out. Charges for these shall be deemed to be included in the equipment price.

The manufacturer shall furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

8.03 Commissioning Checks / Tests

After installation of panels, power and Control wiring and connections, Contractor shall perform commissioning checks as listed below to verify proper operation of switchgear / panels and correctness of all equipment in all respects. In addition, the Contractor shall carry out all other checks and tests recommended by the manufacturers.

8.03.01 General

a. Check name plate details according to specification.
b. Check for physical damage

c. Check tightness of all bolts, clamps and connecting terminals
d. Check earth connections.
e. Check cleanliness of insulators and bushings
f. Check heaters are provided
g. H.V. test on complete switchboard with CT & breaker in position.
h. Check all moving parts are properly lubricated.
i. Check for alignment of busbars with the insulators to ensure alignment and fitness of insulators.
j. Check for interchangeability of breakers.
k. Check continuity and IR value of space heater.
l. Check earth continuity for the complete switchgear board.

8.03.02 Circuit Breaker

a. Check alignment of trucks for free movement.
b. Check correct operation of shutters.
c. Check control wiring for correctness of connections, continuity and IR values.
d. Manual operation of breakers completely assembled.
e. Power closing / opening operation, manually and electrically
f. Closing and tripping time.
g. Trip free and anti-pumping operation.
h. IR values, resistance and minimum pick up voltage of coils.
i. Simultaneous closing of all the three phases.
j. Check electrical and mechanical interlocks provided.
k. Checks on spring charging motor, correct operation of limit switches and time of charging
l. All functional checks.

8.03.03 Current Transformers

a. Megger between windings and winding terminals to body.
b. Polarity tests.
c. Ratio identification checking of all ratios on all cores by primary injection of current.
d. Magnetization characteristics & secondary winding resistance.
e. Spare CT cores, if any to be shorted and earthed.

8.03.04 Voltage Transformers

a. Insulation resistance test.
b. Ratio test on all cores.
c. Polarity test.
d. Line connections as per connection diagram.

8.03.05 Cubicle Wiring

a. Check all switch developments.
b. It should be made sure that the wiring is as per relevant drawings. All interconnections between panels shall similarly be checked.
c. All the wires shall be meggered to earth.

d. Functional checking of all control circuit e.g. closing, tripping interlock, supervision and alarm circuit including proper functioning of component / equipment.
e. Check terminations and connections.
f. Wire ducting.
g. Gap sealing and cable bunching.

8.03.06 Relays

a. Check internal wiring.
b. IR of all terminal body.
c. IR of AC to DC terminals
d. Check operating characteristics by secondary injection.
e. Check operation of electrical/ mechanical targets.
f. Relay settings.

9.00 SYSTEM PARAMETERS:

1	Nominal System voltage	22 kV	11 kV
2	Highest System voltage	24 kV	12 kV
3	Rated Frequency	50 Hz	50 Hz
4	Number of phases/ poles	Three	Three
5	System neutral earthing	As per Vector Group of Transformers	As per Vector Group of Transformers
6	One minute power frequency withstand voltage	50	28
7	1.2/50 microsecond Impulse withstand voltage	150 kV (peak)	75 kV (peak)
8	Short time rating for bus bars, CB, CT and switchgear Assembly..	25 kA (rms) for one (1) sec.	25 kA (rms) for one (1) sec.
9	Dynamic withstand rating	62.5 kA (peak)	62.5 kA (peak)
10	IAC Rating	25kA, 1.0 Sec	25kA, 1.0 Sec
11	Control supply voltage		
12	- Trip and closing coils	As per Station DC Supply	As per Station DC Supply
	- Spring charging motor	As per Station DC Supply	As per Station DC Supply
13	Maximum ambient air temperature	50 deg. C	50 deg. C

a)	**CIRCUIT BREAKERS**		
1.	Rated Voltage	22 kV	11 kV
2.	CB rated Current		
a)	Incomer & Sectionaliser Breaker	2500A	2500A
b)	Outgoing feeder Breaker	1250A	1250A
3.	Short circuit breaker Current		
a)	A.C. component	25kA	25kA

b)	D.C. component	As per IS: 13118 or IEC-62271	As per IS: 13118 or IEC-62271
4.	Short Circuit making current	62.5 kA(peak)	62.5 kA(peak)
5.	Out of phase breaking Current capacity	As per IEC	As per IEC
6.	Rated line/cable charging Interrupting current at 90° Leading power factor angle	As per IEC	As per IEC
7.	Maximum allowable switching Over voltage under any switching Condition	As per IEC	As per IEC
8.	Rated small inductive current Switching capability with over Voltage less than 2.3 pu	As per IEC	As per IEC
9.	First pole to clear factor	1.5	1.5
10	Operating Duty	**O-0.3 Sec-CO-3 Min-CO**	**O-0.3 Sec-CO-3 Min-CO**
11	Total break time	Not more than 4 cycles	Not more than 4 cycles
12	Total make time	Not more than 5 cycles	Not more than 5 cycles
13	Reclosing	3 phase auto reclosing	3 phase auto reclosing
14	Max. difference in the instants of closing/opening contacts between poles at rated control Voltage and rated operating and quenching media pressures	As per IEC	As per IEC
15	Auxiliary contacts	2NO+2NC for Employers future use besides scheme requirement	2NO+2NC for Employers future use besides scheme requirement
16	Operating Mechanism	Motor wound spring charged stored energy type as per IEC-62271	Motor wound spring charged stored energy type as per IEC-62271
Current Transformer			
1.	Rated primary voltage	**22kV**	**11kV**
2.	Rated primary current	2400A	2400A
3.	Type of CT	1-Phase	1-Phase
4.	Max temp rise	As per IEC:60044-1	As per IEC:60044-1
5.	Class of Insulation	Class E or better	Class E or better
6.	One minute power frequency withstand voltage between secondary terminal & earth	2kV	2kV
7.	No. of Secondary cores	3	3

1.	Rated primary voltage	**22kV**	**11kV**
2.	Rated primary current	600A	600A
3.	Max temp rise	As per IEC:60044-1	As per IEC:60044-1
4.	Class of Insulation	Class E or better	Class E or better
5.	One minute power frequency withstand voltage between secondary terminal & earth	2kV	2kV
6.	Nos. of Secondary cores	2	2
1.	Rated primary Voltage	**22kV**	**11kV**
2.	Rated primary current	40A	40A
3.	Max temp rise	As per IEC:60044-1	As per IEC:60044-1
4.	Class of Insulation	Class E or better	Class E or better
5.	One minute power frequency withstand voltage between secondary terminal & earth	2kV	2kV
6.	Nos. of Secondary cores	2	2
	Lapsephedi		
1.	Rated primary Voltage	**22kV**	**11kV**
2.	Rated primary current	300A	300A
3.	Max temp rise	As per IEC:60044-1	As per IEC:60044-1
4.	Class of Insulation	Class E or better	Class E or better
5.	One minute power frequency withstand voltage between secondary terminal & earth	2kV	2kV
6.	Nos. of Secondary cores	2	2
1.	Rated primary Voltage	22kV	11kV
2.	Type	1-Phase	1-Phase
3.	Voltage ratio (kV)	(11/√3)/(0.11/√3)	(11/√3)/(0.11/√3)
4.	Rated Voltage Factor	1.2 continuous and 1.5 for 30 seconds	1.2 continuous and 1.5 for 30 seconds
5.	Nos. of Secondary cores	2	2
6.	Accuracy of Secondary core	Protn / Metering: 3P / 0.5	Protn. / Metering: 3P / 0.5
7.	Class of insulation	Class E or better	Class E or better
8.	Rated output burden (Minimum)	15VA	15VA

Notes: The ratings indicated for instrument transformers are tentative only and may be changed to meet the functional requirements.

10.00 INPUT SIGNAL TO SAS SYSTEM

The following digital input of 11kV Indoor switchgear bays shall be provided through IEDs in the SAS system:

i) Status of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Trip circuit faulty
v) Bus VT FUSE Fail
vi) Back-up overcurrent & earth fault protection Operated
vii) DC source fail

11.00 MULTIFUNCTION METER

The Multifunction meter shall have feature to measure KV, I, MW, MVAr, PF, MWhr, MVAr-hr with accuracy class of 0.5S. Further, multifunction meter shall have bi-directional feature to register/record MWhr values.

REQUIREMENT FOR 11kV CURRENT TRANSFORMERS

(INCOMER / BUS COUPLER FEEDER)

	Metering	O/C & E/F Protn.	Diff. Protn.
Current ratio	2400-1200/1	2400-1200/1	2400-1200/1
Accuracy class	0.5S class	5P20	PS
Knee point voltage (at minimum ratio)	-	-	1200V
Rated burden	7.5VA	-	-

REQUIREMENT FOR 11KV CURRENT TRANSFORMERS (LINE FEEDER)

	Metering	O/C & E/F Protn.
Current ratio	600-300/1	600-300/1
Accuracy class	0.5S class	5P20
Knee point voltage (at minimum ratio)	-	-
Rated burden	7.5VA	-

REQUIREMENT FOR 11KV CURRENT TRANSFORMERS (LT TRANSFORMER FEEDER)

	Metering	O/C & E/F Protn.
Current ratio	40-20/1	40-20/1
Accuracy class	0.5S class	5P20
Knee point voltage (at minimum ratio)	-	-
Rated burden	7.5VA	-

SECTION 22: EHV XLPE POWER CABLE

1 CABLE CONSTRUCTION DETAILS

1.1 The XLPE insulated EHV cable shall conform to the requirements of IEC 60502-2 (applicable clauses only) for construction and IEC 60840/IEC 62067 (as applicable) for testing. The terminating accessories shall conform to IEC 60840/ IEC 62067 (as applicable). The offered cables and its terminating accessories shall be compatible with each other.

1.2 The EHV grade cable shall be single core, unarmoured, stranded, compacted **Aluminium/Copper (as specified in BPS)** conductor, core screening by a layer of semiconducting tape followed by a layer of semiconducting compound, cross linked polyethylene (XLPE) dry cured insulation, insulation screening with semiconducting compound extruded directly over the insulation, longitudinal sealing by a layer of non-woven tape with water swellable absorbent over insulation screen, followed by radial sealing (Metal sheath of extruded corrugated aluminium), metallic screening by concentric layer of plain copper wire (if required) to meet short time current requirement, followed by an open helix of copper & overall HDPE sheathed & graphite coated and conforming to the technical particulars of specification. Bidder may offer necessary layers such as separation tape, binder tapes etc additionally as per their manufacturing practices for meeting required performance of the offered cable.

1.3 The cable shall be suitable for laying under the climate conditions (as specified in Section-Project) and underground buried installation with uncontrolled back fill and chances of flooding by water.

1.4 Cable shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions.

1.5 Progressive sequential marking of the cable length (in metres), at every one metre, shall be provided on the outer sheath of the cable.

1.6 Repaired cables shall not be accepted.

1.7 Allowable tolerance on the overall diameter of the cables shall be $\pm$ 2 mm.

1.8 CONDUCTOR

The conductor shall be of **Copper/Aluminium** wires as specified in the Bid Price Schedule **(BPS)**. The shape of conductor shall be compacted segmental having high compactness and smooth surface finish.

1.9 CONDUCTOR SCREEN

The conductor screen shall consist of extruded semi-conducting XLPE. Semi-conducting separator tapes may be applied between conductor and the extruded semi-conductor XLPE. The conductors screen (non-metallic semi-conductive) shall be extruded in a single one-time process to ensure homogeneity and absence of voids.

1.10 INSULATION

The extruded XLPE insulation shall be applied over the conductor screen to the desired thickness in a void free manner.

1.11 INSULATION SCREEN

The insulation screen shall consist of extruded semi-conducting XLPE. Suitable bedding tapes shall be applied over the extruded semi-conducting XLPE.

1.12 MOISTURE BARRIER

Longitudinal water barrier:
The longitudinal water barrier shall be applied over insulation screen by a layer of non woven synthetic tape with suitable water swellable absorbent.

Radial Moisture Barrier:
This shall be of extruded corrugated aluminium sheath.

1.13 METALLIC SCREEN:

The metal sheath shall consist of a tube of corrugated aluminium of at least 99.5% purity. The thickness of the corrugated aluminium sheath shall be designed to meet the requirement of the system short circuit rating as specified in **the bidding documents**.

The sheath shall be continuously extruded, of uniform thickness and homogeneous construction, close fitting, seamless and free from defects.

A thin layer of bitumen or other suitable anti-corrosion compound shall be applied over the aluminium sheath.

1.14 OUTER SHEATH

The outer sheath shall consist of extruded black coloured HDPE with graphite coating. The outer sheath shall be suitably designed by the addition of chemicals in the outer sheath for protection against termite and rodent attack and shall be coated with graphite.

1.15 RATING

The contractor/ manufacturer shall declare current rating of cable for maximum conductor temperature of 90 degree C under continuous operation and 250 degree C during short-circuit condition. The contractor/ manufacturer shall also declare over load curve with duration for conductor temperature of 105 Deg C. A complete set of calculation made in arriving at the current rating shall be furnished, for laying condition envisaged under the project, during detailed engineering for Employer/Employer's reference.

1.16 CABLE JOINTING ACCESSORIES

4.16.2 The cable jointing accessories shall include all the straight through joints, Cross bonding, earth continuity cables, Link boxes, Sheath Voltage Limiters (SVLs) etc as required for entire cable route. Bidder shall arrange all special tools and tackles required for making these joints at his own cost. **Unless specified separately** in BPS, **cable end terminating kits** shall be deemed included as part of cable jointing accessories.

4.16.3 The straight through joint shall preferably be built up from the same material as the main cable and shall have electrical and mechanical withstand capabilities same as or better than the main cable. The joints shall be suitable for tropical conditions as specified in **Section-Project**.

4.16.4 The straight through joints and cable end terminations shall be of proven design and should have been type tested as per relevant IEC. A list of supply of cable jointing accessories which are in successful operation in projects, shall be furnished.

4.16.5 The detailed description on jointing procedure shall be furnished during detailed engineering.

4.16.6 The cable end terminations shall be of anti-fog type and shall be of Polymer type/Porcelain type suitable for withstanding the climatic conditions with required Creepage distance as specified in **bidding documents**. The cable end terminals for terminating the cables shall be complete with accessories & fully compatible with the cables to be supplied. The terminations shall also be capable to withstand mechanical forces during normal and short circuit operations.

4.16.7 The cable end terminations envisaged for **mounting on Transmission Line (T/L) Towers** shall necessarily be of Composite Polymer type to reduce the weight on T/L towers. The cable end terminations envisaged for **GIS interface,** shall comply to IEC 60840. It will be the responsibility of the contractor to ensure smooth interface with GIS equipment.

2 CABLE DRUMS

2.1 Cables shall be supplied in returnable steel drums of heavy construction of suitable size and packed conforming to applicable standards.

2.2 Standard drum lengths for manufacturing shall be finalised during detailed engineering. Each drum shall carry the manufacturer's name, the employer's name, address and contract number and type, size and length of the cable, net and gross weight stencilled on both sides of drum. A tag containing the same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

2.3 Packing shall be sturdy and adequate to protect the cables from any injury due to mishandling or other conditions encountered during transportation, handling and storage. Both cable ends shall be sealed with PE/Rubber caps so as to eliminate ingress of water during transportation and erection.

3 TESTS ON CABLES

All XLPE insulated EHV cables shall conform to all Type, Routine and Acceptance tests listed in the relevant IEC & shall submit the type test reports for Employer’s approval. If specified in Section-Project, Type tests shall be carried out on the EHV cable as per relevant standard.

4 TESTS ON ACCESSORIES

Contractor shall submit type test reports for accessories, as per IEC 60840:1999/ IEC 62067 for Employer’s acceptance. Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Section: GTR for Employer’s acceptance.

5 TESTS AFTER INSTALLATION

All tests on cable system as prescribed in IEC 60840:1999/IEC 62067 (as applicable) shall be performed after installation.

FLEXIBLE PIPES FOR XLPE Cable

a) General

The flexible conduit pipe of 125 mm or higher diameter, corrugated hard polyethylene pipe shall be used for installation of XLPE power cable. The flexible pipe shall be buried before the cable installation and, then the cables shall be pulled in.

b) Requirement

The flexible conduit pipe shall be of polyethylene and shall be strong enough to withstand the compression force from heavy trucks or lorries when it is buried more than 80 cm below the ground level and temperature rise up to 800 degree Celsius.
The pipe's projected cross section shall be practically rounded.
The pipe shall be corrugated to get flexibility.
The colour of the pipes shall be black.

b) Accessories

The flexible conduit pipe shall be provided with necessary accessories, such as joints and sealing material etc. The straight joint sleeve shall be made of high density polyethylene black coloured and to be so designed as to be screwed on to flexible pipe.
Bell mouth shall be fixed to the end of corrugated pipe to facilitate cable pulling in. The bell mouth shall be so designed as to screwed into the pipe. It shall be made of hard density polyethylene and colored black.
Water proof materials for pipes in manhole shall be mounted to an outlet of duct to keep the water tightness.
The waterproof materials shall be comprised the components such as sand-proof seal, sealing tape, neo seal compound, VUL-CO tape, PVC tape and other necessary materials to complete the specified scope of works.

6 LAYING AND INSTALLATION

6.1 The bidder is advised to visit the site and acquaint themselves with the topography, infrastructure etc. The contractor shall be fully responsible for providing all equipment, materials, system and services specified or otherwise which are required to complete the erection and successful commissioning of XLPE cables in all respects.

6.2 Cables shall be laid in the trench throughout the route. Further, as per requirement of the field, the cables shall also have to be laid in the followings (with prior approval of employer):

a. In ducts
b. In HDPE pipes (pipes to be filled with sand/suitable material after cabling)
c. In air at terminations
d. At varying depths due to obstructions
e. As per approved drawings

6.3 At places where the cables cross private roads, gates of residential houses or buildings, the cables shall be laid in HDPE pipes of adequate strength.

6.4 Concrete trenches with precast covers may be used in exceptional cases in smaller portions, wherever bending of cables are involved and HDPE pipes can't be laid.

6.5 The arrangement of laying the cable en-route shall be submitted by contractor during detailed engineering for Employer's acceptance.

7 TRENCHING

7.1 The cable trench work involves earth excavation for cable trench, back filling and removal of excess earth from site. The work site shall be left as clean as possible.

7.2 The trench shall be excavated using manual /mechanical modes as per field conditions. Most main roads are of asphalt surface and some of the roads with cement concrete surface. The sides of the excavated trenches shall wherever required, be well shored up.

7.3 Where paved footpaths are encountered, the pavement slabs shall be properly stored and reinstated. Identification markers of other services shall be properly stored and restored. The excavated material shall be properly stored to avoid obstruction to public and traffic movement.

7.4 Suitable barriers should be erected between the cable trench and pedestrian/ motorway to prevent accidents. The barriers shall be painted with yellow and black or red and white coloured cross stripes. Warning and caution boards should be consciously displayed. Red lights as warning signal should be placed along the trench during the nights.

7.5 The bottom of the excavated trench should be levelled flat and free from any object which would damage the cables. Any gradient encountered shall be gradual.

8 TREFOIL/FLAT FORMATION

Cables shall be laid in trefoil/flat formation **(as per bidding documents)** for entire route. The contractor shall submit drawings and arrangements for Employer approval.

9 CABLE HANDLING

The inspection of cable on receipt, handling of cables, paying out, flaking, cushioning with sand or sieved compacted soil, back-filling, reinstatement of road surfaces, providing and fixing joint markers, route indicators, precautions of joint holes, sump holes and all necessary precautions that are required shall be carefully planned and in accordance with acceptable standard practices/statutory requirements.

10 DAMAGE TO PROPERTY

The contractor shall take all precautions while excavation of trench, trial pits etc., to protect the public and private properties and to avoid accidental damage. Any damage so caused shall be immediately repaired and brought to the notice of the concerned and to the Employer. The contractor shall bear all responsibilities and liabilities and shall bear all costs of the damages so caused by him or by his workman or agents.

11 CABLE ROUTE MARKERS/CABLE JOINT MARKERS

Permanent means of indicating the position of joints and cable route shall be fabricated supplied and erected as per approved drawings.

Markers provided shall be as per the field requirement, if the route passes through open fields, markers should be conspicuously visible and above ground surface.

The marker should incorporate the relevant information such that the name of the Employer, voltage, circuit and distance of cable from the marker.

12 DEPTH OF LAYING OF CABLES

Depth of laying shall be as per drawing enclosed with Specification. Laying at varying depths due to obstructions/site conditions may be accepted in extreme cases with prior approval of Employer during detailed engineering.

13 PAYING OUT THE CABLE

The excavated cable trench shall be drained of all water and the bed surface shall be smooth, uniform and fairly hard before paying out the cable. The cable shall be rolled in the trench on cable rollers, spaced out at uniform intervals. The paying out process must be smooth and steady without subjecting the cable to abnormal tension. The cable on being paid out shall be smoothly and evenly transferred to the ground after providing the cushion. The cables shall never be dropped. All snake bends shall be straightened. Suitable size cable stocking pulling eye shall be used for pulling the cable. While pulling the cable by winches or machines, the tension/ loading shall be monitored by tension indicator and shall not exceed the permissible value for the cable. The cable laying shall be performed continuously at a speed as recommended by manufacturer.

The cable end seals shall be checked after laying and if found damaged shall immediately be resealed. Sufficient number of heat shrinkable cable end sealing caps shall be stocked at site stores for testing and jointing work. The integrity of the outer sheath shall be checked after the cable is laid in position.

14 SAND BEDDING

The cable shall be completely surrounded by well-compacted cable sand to such a thickness and of such size that the cable is protected against damage (applicable where cables are not to be laid in pipes).

15 SNAKING

Snaking shall be done at necessary places recommended by manufacturer with prior approval of Employer.

16 THERMAL BACKFILL

If specifically mentioned in Section-Project, Thermal Backfilling shall be carried out based on the evaluation of soil thermal resistivity along the cable route and after approval from the Employer the contractor shall design, specify, supply, lay and monitor the installation of thermal backfill surrounding the cables. Thermal back fill shall be of thermal resistivity of 1.20 Km/W or better.

17 IMMEDIATE ENVELOPE TO CABLE

The option on the use of the material that immediately envelopes the cable viz., thermal backfill or sand or sieved native soil rests with the Employer/Employer. The contractor shall seek prior approval on the use of the envelop material from the Employer/Employer before execution of the works.

18 BACK FILLING

Normally back filling shall consist of the material earlier excavated. However, bigger stones or pieces of rock should be removed.

19 WARNING TAPE

A pre-warning, Red colour plastic/ PVC tape, of atleast 250 mm wide 100 microns thick, shall be laid at approx. 0.4 m above the cable specified depth, throughout the cable route.

The tape shall carry the legend printed in black continuously as under CAUTION; EMPLOYER, VOLTAGE CLASS of CABLES.

20 PREVENTION OF DAMAGE DUE TO SHARP EDGES

After the cables have been laid in the trench and until the cables are covered with protective covering, no sharp metal tool shall be used in the trench or placed in such a position that may fall into the trench. Straight and curved rollers used shall have no sharp projecting parts liable to damage the cable. While pulling through pipes and ducts, the cable shall be protected to avoid damage due to sharp edges. The cables shall never be bent, beyond the specified bending radius.

21 ROAD, RAIL & CANAL CROSSINGS

21.1 The road cutting, whether cement concrete asphalt or macadam road surface; Railway track crossing and canal crossing shall be taken after obtaining approval for cutting/crossing from the concerned authorities i.e. civic authorities, traffic police, telephone authorities, Railway authorities, Irrigation deptt etc., and work should be planned to be completed in the shortest possible time. Where necessary the work shall be planned during night or light traffic periods. HDPE pipes shall be used for crossing. HDPE pipes diameter should not be less than 1.5 times the cable diameter.

21.2 **Trenchless Digging**:

It is envisaged that trenchless digging shall be used for crossing the National highways, Railway tracks and Canals etc. and the same shall be in the scope of bidder. Trenchless digging shall also be used where the concerned authorities do not permit open cut method and it is essentially required to carry out for installation of underground cables. The trenchless digging methods shall generally conform to ITU-T L.38. The various methods of trenchless digging such as hand/ manual auguring (up to 15m), impact moling (from 16m to about 40-50m), HDD (above 40-50m) shall be adopted based on the soil/site conditions and the requirement. The exact method for trenchless digging shall be finalised during detail engineering as per actual site/soil condition. The equipment used for HDD shall be capable of drilling at least 100m at one go. The contractor shall propose the exact methods and procedures for implementation of trenchless digging at various crossings taking into consideration the following guidelines, for approval by the Employer.

a) Excavation and backfilling of trial pits and verification of soil condition
b) Excavation of entry and Exit pits
c) Erection of drill machine for Drilling of pilot hole
d) Placement and driving hand augur
e) Placement and carrying out impact moling
f) Reaming and widening of bore holes in steps (if required)
g) Pulling of product pipe

22 FOOTPATH CUTTING

The slabs, kerbstones, on the roads shall be removed and reinstated without damage.

23 REINSTATEMENT

After the cables and pipes have been laid and before the trench is backfilled all joints and cable positions should be carefully plotted and preserved till such time the cable is energized and taken over by the Engineer in charge. The protective covers shall then be provided, the excavated soil riddled, sieved and replaced. It is advisable to leave a crown of earth not less than 50 mm and not more than 100 mm in the centre and tapering towards the sides of the trench.

The temporary reinstatement of roadways should be inspected at regular intervals, more frequently in rainy season and immediately after overnight rain for checking settlement and if required the temporary reinstatement should be done.

After the subsidence has ceased the trench may be permanently reinstated and the surface restored to the best possible condition.

24 MANHOLES

Manholes shall be provided at every proposed joint location for jointing bays. The bidder shall identify the location of the joint bays after carrying out detailed survey of the cable route and excavation of the trial pits. The delivery lengths of the cables shall match the location.

The Contractor shall get inspected, by a representative of the Employer, all manholes before carrying out the backfilling. Pipe & cable sealing, installation of joint box and cable service loops as per approved drawings shall be visually inspected and checked for tightness.

The contractor shall submit design and drawing of joint bay including manholes for withstanding a live load of 20 ton vehicle plus 30% for impact from moving vehicle. The Contractor shall propose a suitable procedure for testing the manhole for approval by the Employer. Manholes type approved by the Employer only shall be acceptable. The manhole shall include sufficient number of suitable entries.

25 TOOLS AND PLANTS

The successful bidder shall arrange, at his own cost, all necessary tools, plant and equipment to carry out the survey and cable installation work. The bidders are instructed to give all the details of equipment at their disposal, to carry out the work successfully and speedily.

26 BENDING RADIUS

The minimum bending radius of XLPE insulated cables shall be 20XD where “D” means the Outer diameter of the cable.

27 JOINTING AND TERMINATION OF CABLES

The cable jointing personnel and his crew shall have good experience in the type of joints and terminations that are used. The jointing work shall commence as soon as two or three lengths of cables have been laid. All care should be taken to protect the factory-plumbed caps/ seals on the cable ends, and the cable end shall be sealed whenever the end is exposed for tests.

Jointing of cables in carriage ways, drive ways under costly pavings, under concrete or asphalt surfaces and in proximity to telephone cables and water mains should be avoided whenever possible.

Sufficient over lap of cables shall be allowed for making the joints.

The joint bay should be of sufficient dimensions to allow the jointers to work with as much freedom of movement and comfort as possible. Sufficient space should be kept below the cable to be jointed.

The joints of different phases shall be staggered in the jointing bay.

27.1 SUMPHOLES

When jointing cables in water logged ground or under unforeseen rainy conditions, a sumphole should be made at one end of the joint bay, in such a position so that the accumulated water can be pumped or baled out by buckets, without causing interference to the jointing operation.

27.2 TENTS/COVERS

An enclosure or suitable protection cover shall be used in all circumstances wherever jointing work is carried out in the open, irrespective of the weather conditions. The joint shall be made in dust free, moisture free and clean atmosphere.

27.3 PRECAUTIONS BEFORE MAKING A JOINT

The cable end seals should not be opened until all necessary precautions have been taken to prevent circumstances arising out of rainy/ inclement weather conditions, which might become uncontrollable.

If the cable end seals or cable ends are found to have suffered damage the cables should not be jointed, without tests and rectification.

27.4 MEASUREMENT OF INSULATION RESISTANCE

Before jointing, the insulation resistance of both sections of cables shall be checked.

27.5 IDENTIFICATION

The identification of each phase, shall be clearly and properly noted. The cables shall be jointed as per the approved design. Each cable shall have identification for phase at joint bays.

27.6 MAKING A JOINT

Comprehensive jointing instructions should be obtained from the manufacture of jointing kits and meticulously followed.

The materials used in the joints like ferrules, screen/sheath continuity bonds, lugs etc., shall be of good quality and conform to standards.

The jointing tools shall be appropriate and as per the requirement of jointing EHV XLPE cables.

28 CABLE LAYING & TERMINATIONS

The preparation of the cable end for installing the terminations and the precautions to be taken before fixing the terminations shall be followed as in the case of the cable jointing procedures. The instructions furnished by the termination manufacturer shall be strictly followed.

At cable terminating end, the following provisions for supply and erections are to be included:

(i) A sufficient length of spare cable shall be left in the ground, for future needs.
(ii) The rise of the cable immediately from the ground shall be enclosed in PVC/PE pipe of suitable diameter to protect against direct exposure to the sun.

(iii) The cable shall be properly fastened using non-metallic clamps.
(iv) Appropriate labels shall be fixed identifying the phase circuit, voltage and date of commissioning etc., on the cable supporting structure.
(v) The sealing end shall be mounted on pedestal insulators to isolate them from their supporting steel work.
(vi) Protection from contact with the exposed metal work at the termination shall be provided by resin bonded glass fibre shroud.
(vii) Providing earth stations with all required materials, like leads, connectors etc. Earth pits shall conform to IS–3043:1987 (Code of practice for earthing)/ or equivalent International standards.

29 BONDING OF SCREEN/ SHEATH

The screens/sheath shall be cross-bonded under each segment of specified route in accordance with IS-3043 (Code of practice for earthing) or applicable International codes & practices. The bidder shall offer complete cable system in order to limit maximum sheath voltage in accordance with relevant standards and furnish complete set of calculations in support of the same. The screen/sheath shall be connected to the earth stations/ earth pits through disconnecting type link boxes & through Sheath Voltage Limiter (SVL) as required.

All required materials used in the Cross bonding, termination of earth continuity cable, Link box, SVL etc to comply with specification/statutory requirements shall be in the scope of bidder and should be of good quality and compatible with the cable.

30 CONNECTION OF RADIAL WATER BARRIER AND CABLE SCREEN

If the metallic radial water barrier is insulated from the metallic wire screen, a connection suitable to carry the currents occurring during operation must be installed between metallic radial water barrier of the cable and metallic wire screen in joints and sealing ends.

31 CABLE TERMINATING STRUCTURES

31.1 The terminating structure being supplied, should be designed as per the project requirement for the cable end terminations i.e. for Standalone Outdoor AIS terminations, GIS end terminations and Transmission line Tower end terminations as per requirement specified in BPS.
31.2 The mounting structure shall be fixed on the reinforced cement concrete foundation, the design & drawings of which shall be submitted to Employer for review & acceptance during detailed engineering.
31.3 The mounting structure includes the supports for cable end boxes, link boxes and any other item required for the intent of the contract. All steel sections used shall be free from all imperfections, mill scales, slag intrusions, laminations, fillings, rust etc. that may impair their strength, durability and appearance. All materials shall be of tested quality only unless otherwise permitted by the Employer. The steel for mounting structure shall confirm to IS-2062 (latest).
31.4 In case of cable terminations on transmission line towers, the cable termination kit, LA, Link Box, SVL etc shall be fixed suitably on the tower for which necessary interface details shall be coordinated for Tower design during detailed engineering. After fixing the end terminations, the cable shall be suitably fixed to the tower members, with non-magnetic material clamps to the required height securely. The cable in air shall be suitably protected using HDPE pipes up to certain height.
31.5 In case of GIS end terminations, the structure & foundations shall be suitably designed in coordination with GIS terminations during detailed engineering.

32 MEASUREMENT (for Civil Works)

The buried cable trench shall be measured in the running meters including excavation, back filling, thermal back filling (if applicable), compaction, laying of concrete/

reinforcement, placing of warning tap markers, dewatering as required as per the drawing & specification & any other job required for successful completion of work.

33 DISTRIBUTED TEMPERATURE MONITORING SYSTEM (DTS)

The bidder shall include and provide separate “Distributed Temperature Monitoring System (DTS)” for entire route for EHV cables complete in all respects along with terminal coupling equipment, workstation and all required hardware & software for real time monitoring of conductor temperature profile and to provide load predictions. The offered system should be able to provide maximum possible transmission capacity of the cable for each circuit. The distributed temperature monitoring system shall be optical fibre based, must be of proven technology and should be in operation for similar use along with EHV cables as per latest practices. The “terminal coupling equipment” and “workstation” shall preferably be microprocessor based with HMI, for displaying temperature along the length of the cable system. System shall provide potential free output contact for signalling to SCADA. The bidder shall provide brochures and catalogues for offered distributed temperature monitoring system along with the bid.

Optical fibre cables along with all jointing accessories etc required for DTS shall also be included in the scope of bidder. Optical fibre cables associated with DTS shall be laid in the same EHV cable trench.

34 OPTICAL FIBRE CABLE (For Communication Equipments)

If specified in the bidding documents, Optical fibre cable required for Communication Equipments shall also be laid in the same cable trench in separate HDPE pipe.

SECTION 23

TECHNICAL DATA SHEET

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.1: 45MVA POWER TRANSFORMER **Sheet 1 of 6**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
				132/11kV, 45MVA
1	**Manufacturer and Country of Origin**			
2	**Year of manufacturing experience**	Years	7	
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC	
5	**Type**		Outdoor, oil immersed, Core Type	
6	**Winding / Phase**		Three	
7	**Cooling**		ONAN	
8 8.1 8.1.1 8.1.2	**Ratings** Rated MVA ONAN ONAF	 MVA MVA	 45	
8.2 8.2.1 8.2.2 8.2.3	Rated Voltage Primary Secondary Tertiary(If Provided)	 kV kV kV	 132 11	
8.3 8.3.1 8.3.2 8.3.3	Maximum Voltage Primary Secondary Tertiary (If Provided)	 kV kV kV	 145 12	
8.4	**Number of Phases**		Three	
8.5	**Rated Frequency**	Hz	50	
9	**Noise Level** On ONAN Rating On ONAF Rating Rated Voltage	 dB dB	 <73 <75	
10	**Temperature Rise**			
10.1	Temperature Rise above 45°C ambient - In Oil by Thermometer - In Winding By Resistance	 °C °C	 50 55	
10.2	Hottest Spot Temperature in Winding Limited to	°C	55	
10.3	Temperature Indicators Make		KHILSTROM, Sweden or Equi.	
11 11.1	**Connection** High Voltage		 Star	
11.2	Low Voltage		Star	
11.3	Tertiary(if provided)		Delta	
11.3	Vector Group Ref in accordance with IEC 76		YNyn0	
	Vector Group		YNyn0 D11	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No. 2: 45MVA POWER TRANSFORMER **Sheet 2 of 6**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
				132/11kV, 45MVA
12	**Taps**			
12.1	Type of Tap changer		OLTC	
12.2	Tap Step		1.25%	
12.3	Tap Range		± 10%	
12.4	Nos. of Tap		17	
13	**Cooling Equipment (For ONAF)**			
13.1	Manufacturer/ Type			
13.2	Number of Fans Connected	Nos		
13.3	Rated Operating Voltage, Vac	Vac	230/400, 50Hz	
13.4	Rated Control Voltage, V	Vdc	110	
13.5	Rated Power	KW		
14	**OLTC Gear**			
14.1	Manufacturer / Type	MR, Germany, ABB, Sweden or Equivalent		
14.2	Rating - Rated Voltage - Rated Current - Step Voltage - Numbers of Steps	 KV A V Nos	 Suitable for 132kV class 17	
14.3	Control Suitable For - Remote / Local Operation - Auto / Manual Operation - Parallel Operation - Master Slave Operation	 Yes/No Yes/No	 Remote / Local Auto / Manual Yes Yes	
14.4	Rated voltage of Drive Motor	Vac	230/400 50Hz	
15	**Guaranteed losses**			
15.1	No Load Losses at Rated Voltage and Frequency on Max. MVA Base.	kW		
15.2	Load Losses ar rated Current and and at 75°C on max. MVA base	kW		
15.3	Cooler Losses for full load operation on max. MVA base	kW		
16	**Impedance at Rated Current and Frequency at 75°C Winding Temperatures on ONAF, MVA Base.** (Tolerance ±7.5% of the Declared Value)	%		
16.1	Positive Sequence Impedance at nameplate Normal tap	%	> 11	
16.2	Positive Sequence at Maximum Voltage Tap **(Tap 17)**	%		
16.3	Positive Sequence at Minimum Voltage Tap **(Tap 1)**	%		
16.4	Zero Sequence at Nameplate Tap			

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No. 2: 45MVA POWER TRANSFORMER **Sheet 3 of 6**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
				132/11kV, 45MVA
17	**Reactance** at rated current and Frequency at 75°C on Maximum MVA base at a nameplate tap			
18	**Efficiency at 75°C Winding Temperature at PF=0.9**			
18.1	At 100% Load	%		
18.2	At 75% Load	%		
18.3	At 50% Load	%	Above 99%	
19	**Load in Percentage** of Full Load and Power Factor at which maximum efficiency occurs.			
20	**Regulation at full Load and at 75C**			
20.1	At Unity Power Factor			
20.2	At 0.85 Power Factor Lagging			
21	**No Load Current in Percentage** of rated Current referred to HV and 50Hz.			
21.1	At 90% Rated Voltage	%		
21.2	At 100% Rated Voltage	%	<1	
21.3	At 110% Rated Voltage	%		
22	**Clearances**			
22.1	Minimum Clearances in air-HV/LV	mm		
22.2	Between Phases Between Phase and Earth	mm		
23	**Insulation Level**			
23.1	Power Frequency Withstand Voltage (1Min rms)			
23.1.1	Primary	kV	275	
23.1.2	Secondary	kV	28	
23.1.3	Tertiary (if Provided)	kV		
23.2	**Impulse Withstand Voltage**			
23.2.1	Primary	kV	650 (Crest)	
23.2.2	Secondary	kV	75 (Crest)	
23.2.2	Tertiary (if Provided)	kV		
24	**Details of Oil Preservation System**			
24.1	Type		Conservator Type	
24.2	Details of Oil Preservation System			
24.3	If Conservator Type, Urethane Air Cell provided	Yes/No	Yes	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No. 2: 45MVA POWER TRANSFORMER **Sheet 4 of 6**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
				132/11kV, 45MVA
24.4	Volume of Conservator	Cu.m		
24.5	Volume of Oil Between the highest and Lowest Levels	Ltrs		
25	**Pressure Relief Device** Min. pressure setting	Kg/cm2		
26 26.1	**Details of Bushings HV / LV / Neutral** Manufacturer / Type			
26.2	Voltage class	KV	145/12	
26.2	Creepage Distance	mm	25mm/kV	
26.3	Weight of Bushing	kg		
26.4	Standard Reference		IEC	
26.5	Dry Flash over Voltage	KV	275/28	
26.6	Wet Flash Over Voltage	KV	275/(28	
26.7	Impulse Withstand Voltage	KV	650/75	
27	**Insulating Oil**			
i	**Manufacturer and Country of Origin**			
ii	**Manufacturer's type designation**			
iii	**Type**		Insulating Oil	
iv	**Applicable standard**			
v	**Technical Specifications**			
v.1	Dielectric Breakdown Strength (Min) at 2.5mm gap	kV	30	
v.2	Flash Point (Min)	°C	135	
v.3	Density at 20ºC (Max)	g/Cu.cm	0.895	
v.4	Viscosity at 40ºC (Max)	mm^2/s	12	
v.5	Viscosity at -30ºC (Max)	mm^2/s	1800	
v.6	Acidity Neutralization Value (Max)	mgKOH/g	0.01	
v.7	Sludge Value (Max)		0.1%	
v.8	Pour Point (Max)	°C	-40 C	
v.9	Corrosive Sulphur		Non-corrosive	
v.10	Water Content (Max)	ppm	40	
v.11	Dielectric Dissipation factor at 90 (Max)		0.005	
v.12	Appearance		clean free from sediment and suspended matter	
vi.	PCB Content		Not Detectable	
vii.	Approx. volume of Oil, ltrs			
Viii	Whether First filled of Oil with 5% excess provided	Yes/No	Yes	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No. 2: 45MVA POWER TRANSFORMER **Sheet 5 of 6**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
28	**Core Material**			***132/11kV, 45MVA***
28.1	Maximum flux density at rated voltage on principal tapping and rated frequency:			
	Transformer legs	T		
	Transformer yokes	T		
28.2	Maximum flux density at 110% voltage			
	Transformer legs	T	< 1.9	
	Transformer yokes	T	< 1.9	
28.3	Grade of core used	Prime core		
	Type of Core	CRGO		
	Thickness of core lamination			
	Rated Loss per kg			
29.1	Maximum current density in windings at rated output:			
	Primary (HV)	A/mm^2		
	Secondary (LV)	A/mm^2		
	Weight of copper in windings:			
	Primary (HV)			
	Secondary (LV)			
30	**Bushing Current Transformers**			
30.1	Numbers of Cores - HV - LV - Neutral	 Nos Nos Nos	 1 / phase 1 / phase 1	
30.2	Accuracy class / Burden/Ratio - HV / HV Neutral - LV / LV Neutral		 PS / 15VA/200/1 PS / 15VA/2400/1	
31	**Lightning Arrestor mounted on** - HV - LV	 Yes/No Yes/No	 No Yes	
32	**RTCC Panel Details**			
32.1	AVR make / Model	MR, Germany, ABB, Sweden or Equivalent		
32.2	Annunciator 12 Windows provided	Yes/No	Yes	
32.3	Indicating Voltmeter	Yes/No	Yes	
32.4	Facilities and Provision as per specification provided?	Yes/No	Yes	
33	**Approximate Overall Dimension (L x W x H)**			

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No. 2: 45MVA POWER TRANSFORMER **Sheet 6 of 6**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
34	**Approximate Weights**			
34.1	Core and Coil	Kg		
34.2	Tank and fittings	Kg		
34.3	Oil	Kg		
34.4	Total Weight	Kg		
35	Delivery of Equipment in Months, following the Award of Contract (Allowing the time for Drawing Approval)		Months	
36	Is manufacturer ISO 9001 holder?	Yes/No	Yes	
37	Type test certificate submitted?	Yes/No	Yes	
38	Has manufacturer exported units?	Yes/No	Yes	
39	User's certificate submitted?	Yes/No	Yes	
40	Technical literature / drawings submitted?	Yes/No	Yes	

NOTE: The bidder must submit the user certificate of the manufacturer of Transformer.

Deviations from technical requirements:

Signed…… As representative for……

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.2: 630kV STATION TRANSFORMER **Sheet 1 of 1**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
1	Manufacturer and Country of Origin			
2	Rated power	kVA	630	
3	Rated voltage		IEC	
4	Voltage rating			
	a) Primary	kV	11	
	b) Secondary	V	400	
5	Max system Voltage			
	a) Primary	kV	12	
	b) Secondary	V	440	
6	Conection -Primary / secondary		Delta /Y	
7	Cooling		ONAN	
8	Vector group		Dyn 11	
9	Rated impedance voltage		5 %	
10	Withstand Voltage -Primary -Secondary	 kV kV	 75 3	
11	BIL of winding (primary)	kV	75	
12	Off circuit tap changer		+/- 5%	
13	Max. noise level	dB	44	
14	No load loss	W		
15	Load loss	W		
16	Applicable standard		IEC	
17	**Approximate Overall Dimension (L x W x H)**			
18	**Approximate Weights**			
18.1	Core and Coil	Kg		
18.2	Tank and fittings	Kg		
18.3	Oil	Kg		
18.4	Total Weight	Kg		
19	Delivery of Equipment in Months, following the Award of Contract (Allowing the time for Drawing Approval)		Months	
20	Is manufacturer ISO 9001 holder?	Yes/No	Yes	
22	Technical literature / drawings submitted?	Yes/No	Yes	

Deviations from technical requirements:

Signed…… As representative for……

Address…… Date ……

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.3 : 132kV GIS (132kV CIRCUIT BREAKER) **Sheet 1 of 2**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
				132kV
1	**Manufacturer and Country of Origin**			
2	**Year of manufacturing experience**	Years	7	
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC	
5	**Type**		GIS	
6	**Poles**		Three pole	
8	**Rated Voltage**	kV	132	
9	**Rated current**			
9.1	Continuous at 50 degree ambient	A	1250 2000 (B/C)	As per PSR
9.2	Short time for 1 sec at max. kV	kA	31.5	
10	**Frequency**	Hz	50	
11	**Temperature rise above 45 degree C ambient**		As per IEC	
11.1	Contacts	°C	65	
11.2	Terminals	°C	65	
12	**Rated short circuit breaking current**	**kA**	**31.5**	
13	**Rated short circuit making current**			
13.1	Peak	kA	80	
14	**Interrupting time at 100% capacity**			
14.1	Maximum opening time	mS		
14.2	Total interrupting time	mS		
15	**Closing time**	mS		
17	**Maximum capacitive current breaking capacity (rms)**	A		
18	**Insulation level**			
18.1	Impulse withstand voltage (crest)	kV	650	
18.2	Power frequency withstand voltage	kV	275	
19	**Operating mechanism**			
19.1	Type		Spring operated	
19.2	Number of mechanism per breaker		1	
19.3	Single/three phase auto-reclosure		3	
19.4	Operating voltage of closing and tripping coil	V DC	220	
19.5	Operaing voltage range -Closing -Tripping	% of rated voltage	 85-110% 70-110%	
19.6	Closing and tripping current	A		
19.7	Spring charging motor rating -Capacity -Rated voltage	 kW V	 220V DC	
19.8	Time required by motor to charge the spring completely	Sec	<30	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No. 3a : 132kV GIS (132kV CIRCUIT BREAKER) **Sheet 2 of 2**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
				132kV
20	Anti pumping device provided	Yes/No	Yes	
21	Trip-free feature provided	Yes/No	Yes	
22	**Number of N.C. contacts**	No.	8	
23	**Number of N.O. contacts**	No.	8	

ITEM No. 3b: 132kV DISCONNECTING SWITCH & EARTH SWITCH				
	DESCRIPTION	**UNIT**	**NEA REQ**	**DATA to be Filled**
			132kV	**132kV**
1	**Applicable standard**		IEC	
2	**Type**		3 pole group operated	
4	**Rated Voltage**			
4.1	Nominal	kV	132	
4.2	Maximum	kV	145	
5	**Rated current**			
5.1	Continuous at 50°C ambient	A	1250 / 2000	
5.2	Short time for 1 sec at max. kV	kA	31.5	
6	**Temperature rise above 45 degree C ambient at normal rated current**		As per IEC	
6.1	Contacts	°C		
6.2	Current carrying parts	°C		
7	**Insulation level**			
7.1	Impulse withstand voltage(peak)	kV	650	
7.2	Power frequency withstand voltage (1min, rms)	kV	275	
13	**Main contacts**			
	- Material of fixed contacts		Provide	
	- Material of moving contacts		Provide	
	- Material of the contacts of the earthing switch		Provide	
19	**Auxiliary power supply**			
19.2	Control circuit	V, DC	220V DC	
19.3	Operating motor	V, phase	220V DC	
22	**Number of N.C. contacts**	No.	4 min	
23	**Number of N.O. contacts**	No.	4 min	
25	**Operating mechanism**		Motor & Manual Operated	
	Operating motor	W		
26	**Types of interlocks furnished**		Electrical and manual	
27	**Earthing Switch**			
27.1	Operating Mechanism		Manual and Motor Operated	
	Operating motor	W		
27.2	Type of Interlocks		Electrical and manual	
22	**Number of N.C. contacts**	No.	4	
23	**Number of N.O. contacts**	No.	4	
24	**Operating duty cycle**		O - 0.3sec – CO - 3min – CO	

ITEM No. 3c: 132kV CURRENT TRANSFORMER				
	DESCRIPTION	**UNIT**	**NEA REQ**	**DATA to be Filled**
			132kV	**132kV**
1.	**Type**		Indoor, Metal enclosed	
2.	**Number of cores in each CT**	NO.	5	
3.	**Rated Primary Voltage**			
3.1	Nominal	kV	132	
3.2	Maximum	kV	145	
4.	**Insulation level**			
4.1	Impulse withstand voltage(peak)	kV	650	
4.2.	Power frequency withstand voltage (1min, rms)	kV	275	
5.	**Short time thermal rating**	kA	31.5	
6.	**Rated Peak Short circuit Current**	kA	80	
7.	**Rated VA burden for each core**	VA	As per PSR	
8.	**Accuracy class**	5P20 for protection 0.2 for metering PS for diff / Bus		
9	**Current Ratio**	A	As per Technical Data in specification	
10.	**Overvoltage factor**		1.1	
11	**Rated continuous thermal current**		1.2x	

ITEM No. 3d: 132kV VOLTAGE TRANSFORMER				
	DESCRIPTION	**UNIT**	**NEA REQ**	**DATA to be Filled**
1	4. Applicable standard		IEC	
2	5. Type		Indoor Metal enclosed	
3	7. Rated primary voltage			
	a) Nominal	kV	132/√3	
	b) Maximum voltage	kV	145/√3	
4	8. Insulation level			
	a) Impulse withstand voltage (primary)	kV	650	
	b) Power frequency withstand (1 min. rms) (primary)	kV	275	
5	10. Rating			
	a) Voltage ratio	kV	132/√3: 0.11/√3	
	b) Rated burden	VA	50	
	c) Accuracy class		3P & 0.2 for metering	
	d) Overvoltage factor			
	- Continuous		1.1	
	- 30 seconds		1.5	
	h) Number of secondary windings		*2/ 3*	

ITEM No. 3e: 132 kV LIGHTNING ARRESTOR				
	DESCRIPTION	**UNIT**	**NEA REQ**	**DATA to be Filled**
			132kV	**132kV**
1	**Type**		Outdoor, gapless, Metal-Oxide	
2	**Voltage rating of L.A**	kV	120	
3	**Nominal discharge current**	kA	10	
4	**Surge counter with insulating base furnished**	Yes/No	Yes	
5	**Insulation level**			
	a)Impulse withstand voltage(peak)	kV	650	
	b)Power frequency withstand voltage (1min, rms)	kV	275	

3f: GAS INSULATED BUS				
1	**Bus arrangement formation**		Horizontal	
2	**Bus Duct Proposed**	1 or 3 Phase		

3g: GENERAL				
1	**Gas density detector provided**	Yes/No	Yes	
2	**Operation counter provided**	Yes/No	Yes	
3	**Space heater provided for cubicle**	Yes/No	Yes	
4	**Enclosure Protection**		IP55W	
5	**Number of possible operations without maintenance under:** Rated short circuit breaking current Rated normal current	 No No	 10 2000	
6	**Rated SF6 pressure**	kgf/cm2		
7	**Guaranteed SF6 losses/year**	kg	0.5% per Annum	
8	**Padlocking provision for local cubicle**	Yes/No	Yes	
9	UHF sensors for PD detection	Yes/No	Yes	
	Numbers of sensors			
10	**Total weight of the circuit breaker**	Kg		
11	**Mechanical dimension(LXWXH)**	mm x mm x mm		
12	**Delivery of equipment in months** following award of contract	(Allowing time for approval of drawing)		
13	Is manufacturer is ISO 9001 holder?	Yes/No	Yes	
14	Type test certificate submitted?	Yes/No	Yes	
15	Has manufacturer exported units?	Yes/No	Yes	
16	Technical literature / drawings submitted?	Yes/No	Yes	

Deviations from technical requirements:

Signed……. As representative for……

Address……. Date……

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.4: 132 kV LIGHTNING ARRESTOR **Sheet 1 of 1**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
			132kV	132kV
1	**Manufacturer and Country of Origin**			
2	**Year of manufacturing experience**	Years	5	
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC	
5	**Type**		Outdoor, gapless, Zinc-Oxide	
6	**Voltage rating of L.A**	kV	120	
7	**Nominal discharge current**	kA	10	
8	**Surge counter with insulating base furnished**	Yes/No	Yes	
9	**Minimum power frequency sparkover voltage**	kV		
10	**Maximum 1/50 impulse sparkover voltage**	kV		
11	**Maximum front wave sparkover voltage**	kV		
12	**Maximum switching surge sparkover voltage**	kV		
13	**Number of section per Pole**		1	
14	**Insulation level**			
	a)Impulse withstand voltage(peak)	kV	650	
	b)Power frequency withstand voltage (1min, rms)	kV	275	
15	**Porcelain creepage distance**	mm	3300	
16	**Earth terminal with accessories provided**	Yes/No	Yes	
17	**Delivery of equipment in months** following award of contract (Allowing time for approval of drawing)	month		
18	Is manufacturer is ISO 9001 holder?	Yes/No	Yes	
20	Has manufacturer exported units?	Yes/No	Yes	
21	Technical literature/drawings submitted?	Yes/No	Yes	

Deviations from technical requirements:

Signed……. As representative for……

Address……. Date……

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No5: 9 kV LIGHTNING ARRESTOR **Sheet 1 of 1**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
			33 kV	33 kV
1	**Manufacturer and Country of Origin**			
2	**Year of manufacturing experience**	Years	5	
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC	
5	**Type**		Outdoor, gapless, Zinc-Oxide	
6	**Voltage rating of L.A**	kV	9	
7	**Nominal discharge current**	kA	10	
8	**Surge counter with insulating base furnished**	Yes/No	Yes	
9	**Minimum power frequency sparkover voltage**	kV		
10	**Maximum 1/50 impulse sparkover voltage**	kV		
11	**Maximum front wave sparkover voltage**	kV		
12	**Maximum switching surge sparkover voltage**	kV		
13	**Number of section per Pole**		1	
14	**Insulation level**			
	a)Impulse withstand voltage(peak)	kV	28	
	b)Power frequency withstand voltage (1min, rms)	kV	75	
15	**Porcelain creepage distance**	mm	....	
16	**Earth terminal with accessories provided**	Yeas/No	Yes	
17	**Delivery of equipment in months** following award of contract (Allowing time for approval of drawing)	month		
18	Is manufacturer is ISO 9001 holder?	Yes/No	Yes	
19	Has manufacturer exported units?	Yes/No	Yes	
20	Technical literature/drawings submitted?	Yes/No	Yes	

Deviations from technical requirements:

Signed……. As representative for……

Address……. Date……

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.6, 11kV VACUUM SWITCHGEAR PANEL **Sheet 1 of 8**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
A	**SWITCHGEAR MANUFACTURER**			
1	**Manufacturer and Country of Origin**			
2	**Year of manufacturing experience**	Years	5	
3	**Manufacturing's Designation as per submitted catalogue**		To be furnished	
4	**Applicable standard**		IEC	
B	**BUSBAR**			
1	Material			
	-Incomer		Copper	
	-Outgoing feeder		Copper	
2	Size			
	a. Main bus	mm^2		
	b. Ground bus	mm^2		
3	Minimum Clearance			
	a. Phase to phase	mm		
	b. Phase to ground	mm		
4	Bus bar Rated Current			
	a. Continuous at 40 deg. C amb.	A	2500	
	b. Short time current for 3 sec	kA	25	
5	Rated Voltage	kV	12	
6	Bus Support Insulators			
	a. Manufacturer			
	b. Type			
	c. Impulse Withstand Voltage	kV	75	
	d. Power frequency withstand voltage(1 min. rms)	kV	28	
C	**CIRCUIT BREAKER**			
1	Manufacturer			
2	Type		Vacuum, with moving carriage	
3	Manufacturing's Designation as per submitted catalogue /Model No.		To be furnished	
4	Rated Voltage	kV	12	
5	Number of possible operation without maintenance			
	-Rated short circuit breaking current	No.	100	
	-Rated normal current	No.	10000	
	-For mechanism	No.	30000	
6	Frequency	Hz	50	
7	Rated current			
7.1	Continuous at 45 degree ambient Incomer Outgoing Buscoupler Trunking	 A A A A	 2500 1250 2500 2500	
7.2	Short circuit current for 3 sec.	kA	25	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.6 11kV VACUUM SWITCHGEAR PANEL **Sheet 2 of 8**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
8	**Vacuum Interrupter**			
	a. Make			
	b. Rating		2500 / 1250	
9	Rated short circuit breaking current (rms sym.)	kA	25	
10	Interrupting time	ms	60	
11	Rated short circuit making current			
11.1	Peak	kA	63	
12	Closing time, max	mS	120	
13	**Insulation level**			
	a. Impulse Withstand Voltage	kV	75	
	b. Power frequency withstand Voltage	kV	28	
14	**Operating Mechanism**			
	a. Type		Spring with motor charging	
	b. Operating voltage range -Closing -Tripping	% of rated voltage	 85-110% 70-110%	
	c. Closing and Tripping coils current	A		
	d. Duty cycle		CO-15sec -CO	
15	Spring charging motor			
	a. Type and Manufacturer			
	b. Voltage	**V**	220 V DC	
	c. Rating	kW	Spring operated	
	d. Time required by motor to charge the spring completely	sec	<30	
16	Total no. of auxiliary contacts			
	a. Normally open	No.	8	
	b. Normally closed	No.	8	
	c. Contact ratings(make and continuous current)			
	-AC at 230V	A	1	
	-DC inductive at 110 Volt	A	0.5	
17	Overall Dimension (L*W*H)	mm		
D	**CURRENT TRANSFORMER**			
1	Manufacturer			
2	Type		Cubicle mounted, epoxy resin	
3	Manufacturing's Designation as per submitted catalogue /Model No.		To be furnished	
4	Frequency	Hz	50	
5	Voltage Class	kV	12	
6	Reference standard		IEC	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.6 11kV VACUUM SWITCHGEAR PANEL **Sheet 3 of 8**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
7.1	- For Incomer / Buscoupler - Nos. of Core - Ratio / Class / Burden - Metering - Protection - Differential		 3 / 2 As specified in specs 0.5, 15VA 5P20, 15VA PS, 15VA	
7.2	For Outgoing Feeders - Nos. of Core - Ratio / Class / Burden - Metering - Protection		 2 As specified in specs 0.5, 15VA 5P20, 15VA	
8	Insulation level			
	a. Impulse Withstand Voltage	kV	75	
	b. Power frequency withstand Voltage	kV	28	
9	Continuous rated thermal current	A	1.5xIn	
E	**VOLTAGE TRANSFORMER**			
1	Manufacturer			
2	Type		Incomer Cubical mounted	
3	Manufacturing's Designation as per submitted catalogue /Model No.		To be furnished	
4	Frequency	Hz	50	
5	Voltage Class	kV	12	
6	Reference standard		IEC	
7	**Voltage Transformer for Incoming and Ring main Feeder** - Ratio - Accuracy Class - Burden	 kV VA	 11/√3/0.11/√3 0.5, 3P 50	
8	Insulation level			
	a. Impulse Withstand Voltage	kV	75	
	b. Power frequency withstand Voltage	kV	28	
9	Overall Dimension (L*W*H)	mm		
10	Weight	kg		
11	Fuses(HV/LV)			
	a) Type			
	b) Continuous ratings	A		
	c) Symmetrical fault rating	kV		

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.6 11kV VACUUM SWITCHGEAR PANEL **Sheet 4 of 8**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
	METERING INSTRUMENT			
1	**KWh Meter for Incomer and Outgoing Feeders**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital, 3-phase, 4 wire	
iii.	Applicable standard	IEC	IEC	
iv.	Accuracy class		0.5	
v.	Import and Export meter provided	Yes/No	Yes	
vi.	Rated voltage	V	110	
vii.	Rated current	A	1	
viii.	Operating current range	A	1-10	
ix.	Operating Voltage range	V	0-480	
x.	VA Burden Current Coil Voltage Coil	VA		
xi.	Test Impulse output provided	Yes/No	Yes	
xii.	Programmable at Site	Yes/No	Yes	
xiii.	Software and optical probe provided as per Price schedule & BOQ	Yes/No	Yes	
xiv.	Load profile can be downloaded	Yes/No	Yes	
2	**Ammeter**			
i.	Manufacturer and Country of Origin			
ii.	Type			
iii.	Accuracy class		0.5	
v.	Scale			
	-Range of indication For Incomer / Buscoupler For Outgoing Feeder	 A A	As required	
	-Overload range	%	1.5	
vi.	VA Burden			
3	**Voltmeter for Incomer Only**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital	
iii.	Accuracy class		o.5	
iv.	**Scale**			
	-Range of indication	kV	0-15	
v.	VA Burden			
4	**Watt Meter (MW)**			
i.	Manufacturer and Country of Origin			
ii	Type			
iii	Rated voltage	kV	$11/\sqrt{3} : 0.11/\sqrt{3}$	
iv	Rated current	A		
vi	Accuracy class		0.5	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.6, 11kV VACUUM SWITCHGEAR PANEL **Sheet 5 of 8**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
vii	Range of indication			
	- Incomer	MW	0-45/60	
	- Outgoing feeder	MW	0-10/20	
G	**ANNUNCIATORS**			
I	Manufacturer and Country of Origin			
ii.	Type			
vi.	Number of active points	No.	6	
ix.	Type of mounting		Flush	
x.	Replacement of individual inscription plates and lamps from front panel possible	Yes/No	Yes	
xi.	Sequence of operation as per specification	Yes/No	Yes	
H	**PROTECTIVE RELAYS**			
1	Manufacturer & country of origin			
2	Years of manufacturing service	Years	10	
3	Reference standard		IEC	
4	**Overcurrent Relays, (Non-Directional) for Outgoing Feeders / Buscoupler**			
i.	Manufacturer and Country of Origin			
ii.	Type		Numerical Non-Directional	
iii.	Manufacturer's type designation			
v.	No of Pole		Three	
vi.	Current setting range	% of rated current	20-250%	
vii.	Operating time at 10 times current setting	sec	3	
viii.	Reset time	mS		
ix.	Characteristics		IDMT(standard inverse)	
x.	Instantaneous unit provided -Current setting range -Operating range -NO Contacts	Yes/No % of rated current	Yes 200-2500%	
xi.	Insulating test according to IEC	Yes/No		
xii.	Indication -Hand reset flags provided -Light emitting diode provided	 Yes/No Yes/No		
xiii.	Auxilliary DC Supply	V	110	
xvi.	Technical literature submitted	Yes/No	Yes	
5	**Earth fault relays** (non directional) for Outgoing Feeders			
i.	Manufacturer and Country of Origin			
ii.	Type	Numerical/ Non-Directional		
iv.	Applicable standard			
vi.	Continuous overload capacity	x In		
vii.	Current setting range	%of In	10-100%	
viii.	Operating time at 10 times current setting	sec	3	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.6 11kV VACUUM SWITCHGEAR PANEL **Sheet 6 of 8**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
ix.	Characteristics		IDMT(standard inverse)	
x.	Instantaneous unit provided -Current setting range -Operating range -NO Contacts, Nos	Yes/No % of In	Yes 50-500%	
xi.	Insulating test according to IEC	Yes/No		
xii.	Indication -Hand reset flags provided -Light emitting diode provided	 Yes/No Yes/No		
xiii.	Auxilliary DC Supply	V	110	
xiv.	Technical literature submitted	Yes/No	Yes	
xv	Type test certificate submitted	Yes/No	Yes	
6	**Directional Phase Over current Relays for Incomer Panel**			
i.	Manufacturer and Country of Origin			
ii.	Type		Static (Numerical) Directional	
iii.	Manufacturer's type designation			
iv.	Applicable standard			
v.	Triple pole or single pole		triple	
vi.	Current setting range	% of rated current	50-200%	
vii.	Operating time at 10 times current setting	sec	3	
viii.	Reset time	mS		
	Contact rating at 125V DC	A		
ix.	Characteristics Characteristic Angle		IDMT(standard inverse), 45°	
x.	Instantaneous unit provided -Current setting range -Operating range -NO Contacts	Yes/No % of rated current	Yes 500-2000%	
xi.	Insulating test according to IEC	Yes/No		
xii.	Indication -Hand reset flags provided -Light emitting diode provided	 Yes/No Yes/No		
xiii.	Auxiliary DC Supply	V	110	
7	**DIRECTIONAL EARTH FAULT RELAYS for Incomer Panel**			
i.	Manufacturer and Country of Origin			
ii.	Type		Static (Numerical) / Directional	
iii.	Manufacturer's type designation			
iv.	Applicable standard			
v.	Triple pole or single pole		Single	
vi.	Continuous overload capacity	x In		
vii.	Current setting range	% of rated current	10-80%	
viii.	Operating time at 10 times current setting	sec	3	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.6 11kV VACUUM SWITCHGEAR PANEL **Sheet 7 of 8**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
ix.	Characteristics		IDMT(standard inverse), 45°	
x.	Instantaneous unit provided -Current setting range -Operating range -NO Contacts, Nos	Yes/No % of rated current mS	Yes 500-2000%	
xi.	Insulating test according to IEC	Yes/No		
xii.	Indication -Hand reset flags provided -Light emitting diode provided	 Yes/No Yes/No		
xiii.	Auxilliary DC Supply	V	110	
xvii.	Technical literature/drawings submitted?	Yes/No	Yes	
8	**Auxiliary Tripping & Lockout Relays**			
i.	Manufacturer and Country of Origin			
ii.	Type			
iii.	Manufacturer's type designation			
v.	Operating time	mS	<15	
viii.	Contact rating at 125V DC	A		
I	**EARTHING SWITCH**			
	- Type - Rating - Interlocking		Integrated Yes / No	
J	**SURGE ARRESTORS for Incomer** Type rating	 kA	 ZnO 9kV, 10kA	
K	**SWITCHGEAR ASSEMBLY**			
1	Type of Switchgear			
2	Enclosure			
	a. Type			
	b. Thickness of metal sheet(min)	mm	2	
	c. Degree of protection provided by the enclosure		IP4X	
3	Breaker assembly			
	a. Breaker provided with service test and withdrawn position	Yes/No	Yes	
	b. type of Indication provided for breaker position		LED	
	c. Cubicle door can be closed with breaker in service or test position	Yes/No	Yes	
4	Space Heater			
	a. Thermostat controlled space heater furnished for each cubicle?	Yes/No	Yes	
	b. Ratings			
	-Voltage	V, AC	230	
	-Watts			
5	Overall Mechanical dimension (LXWXH)	mm x mm x mm		
6	Approximate weight (complete panel)			

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.6 11kV VACUUM SWITCHGEAR PANEL **Sheet 8 of 8**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
7	Shipping dimension(LxWxH) of complete panel			
8	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)			
9	Type test certificate submitted?	Yes/No	Yes	
10	Has manufacturer exported units?	Yes/No	Yes	
11	User's certificate submitted?	Yes/No	Yes	
12	Technical literature/drawings submitted?	Yes/No	Yes	

Deviations from technical requirements:

Signed…… As representative for……

Address…… Date……

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No. 7: CONTROL AND RELAY PANEL FOR TRANSFORMER **Sheet 1 of 6**

	DESCRIPTION	UNIT		DATA to be Filled
1	**CONTROL AND RELAY PANEL TYPE**	**Duplex / Simplex**		
1.1	Manufacturer and Country of Origin			
1.2	Year of manufacturing experience	Years	5	
1.3	Manufacturing's Designation as per submitted catalogue			
5	**INDICATING INSTRUMENTS**			
5.1	**Ammeter**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital	
iv.	Accuracy class		0.5	
v.	**Scale**			
	-Type of scale			
	-Range of indication (……./1 Amp CT operated)	A	As required	
	-Overload range	%	1.5	
vi.	VA Burden			
vi.	Transducer operated	Yes/No	Yes	
5.2	**Apparent Power Meter (VA)**			
i.	Manufacturer and Country of Origin			
ii	Type		Digital	
iii	Rated voltage	kV	132/√3 : 0.11/√3	
iv	Rated current	A	……/1	
vi	Accuracy class		0.5	
vii	Scale		Centre zero	
	-Range of indication	MVA	As Required	
viii.	VA Burden Current Coil Voltage Coil			
x	Transducer operated	Yes/No	Yes	
5.3	**KWh Meter**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital, 3-phase, 4 wire	
iii.	Applicable standard	IEC	IEC	
iv.	Accuracy class		0.2	
v.	Import and Export meter provided	Yes/No	Yes	
vi.	Rated voltage	kV	132/√3 : 0.11/√3	
vii.	Rated current	A	……../1	
viii.	Operating current range	A		
ix.	Operating Voltage range	A		
x.	VA Burden Current Coil Voltage Coil	VA		

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.7: CONTROL AND RELAY PANEL FOR TRANSFORMER **Sheet 2 of 6**

	DESCRIPTION	UNIT		DATA to be Filled
xi.	Impulse contact provided	Yes/No	Yes	
xii.	Programmable at Site		Yes	
xiii.	Software and optical probe provided as per Price schedule & BOQ		Yes	
5.4	**Watt meter, MW**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital	
iii.	Accuracy class		0.5	
iii	Rated voltage	kV	132/√3 : 0.11/√3	
iv	Rated current	A	……/1	
	-Range of indication	MW	0-50-100	
5.6	**Annunciators**			
I	Manufacturer and Country of Origin			
ii.	Type			
iii.	Manufacturer's type designation			
iv.	Catalogue furnished	Yes/No	Yes	
vi.	Number of active points	No.	24	
vii.	Number of rows	No.	4	
viii.	Number of column	No.	6	
ix.	Type of mounting		Flush	
x.	Replacement of individual inscription plates and lamps from front panel possible	Yes/No	Yes	
xi.	Sequence of operation as per specification	Yes/No	Yes	
6	**PROTECTIVE RELAYS**			
6.1	**PHASE OVERCURRENT RELAYS**			
i.	Manufacturer and Country of Origin			
ii.	Type		Numerical Non Directional	
iii.	Manufacturer's type designation			
iv.	Applicable standard	IEC	IEC	
v.	Triple pole or single pole		Triple Pole	
vi.	Current setting range	% of rated current	20-200%	
vii.	Operating time at 10 times current setting	sec	3	
viii.	Reset time	mS		
ix.	Characteristics		IDMT(standard inverse)	
x.	Instantaneous unit provided -Current setting range -Operating range -NO Contacts	Yes/No % of rated current	Yes 500-2000%	
xi.	Insulating test according to IEC	Yes/No		
xii.	Indication -Hand reset flags provided -Light emitting diode provided	 Yes/No Yes/No		
xiii.	Auxiliary DC Supply	V_{dc}	110	
xiv.	Technical literature submitted	Yes/No	Yes	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.7: CONTROL AND RELAY PANEL FOR TRANSFORMER **Sheet 3 of 6**

	DESCRIPTION	UNIT		DATA to be Filled
6.2	EARTH FAULT RELAYS			
i.	Manufacturer and Country of Origin			
ii.	Type		Numerical, Non-Directional	
iii.	Manufacturer's type designation			
iv.	Applicable standard	IEC	IEC	
v.	Triple pole or single pole		Triple	
vi.	Continuous overload capacity	x In		
vii.	Current setting range	% of rated current	10-80%	
viii.	Operating time at 10 times current setting	sec	3	
ix.	Characteristics		IDMT(standard inverse)	
x.	Instantaneous unit provided -Current setting range -Operating range -NO Contacts, Nos	Yes/No % of rated current mS	Yes 500-2000%	
xi.	Insulating test according to IEC	Yes/No		
xii.	Indication -Hand reset flags provided -Light emitting diode provided	 Yes/No Yes/No		
xiii.	Auxiliary DC Supply	V_{dc}	110	
xvi.	Technical literature submitted	Yes/No	Yes	
6.3	**Directional Overcurrent Relay**			
i.	Manufacturer and Country of Origin			
ii.	Type		Numerical Directional	
iii.	Manufacturer's type designation			
iv.	Applicable standard	IEC	IEC	
v.	Triple pole or single pole		Triple	
vi.	Current setting range	% of rated current	20-200%	
vii.	Operating time at 10 times current setting	sec	3	
viii.	Reset time	mS		
ix.	Characteristics Characteristic Angle		IDMT(standard inverse), 45°	
x.	Instantaneous unit provided -Current setting range -Operating range	Yes/No % of rated current, mS	Yes 500-2000%	
xi.	Insulating test according to IEC	Yes/No		
xii.	Indication -Hand reset flags provided -Light emitting diode provided	 Yes/No Yes/No		
xiii.	Auxiliary DC Supply	Vdc	110	
6.4	**Directional Earthfault Relay**			
i.	Manufacturer and Country of Origin			
ii.	Type		Numerical Directional	
iii.	Manufacturer's type designation			

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.7: CONTROL AND RELAY PANEL FOR TRANSFORMER **Sheet 4 of 6**

	DESCRIPTION	UNIT		DATA to be Filled
iv.	Applicable standard	IEC	IEC	
v.	Triple pole or single pole		Triple	
vi.	Continuous overload capacity	xIn		
vii.	Current setting range	% of rated current	10-80%	
viii.	Operating time at 10 times current setting	sec	3	
ix.	Characteristics Characteristic Angle		IDMT(standard inverse), 45°	
x.	Instantaneous unit provided -Current setting range -Operating range	Yes/No % of rated current mS	Yes 500-2000%	
xi.	Insulating test according to IEC	Yes/No		
xii.	Indication -Hand reset flags provided -Light emitting diode provided	 Yes/No Yes/No		
xiii.	Technical literature submitted	Yes/No	Yes	
6.5	Transformer Differential relay			
i.	Manufacturer / Country of Origin			
ii.	Standard Reference	IEC	IEC	
iii.	Type of Construction			
iv.	Type		Numerical	
v.	Voltage Rating	V	110	
vi.	Type of Mounting		Flush	
vii.	Operating Time Setting, Sec	mS	<30	
viii.	Sensitivity Setting		20-50% x In	
ix.	Bias Setting			
x.	CT Ratio Compensating Range			
xi.	Burden for Current Circuit	VA		
xii.	DC Burden	VA		
xiii.	Tripping	A		
xiv.	Making current	A		
xv.	Closing Load (At 110V DC)	A		
6.6	**AUXILIARY TRIPPING & LOCKOUT RELAYS**			
i.	Manufacturer and Country of Origin			
ii.	Type			
iii.	Manufacturer's type designation			
iv.	Applicable standard	IEC	IEC	
v.	Operating time	mS	<15	
vi.	Does the lockout relay reset by the manually operated or electrically operated reset device			
vii.	Is the cut-off contact provided to interrupt the operating coil ?	Yes/No		
viii.	Contact rating at 125V DC	A		
xi.	Technical literature submitted	Yes/No	Yes	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.7: CONTROL AND RELAY PANEL FOR TRANSFORMER **Sheet 5 of6**

	DESCRIPTION	UNIT		DATA to be Filled
6.7	**Breaker Fail Lockout Relay, 86K**			
i.	DC VVoltage Rating, V	V	110	
ii.	Nos. of Electrically separate NO & NC Contacts			
6.8	**Breaker Failure Lockout Relay, 86BF & LBB Protection**			
i.	DC Voltage Rating, V	V	110	
ii.	Nos of Electrically separate NO & NC Contacts			
v.	Technical literature submitted	Yes/No	Yes	
6.9	**BREAKER FAILURE PROTECTION RELAYS**			
i.	Manufacturer and Country of Origin			
ii.	Manufacturer's type designation			
iii.	Applicable standard	IEC	IEC	
iv.	Triple pole or single pole		Triple Pole	
v.	Current setting range	% of rated current	20-200%	
vi.	Time setting range	sec		
vii.	Reset time	mS		
viii.	Insulating test according to IEC	Yes/No		
ix.	Indication -Hand reset flags provided -Light emitting diode provided	 Yes/No Yes/No		
x.	Auxiliary DC Supply	V_{dc}	110	
xi.	Is manufacturer ISO 9001 holder?	Yes/No	Yes	
xii.	ISO certificate submitted	Yes/No	Yes	
xiii.	Technical literature submitted	Yes/No	Yes	
7	**CONSTRUCTION OF CONTROL & RELAY PANEL**			
i.	Type(Simplex/Duplex)		Duplex	
ii.	Manufacturer's type designation			
iii.	Applicable standard	IEC	IEC	
iv.	Control panels furnished as per specifications	Yes/No	Yes	
v.	Enclosure protection class	IP	IP 4X	
vi.	Thickness of sheet metal used -Front and rear portion -Side, top and bottom covers -Doors	 mm mm mm	 >=3 >=2 >=3	
vii.	All instruments, meters, relays and control switches flush or semi-flush type		Flush	
viii.	Ground bus -Material -Size	 mm x mm	 Copper 25 X 6	
ix.	Internal Wiring - Type of Insulation - Voltage Grade of Wires - Cross Section of wire Current circuit Voltage & auxiliary Circuit	 V Sq.mm	 600	
x.	Overall dimension of control boards (LxWxH)	mm		

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.7: CONTROL AND RELAY PANEL FOR TRANSFORMER **Sheet 6 of 6**

	DESCRIPTION	UNIT		DATA to be Filled
xi.	Shipping data -Size of large package -Weight of the heaviest package	 mm Kg		
xii.	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		
xiii.	Is manufacturer is ISO 9001 holder?	Yes/No	Yes	
xiv.	ISO 9001 certificate submitted?	Yes/No	Yes	
xv.	Has manufacturer exported units?	Yes/No	Yes	
xvi.	User's certificate submitted?	Yes/No	Yes	
xvii.	Technical literature/drawings submitted?	Yes/No	Yes	

Deviations from technical requirements:

Signed……. As representative for……

Address……. Date……

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.8: CONTROL AND RELAY PANEL FOR LINE **Sheet 1 of 4**

	DESCRIPTION	UNIT		DATA to be Filled
1	**CONTROL AND RELAY PANEL TYPE**	**Duplex / Simplex**		
1.1	Manufacturer and Country of Origin			
1.2	Year of manufacturing experience	Years	5	
1.3	Manufacturing's Designation as per submitted catalogue			
2	**CONTROL DISCREPANCY SWITCHES**			
2.1	Manufacturer and Country of Origin			
2.2	Type		Discrepancy	
2.3	Current Rating	A		
3	**PUSH BUTTON**			
3.1	Manufacturer and Country of Origin			
3.2	Type			
3.3	Contact Rating, continuous Making Current Breaking Current	Amp Amp Amp		
4	**INDICATING LAMPS**			
4.1	Manufacturer			
4.2	Voltage Rating	V		
4.3	Wattage	W		
5	**INDICATING INSTRUMENTS**			
5.1	**Ammeter**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital	
iv.	Accuracy class		0.5	
v.	**Scale**			
	-Range of indication (……./1 Amp CT operated)	A	As Required	
	-Overload range	%	1.5	
vi.	VA Burden			
vi.	Transducer operated	Yes/No	Yes	
5.2	**Apparent Power Meter (VA)**			
i.	Manufacturer and Country of Origin			
ii	Type		Digital	
iii	Rated voltage	kV	132/√3 : 0.11/√3	
iv	Rated current	A	……/1	
vi	Accuracy class		0.5	
vii	Scale		Centre zero	
	-Range of indication	MVA	As Required	
viii.	VA Burden Current Coil Voltage Coil			
x	Transducer operated	Yes/No	Yes	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.8: CONTROL AND RELAY PANEL FOR LINE **Sheet 2 of 4**

	DESCRIPTION	UNIT		DATA to be Filled
5.3	**KWh Meter**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital, 3-phase, 4 wire	
iii.	Applicable standard	IEC	IEC	
iv.	Accuracy class		0.2	
v.	Import and Export meter provided	Yes/No	Yes	
vi.	Rated voltage	kV	132/√3 : 0.11/√3	
vii.	Rated current	A	……../1	
viii.	Operating current range	A	1-10A	
ix.	Operating Voltage range	A	0-480V	
x.	VA Burden Current Coil Voltage Coil	VA		
xi.	Impulse contact provided	Yes/No	Yes	
xii.	Programmable at Site		Yes	
xiii.	Software and optical probe provided as per Price schedule & BOQ		Yes	
5.4	**Power Factor meter, PF**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital	
iii.	Accuracy class		0.5	
iii	Rated voltage	kV	132/√3 : 0.11/√3	
iv	Rated current	A	……/1	
5.5	**Voltmeter meter, V**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital	
iii.	Accuracy class		0.5	
iii	Rated voltage	kV	132/√3 : 0.11/√3	
iv.	-Range of indication	V	0-150	
5.6	**Frequency Meter**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital	
iii.	Accuracy class		0.5	
iii	Rated voltage	kV	132/√3 : 0.11/√3	
5.7	**Annunciators**			
I	Manufacturer and Country of Origin			
ii.	Type			
iii.	Manufacturer's type designation			
iv.	Catalogue furnished	Yes/No	Yes	
vi.	Number of active points	No.	Min 18	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.8: CONTROL AND RELAY PANEL FOR LINE **Sheet 3 of 4**

	DESCRIPTION	UNIT		DATA to be Filled
6	**PROTECTIVE RELAYS**			
6.1	**PHASE OVERCURRENT RELAYS**			
i.	Manufacturer and Country of Origin			
ii.	Type		Numerical Directional	
iii.	Manufacturer's type designation			
iv.	Applicable standard	IEC	IEC	
v.	Triple pole or single pole		Triple	
vi.	Current setting range	% of rated current	20-200%	
vii.	Characteristics Characteristic Angle		IDMT(standard inverse), 45°	
viii.	Instantaneous unit provided -Current setting range -Operating range	Yes/No % of rated current, mS	Yes 500-2000%	
ix.	Auxiliary DC Supply	Vdc	220	
6.2	**Directional Earthfault Relay**			
i.	Manufacturer and Country of Origin			
ii.	Type		Numerical Directional	
iii.	Manufacturer's type designation			
v.	Triple pole or single pole		Triple	
vi.	Current setting range	% of rated current	10-80%	
vii.	Characteristics Characteristic Angle		IDMT(standard inverse), 45°	
x.	Instantaneous unit provided -Current setting range -Operating range	Yes/No % of rated current mS	Yes 500-2000%	
6.3	**Distance Protection**			
i.	Manufacturer / Country of Origin			
ii.	Standard Reference	IEC	IEC	
iii.	Type of Construction			
iv.	Type		Numerical Non switched	
v.	Voltage Rating	V	220	
vi.	Type of Mounting		Flush	
vii.	Stepped Characteristic	mS	<30	
viii.	Number of Zone		3 Fw / 1 Rev	
ix.	Tripping		1 P / 3P	
x.	Weak infeed feature		Yes	
xi.	permissive under reach/ over reach/ blocking communication mode		Yes	
xii.	number of potential free contacts for Carrier aided Tripping, Auto reclosing, CB failure, Disturbance recorder & Data acquisition system		Yes	
xiii.	power swing blocking protection		Yes	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.8: CONTROL AND RELAY PANEL FOR LINE **Sheet 4 of 4**

	DESCRIPTION	UNIT		DATA to be Filled
xiv.	Fault Recorder / Disturbance Recorder		Yes	
xv.	Distance Fault Locator		Yes	
xvi	Other features as per specification		Yes	
6.4	**Auto reclosing Relay**			
i.	Manufacturer and Country of Origin			
ii.	Type			
6.5	**Breaker Failure Lockout Relay, 86BF & LBB Protection**			
i.	DC Voltage Rating, V	V	110	
ii.	Nos of Electrically separate NO & NC Contacts			
6.6	**AUXILIARY TRIPPING & LOCKOUT RELAYS**			
i.	Manufacturer and Country of Origin			
ii.	Type			
iii.	Manufacturer's type designation			
v.	Operating time	mS	<15	
viii.	Insulating test according to IEC	Yes/No		
ix.	Indication -Hand reset flags provided -Light emitting diode provided	 Yes/No Yes/No		
x.	Auxiliary DC Supply	V_{dc}	220	
xi.	Technical literature submitted	Yes/No	Yes	
7	**CONSTRUCTION OF CONTROL & RELAY PANEL**			
i.	Type(Simplex/Duplex)		Duplex	
ii.	Manufacturer's type designation			
iii.	Applicable standard	IEC	IEC	
iv.	Control panels furnished as per specifications	Yes/No	Yes	
v.	Enclosure protection class	IP	IP 4X	
vi.	Thickness of sheet metal used -Front and rear portion -Side, top and bottom covers -Doors	 mm mm mm	 >=3 >=2 >=3	
viii.	Ground bus -Material -Size	 mm x mm	 Copper 25 X 6	
x.	Overall dimension of control boards (LxWxH)	mm		
xii.	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		
xvii.	Technical literature/drawings submitted?	Yes/No	Yes	

Deviations from technical requirements:

Signed……. As representative for……

Address……. Date……

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.9: CONTROL AND RELAY PANEL FOR BUSCOUPLER **Sheet 1 of 3**

	DESCRIPTION	UNIT		DATA to be Filled
1	**CONTROL AND RELAY PANEL TYPE**	**Duplex / Simplex**		
1.1	Manufacturer and Country of Origin			
1.2	Year of manufacturing experience	Years	5	
1.3	Manufacturing's Designation as per submitted catalogue			
2	**CONTROL DISCREPANCY SWITCHES**			
2.1	Manufacturer and Country of Origin			
2.2	Type		Discrepancy	
2.3	Current Rating	A		
2.3	Catalogue furnished	Yes/No	Yes	
3	**PUSH BUTTON**			
3.1	Manufacturer and Country of Origin			
3.2	Type			
3.3	Contact Rating, continuous Making Current Breaking Current	Amp Amp Amp		
4	**INDICATING LAMPS**			
4.1	Manufacturer			
4.2	Voltage Rating	V		
4.3	Wattage	W		
5	**INDICATING INSTRUMENTS**			
5.1	**Ammeter**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital	
iv.	Accuracy class		0.5	
v.	**Scale**			
	-Type of scale		Center zero	
	-Range of indication (……./1 Amp CT operated)	A	As Required	
	-Overload range	%	1.5	
vi.	Transducer operated	Yes/No	Yes	
5.2	**Annunciators**			
I	Manufacturer and Country of Origin			
ii.	Type			
iii.	Manufacturer's type designation			
iv.	Catalogue furnished	Yes/No	Yes	
vi.	Number of active points	No.	Min 18	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.9: CONTROL AND RELAY PANEL FOR BUSCOUPLER **Sheet 2 of 3**

	DESCRIPTION	UNIT		DATA to be Filled
6	**PROTECTIVE RELAYS**			
6.1	**PHASE OVERCURRENT RELAYS**			
i.	Manufacturer and Country of Origin			
ii.	Type		Numerical Non Directional	
iii.	Manufacturer's type designation			
iv.	Applicable standard	IEC	IEC	
v.	Triple pole or single pole		Triple Pole	
vi.	Current setting range	% of rated current	20-200%	
vii.	Characteristics		IDMT(standard inverse)	
viii.	Instantaneous unit provided -Current setting range -Operating range -NO Contacts	Yes/No % of rated current	Yes 500-2000%	
x.	Auxiliary DC Supply	V_{dc}	220	
x.	Technical literature submitted	Yes/No	Yes	
6.2	EARTH FAULT RELAYS			
i.	Manufacturer and Country of Origin			
ii.	Type		Numerical, Non-Directional	
iii.	Manufacturer's type designation			
iv.	Applicable standard	IEC	IEC	
vi.	Continuous overload capacity	x In		
vii.	Current setting range	% of rated current	10-80%	
ix.	Characteristics		IDMT(standard inverse)	
x.	Instantaneous unit provided -Current setting range -Operating range -NO Contacts, Nos	Yes/No % of rated current mS	Yes 500-2000%	
xi.	Auxiliary DC Supply	V_{dc}	220	
xii.	Technical literature submitted	Yes/No	Yes	
6.3	**AUXILIARY TRIPPING & LOCKOUT RELAYS**			
i.	Manufacturer and Country of Origin			
ii.	Type			
iii.	Manufacturer's type designation			
iv.	Applicable standard	IEC	IEC	
v.	Operating time	mS	<15	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.9: CONTROL AND RELAY PANEL FOR BUSCOUPLER **Sheet 3 of 3**

	DESCRIPTION	UNIT		DATA to be Filled
6.4	**BREAKER FAILURE PROTECTION RELAYS**			
i.	Manufacturer and Country of Origin			
ii.	Manufacturer's type designation			
iii.	Applicable standard	IEC	IEC	
iv.	Triple pole or single pole		Triple Pole	
v.	Current setting range	% of rated current	20-200%	
7	**CONSTRUCTION OF CONTROL & RELAY PANEL**			
i.	Type(Simplex/Duplex)		Duplex	
ii.	Manufacturer's type designation			
iii.	Applicable standard	IEC	IEC	
iv.	Control panels furnished as per specifications	Yes/No	Yes	
v.	Enclosure protection class	IP	IP 4X	
vi.	Thickness of sheet metal used -Front and rear portion -Side, top and bottom covers -Doors	 mm mm mm	 >=3 >=2 >=3	
vii.	All instruments, meters, relays and control switches flush or semi-flush type		Flush	
viii.	Ground bus -Material -Size	 mm x mm	 Copper 25 X 6	
x.	Overall dimension of control boards (LxWxH)	mm		
xii.	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		
xiii.	Technical literature/drawings submitted?	Yes/No	Yes	

Deviations from technical requirements:

Signed……. As representative for……

Address……. Date……

This schedule contains GTP for all the possible parameters of SACDA Equipments BCU generally have. Instead of simply confirming, the Bidder shall fill in the particulars against appropriate items in respect of each rating and type of equipment offered in the broad categories listed below along with supporting authentic technical documents.

(In the absence of GTP in the below mentioned format, the purchaser has every right to evaluate the product accordingly and bidder cannot raise any objection against any point of the technical scrutiny.)

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.10: SUBSTATION AUTOMATION SYSTEM **Sheet 1 of 6**

Sr. No.	Parameters	To be filled by bidder
A	**BCU**	
1	Make and Type	
2	Numerical Technology	
3	Modular design	
4	Nos of Analogue Input	
5	Nos of Digital Input	
6	Nos of Output	
7	Data Storage	
8	Self- monitoring	
9	Power supply	
10	IEC 61850 Protocol Compatibility	
11	Binary Input processing & Nos	
12	Analogue Input processing & Nos	
13	Measured value acquisition	
14	Derived values	
15	Digital Outputs	
16	Sub-station/bay inter-locking	
17	Trip Circuit Supervision	
18	Event Logging Nos	
19	Disturbance files & record of wave forms , storage capacity	
20	Gateway support	
21	Local control, Operation and Display	
22	Contact bouncing in digital inputs shall not be assumed as change of state	
23	I/O processing capacities	

TECHNICAL DATA SHEET **(To Be Completed By the Tenderer)**		
ITEM No.10: SUBSTATION AUTOMATION SYSTEM		**Sheet 2 of 6**
24	Internal Ethernet switches	
	Nos of port –	
26	Environmental conditions	
27	Mounting & design	
28	Warranty	
	Bay control functions	
	Control mode selection	
	Command supervision	
	Commands for	
32	Local communication facility through HMI	
	Local communication facility provided on front side for	
34	Compatibility with owner's SCADA for remote control	
35	Extension possibilities with additional I/O's inside the unit or via fiber-optic communication and process bus.	
B	Gateway	
1	Power supply	
2	Processor Type	
3	Chipset	
4	Memory Type	
5	Standard memory	
6	Memory slots	
	Internal hard disk drive	
	Hard disk drive speed	
	Optical drives	
	Video adapter, bus	
	Expansion slots	
	Network Interface	
	External I/O ports	
	Operating system installed.	
	Make	
	Antivirus s/w	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.10: SUBSTATION AUTOMATION SYSTEM **Sheet 3 of 6**

D	**HMI SERVER**	
1	Power supply	
2	Processor Type	
3	Chipset	
4	Memory Type	
5	Standard memory	
6	Memory slots	
7	Memory upgrade	
8	Internal hard disk drive	
9	Hard disk drive speed	
10	Optical drives	
11	Flexible disk drives	
12	Chassis type	
13	Video adapter, bus	
14	Expansion slots	
15	Audio	
16	Modem	
17	Network Interface	
18	External I/O ports	
19	Monitor	
20	Keyboard	
21	Pointing Device	
22	Operating system installed.	
23	Other	
24	Warranty	
25	UPS	
26	Make	
27	Antivirus s/w	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.10: SUBSTATION AUTOMATION SYSTEM **Sheet 4 of 6**

E	**DR WORK STATION**	
1	Power supply	
2	Processor Type	
3	Chipset	
4	Memory Type	
5	Standard memory	
6	Memory slots	
7	Memory upgrade	
8	Internal hard disk drive	
9	Hard disk drive speed	
10	Optical drives	
11	Flexible disk drives	
12	Chassis type	
13	Video adapter, bus	
14	Expansion slots	
15	Audio	
16	Modem	
17	Network Interface	
18	External I/O ports	
19	Monitor	
20	Keyboard	
21	Pointing Device	
22	Operating system installed.	
23	Other	
24	Warranty	
25	UPS	
26	Make	
27	Antivirus s/w	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.10: SUBSTATION AUTOMATION SYSTEM **Sheet 5 of 6**

F	**LINE INTERFACE UNIT**	
1	Area Network Type	
2	Power Supply	
3	Protocol/ Network	
4	Module	
5	No. of Ports	
6	Ports/Interfaces	
7	Features	
8	Make	
9	Manufacturer Warranty	
10	Suitability for Nos of F.O. Inlet/Outlet	
11	IEC 61850 Compatibility	
G	**COLOUR LASER JET PRINTER**	
1	Model	
2	Power Supply	
3	Black Print Speed	
4	Black Print Resolution	
5	Print Memory	
5	Processor	
6	Supported paper sizes	
7	Print technology	
8	Pages quantity	
9	Paper handling	
10	Connectivity	
11	Manufacturer Warranty	
12	Networking:	
13	Supporting OS	
14	Make	
15	Suitability to print all types of drafts and graphics	

TECHNICAL DATA SHEET **(To Be Completed By the Tenderer)** **ITEM No.10: SUBSTATION AUTOMATION SYSTEM** **Sheet 6 of 6**		
H	**LASER JET PRINTER**	
1	Model	
2	Power Supply	
3	Black Print Speed	
4	Black Print Resolution	
5	Print Memory	
6	Processor	
7	Supported paper sizes	
8	Print technology	
9	Pages quantity	
10	Paper handling	
11	Connectivity	
12	Manufacturer Warranty	
13	Networking:	
14	Supporting OS	
15	Make	
16	Suitability to print all types of drafts and graphics	

Deviations from technical requirements and reasons for such deviations:

Signed……. As representative for……

Address……. Date……

TECHNICAL DATA SHEET

(To Be Completed By the Tenderer)

ITEM No.11: 11kV XLPE POWER CABLES **Sheet 1 of 1**

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
1	**Manufacturer and Country of Origin**			
2	**Manufacturer's type designation**			
3	**Type**		Armoured	
4	**Applicable standard**		IEC	
5	**Voltage rating** a) Suitable for max. system voltage b) voltage grade of this cable	 kV kV	 12 6/10(12)	
	c) Rated voltage between each conductor and screen	kV	11/√ 3	
	d) Rated voltage between two conductors	kV	11	
6	**Conductor material**	Copper / Al		
7	**Insulating material**		Polyethylene	
	Thickness			
8	**Overall jacket material**		PVC	
	Thickness			
9	**Overall Cross sectional Area of the cable, Copper**	Sq.mm		
	Copper	Sq.mm		
	Aluminum for Outgoing	Sq.mm		
10	**Type of Cable**	Copper	Single Core	
		Aluminum	Three core	
11	**Continuous Current Rating at 45DegC Ambient Temperature in Duct**	A		
	Copper 630 sq.mm	A		
	Copper 400 sq.mm	A		
	Aluminum 300 Sq.mm	A		
12	**Short Circuit Current rating**	kA	> 20	
13	**Fire Retardive**	Yes	Yes	
14	**Mositure Resistant**	Yes	Yes	
15	**Technical Leaflets provided**	Yes / No	Yes	
16	**Delivery of equipment in months** following award of contract (Allowing time for approval of drawing)	month		

Deviations from technical requirements:

Signed…… As representative for……

Address…… Date……

TECHNICAL DATA FOR 132kV SINGLE CORE 500 SQMM XLPE INSULATED, ARMOURED CABLE:

Sl. No	**Name of the Particulars**	**Desired Value**	
		500 sqmm / 240 Sq.mm	
1	No. of cores	1(Single)	
2	Size (in mm2)	500 / 240	
3	Voltage Grade(in kV)	76/132(145) kV	
4	Type of cable		
5	Standard according to which cable has been manufactured and tested	IEC- 62067, Testing as per IEC- 60840.	
6	Permissible Voltage & Frequency variation for satisfactory operation.		
	Voltage	± 10%	
	Frequency	± 5%	
7	Maximum rated conductor temperature	90^0C	
8	Max. allowable conductor temperature during short circuit	250^0C	
9	Conductor Details		
	(a) Normal Cross-Sectional Area	500 mm^2 / 240	
	(b) Material and Grade	Copper as per Specs	
	(c) Shape of Conductor	Compacted stranded circular	
10	**Conductor Screen**		
	(a)Material	Extruded Semi-Conducting XLPE	
	(b)Nominal Thickness	1.5mm(Approx.)	
11	**Insulation**		
	(a) Material	Cross linked Polyethyle	
	(b) Nominal Thickness	18.0 mm	
12	**Insulation Screen**		
	(a) Material	Extruded Semi-Conducting XLPE (SC) layer followed by water	
	(b) Min. Thickness	1.0 mm followed by water swellable SC tapes	
	(c) Longitudinal Water Sealing	Semiconducting water blocking tape(s) with 50% over lap	
13	**Metallic Sheath**		
	(a) Material	Seam Welded/ Corrugated Aluminum sheath with anti corrosion protection	
	(b) Thickness	3.0 mm	
	(c) Short Circuit current of metallic screen for 1 sec (kA)	>40	

14	**Outer Sheath**		
	(a) Material	Extruded HDPE	
	(b) Colour	Black	
	(c) Thickness (Nom/Min)	4.0 mm	
	(d) Conducting layer over outer sheath	Graphite Coating	
15	Standard Drum Length with Tolerance	500m±5%	
16	Minimum Bending Radius allowable during installation	20 x OD	
17	Safe Pulling force	5kg/mm^2 of CU area.	
20	(a) Impulse Withstand	650kVp	
21	(b) One minute Power Frequency Withstand Voltage (kV)	190kV for 30 sec	
22	Short circuit current for one second(kA)	143	
	Max conductor DC resistance at 20^{0}C		
	Approx. AC resistance at 90^{0}C		
	Max. capacitance		
23	Continuous Current Rating for cable laid in close trefoil formation	**BEB/ SPB**	
	(i) In ground at 30^{0}C ground temp, Depth of laying 1.0 m, Thermal Resistivity of soil 150°C Cm/W		
	(ii) In free air at 40^0 C Ambient Air Temperature		
	BEB: Sheath both end bonded **SPB:** Sheath single point/ Cross bonded		
	1. The following details shall be embossed/ Printed on outer sheath at regular interval not exceeding one metre. (a) Manufacturer"s Name or Trade name (b) Year of Manufacture (c) Voltage grade of Cable i.e. (d) Cable Code i.e. (e) Number of cores & cable size e.g. 1000 Sqmm (Cu) 1 core		

GUARANTEED TECHNICAL PARTICULARS FOR 132 KV CABLE:

Sl. No.	Name of the Particulars	1CX240 SQMM	1CX500 SQMM
1	Type of cable		
2	Standard according to which cable has been manufactured and tested		
3	Rated Voltage (Uo/U}		
4	Highest System Voltage which the cable can withstand		
5	Maximum Conductor temperature for continuous operation		
6	(a) Maximum short time conductor temperature with duration		
	(b) Maximum allowable conductor temp. during overload		
7	Conductor Details		
	Normal Cross-Sectional Area		
	Material and Grade		
	Shape of Conductor		
	Diameter of Conductor		
	No. of Strands and Diameter of each Strand		
	Water swellable powder/yarn provided		
	Conducting water swellable tape with 50% overlap over compacted conductor provided		
8	Extruded Conductor Screen		
	Material		
	Nominal Thickness		
	Diameter over Conductor screen		
	Designed maximum stress at conductor screen		
9	Insulation		
	Material		
	Nominal Thickness		
	Minimum thickness at any point		
	Diameter over insulation		
	Designed maximum stress		
	Detail of vulcanization process		
	Extrusion method		
	Curing method		
	Cooling method		
	CO/ or VOI Line		
10	Extruded Insulation Screen		
	Material		
	Thickness		
	Diameter over insulation screen		
	Strippable/ Bonded		
11	Conducting Longitudinal Water Sealing		
	Material		
	Thickness		
12	Metallic Sheath/ Screen		
	Material		
	No. of strands		
	Diameter of each Strand (Nom/Min)		
	Diameter of Cable after stranding		
	Armour coverage		
13	Non-conducting Longitudinal Water Sealing		
	Material		
	Thickness		

14	HDPE Outer Sheath		
	Type		
	Colour		
	Thickness (Nom/Min)		
	Conductive Coating Provided		
15	Nominal overall Diameter of cable		
16	Nominal OVerall Weight of Cable per Meter		
17	Standard Drum Length with Tolerance		
18	Minimum Bending Radius allowable during installation		
19	Short Circuit Current Rating of Conductor with maximum conductor temperature (90°C) at the commencement of fault 1Sec. Duration		
20	Maximum Continuous Current Rating of a Circuit Comprising of 3 nos. Single Core Cable laid in trefoil formation at a depth of 1.05 M.		
	Soil Temperature		
	Ambient Temperature		
	Soil Thermal Resistivity		
	System of Bonding		
	Laid in ground (at a depth of 1.05 m)		
	Laid in dusts		
	Installed in Air		
21	Short Time Overload capacity (2 hours)		
	Laid in ground (at a depth of 1.05 m)		
	Laid in dusts		
	Installed in Air		
22	Maximum AC Resistance at 90°C		
23	Equivalent Star Reactance of a Circuit comprising of 3 Nos. of Single Core cable laid in Trefoil Formation		
24	Maximum Charging Current per Conductor		
	at Nominal Voltage 1.64 Al km		
25	Loss in Metallic Screen of a Circuit comprising of 3 nos. of Single Core Cable installed in Trefoil Formation		
26	Maximum Current in Metallic Screen when the cable is installed (Circulating Current)		
27	Derating factor of Cable installed under following conditions Ambient Temperature		
	35°C		
	45°C		
28	Group derating factor of Cable Circuits installed under following conditions		
	Laid 100 mm. apart		
	Laid 250 mm. apart		
29	Induced voltage in metallic screen when Conductor is carrying 100 Amps(V/Km)		
30	Circulating current in metallic screen when conductor is carrying 100 Amps		
31	Test Voltages		
	Impulse Withstand Voltage at 90°C		
	Rated Power Frequency Withstand Voltage (kV)		
	Water penetration test as per IEC 60840		
	Abrasion Test on HDPE Outer sheath as per IEC 60229		
	Recommended Test Voltage after installation		
32	Details of Drum		
	Material and Weight of Drum		

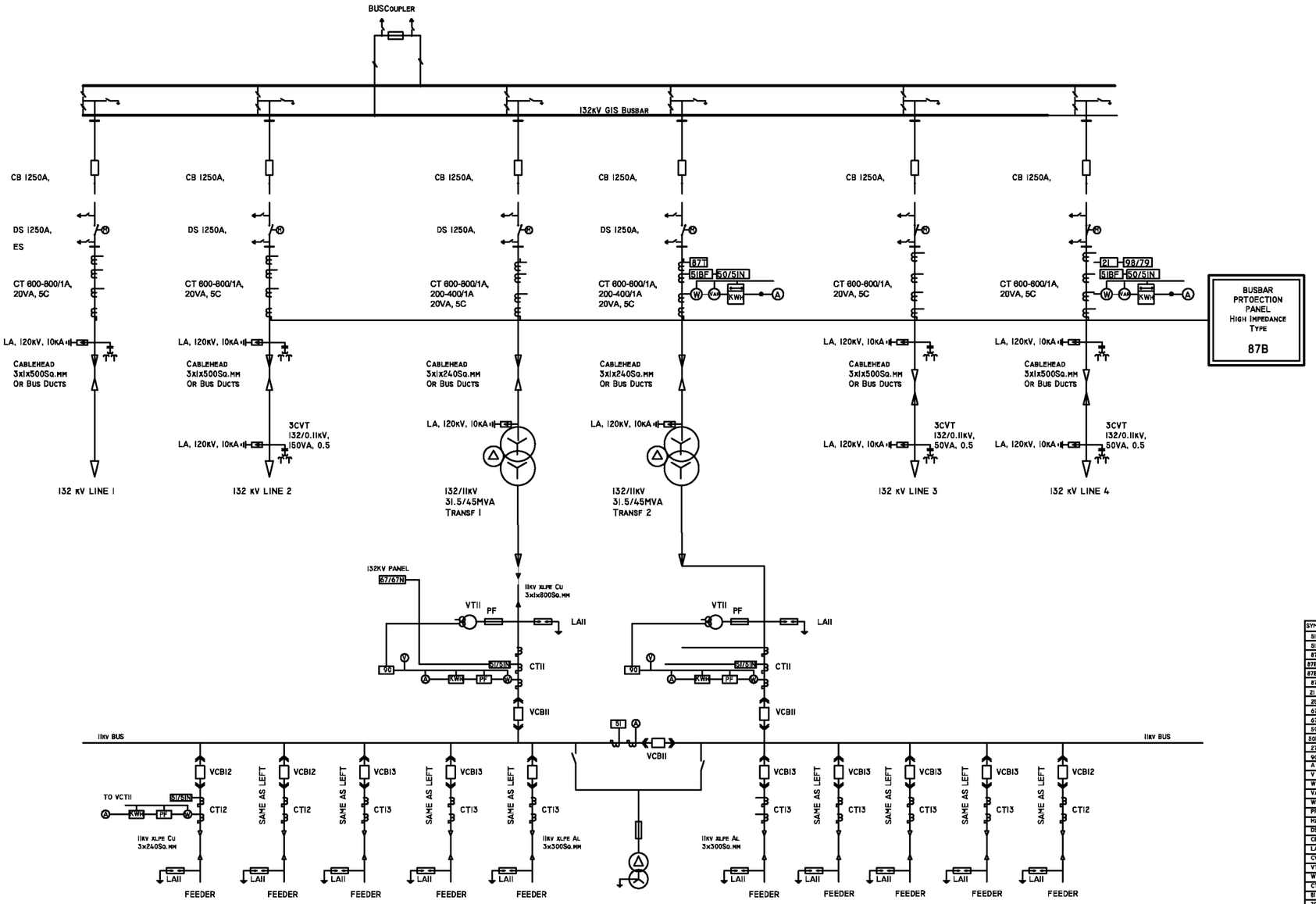
	Weight of Drum with Cable		
	Flange Diameter of Drum		
	Barrel Width of Drum		
	Spindle hole Diameter		
33	Safe Pulling force		
34	Moisture barrier		
	Material		
	Min. Thickness (in mm)		
35	Metallic sheath		
	Material		
	Type of corrugation		
	Gap (in mm)		
	Min & nom thickness		
	Diameter above metallic sheath		
	Anti Corrosive layer		
	Material		
	Tape		
36	The following details shall be embossed/ Printed on outer sheath at regular interval not exceeding one metre.		
	(a) Manufacturer"s Name or Trade name (b) Year of Manufacture (c) Voltage grade of Cable i.e. 132 kV (d) Cable Code (e) Number of cores & cable size e.g. 630 Sq mm (Cu) 1 core 1000 Sqmm (Cu) 1 core		
	Sequential length marking shall also be provided on outer sheath by inkjet printing.		
	Cable shall be supplied in steel drums		

Annexure-I

Technical Specification

(LIST OF TENDER DRAWINGS)

Sl.No.	DRAWING NO.	DRAWING TITLE
I.	**DRAWINGS FOR 132KV MULPANI GIS SUBSTATION**	



SYM.	DESCRIPTIONS
51	OVER CURRENT RELAY
51N	OVER CURRENT GROUND RELAY
87T	TRANSFORMER DIFFERENTIAL RELAY
87BM	BUS DIFFERENTIAL RELAY Main
87BC	BUS DIFFERENTIAL RELAY Check
87L	LINE DIFFERENTIAL RELAY
21	DISTANCE RELAY
25	SYNCHRO CHECK RELAY
67	DIRECTIONAL OVER CURRENT RELAY
67N	DIRECTIONAL O/C GROUND RELAY
59	OVER VOLTAGE RELAY
50BF	BREAKER FAILURE RELAY
27	UNDER VOLTAGE RELAY
90	AUTOMATIC VOLTAGE REGULATOR
A	AMMETER
V	VOLT METER
W	WATT METER
VAR	REACTIVE POWER METER
Wh	ENERGY METER
PF	POWER FACTOR
Hz	FREQUNCY METER
DS	DISCONNECTING SWITCH
CB	CIRCUIT BREAKER
LA	LIGHTNING ARRESTOR
CVT	CAPACITIVE VOLTAGE TRANSFORMER
VT	VOLTAGE TRANSFORMER
WT	WAVE TRAP AND COUPLING CAPCITOR
CT	CURRENT TRANSFORMER
81	FREQUENCY RELAY
79	AUTORECLOSE RELAY
98	FAULT LOCATOR
O/E	OPTICAL TRANSMITTER/ RECEIVER

Reference drawing only for tender proposes

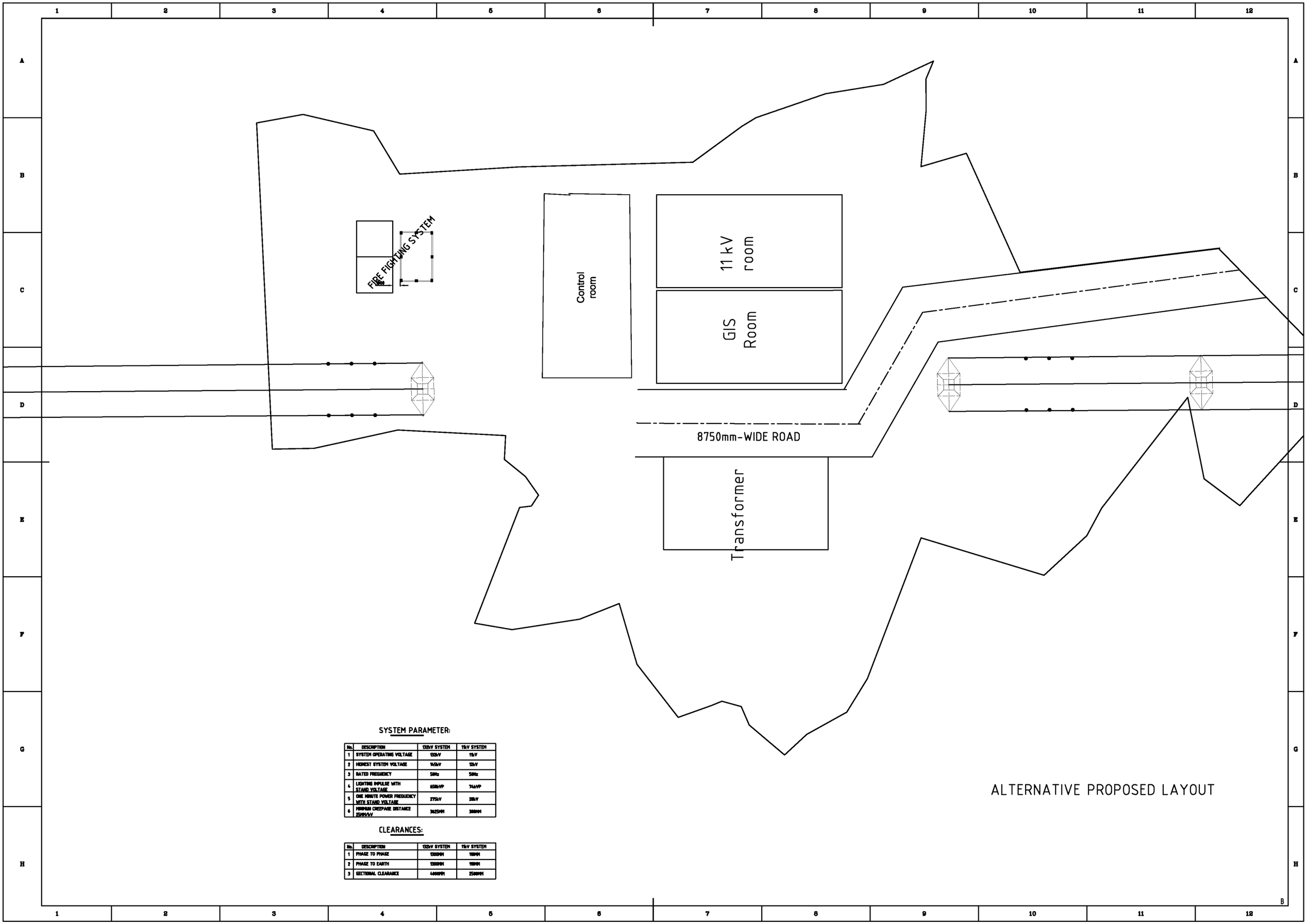
Nepal electricity authority
(GoN Undertaking)
Project Management Directorate
Electricity Grid Modernization Project

Mulpani Substation Construction Project

Title: Single Line Diagram (SLD)

PROJECT: SUPPLY & COMMISSIONING OF 132kV GIS SUBSTATION

	SIGN	DATE		
DRN CHD APPD			General Line Diagram	SCALE: NTS ALL DIMENSIONS ARE IN mm.



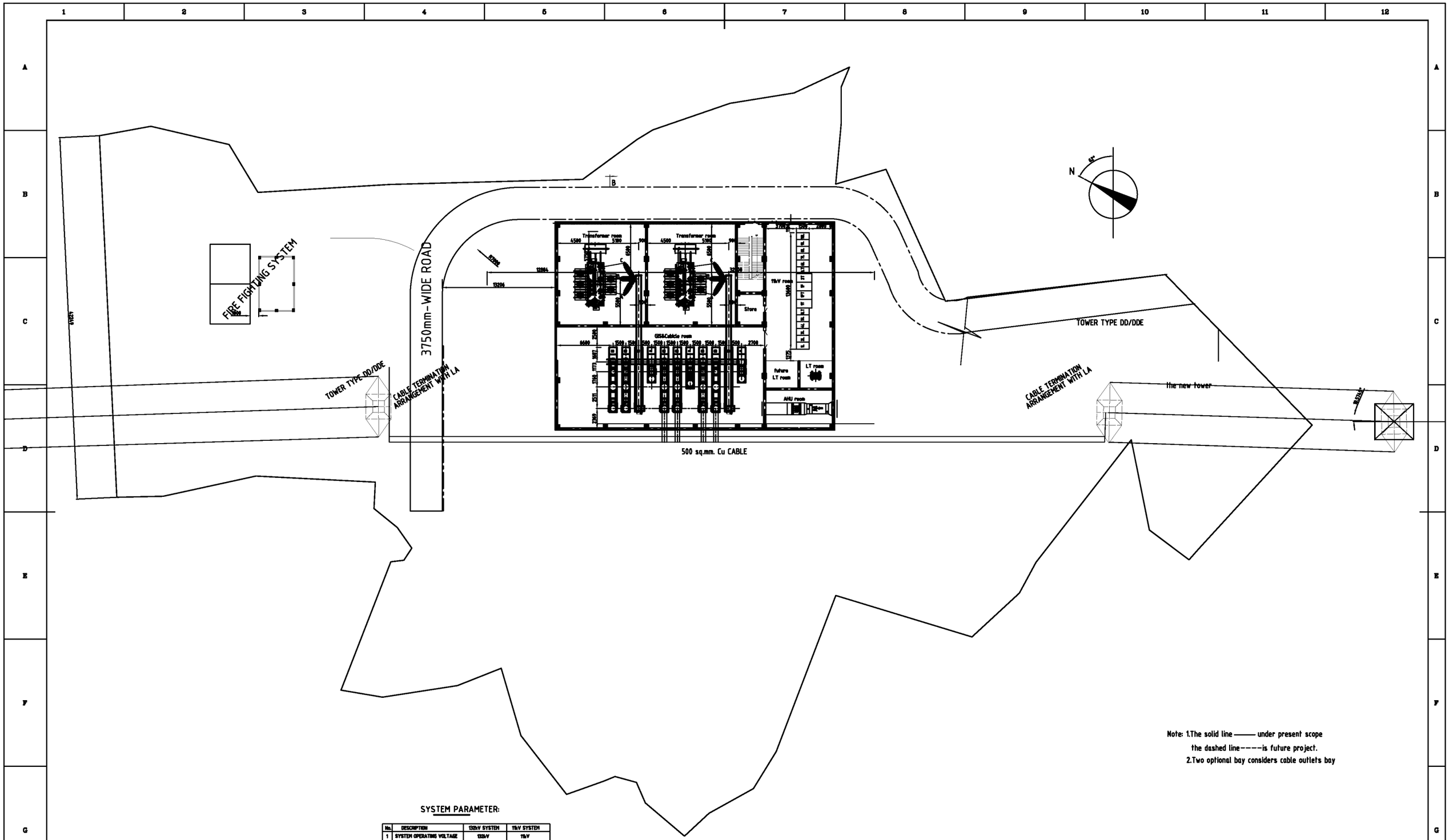
SYSTEM PARAMETER:

No.	DESCRIPTION	132kV SYSTEM	11kV SYSTEM
1	SYSTEM OPERATING VOLTAGE	132kV	11kV
2	HIGHEST SYSTEM VOLTAGE	145kV	12kV
3	RATED FREQUENCY	50Hz	50Hz
4	LIGHTING IMPULSE WITH STAND VOLTAGE	650kVP	74kVP
5	ONE MINUTE POWER FREQUENCY WITH STAND VOLTAGE	275kV	28kV
6	MINIMUM CREEPAGE DISTANCE 25MM/kV	3625MM	300MM

CLEARANCES:

No.	DESCRIPTION	132kV SYSTEM	11kV SYSTEM
1	PHASE TO PHASE	1300MM	110MM
2	PHASE TO EARTH	1300MM	110MM
3	SECTIONAL CLEARANCE	4000MM	2500MM

ALTERNATIVE PROPOSED LAYOUT



SYSTEM PARAMETER:

No.	DESCRIPTION	132kV SYSTEM	11kV SYSTEM
1	SYSTEM OPERATING VOLTAGE	132kV	11kV
2	HIGHEST SYSTEM VOLTAGE	145kV	12kV
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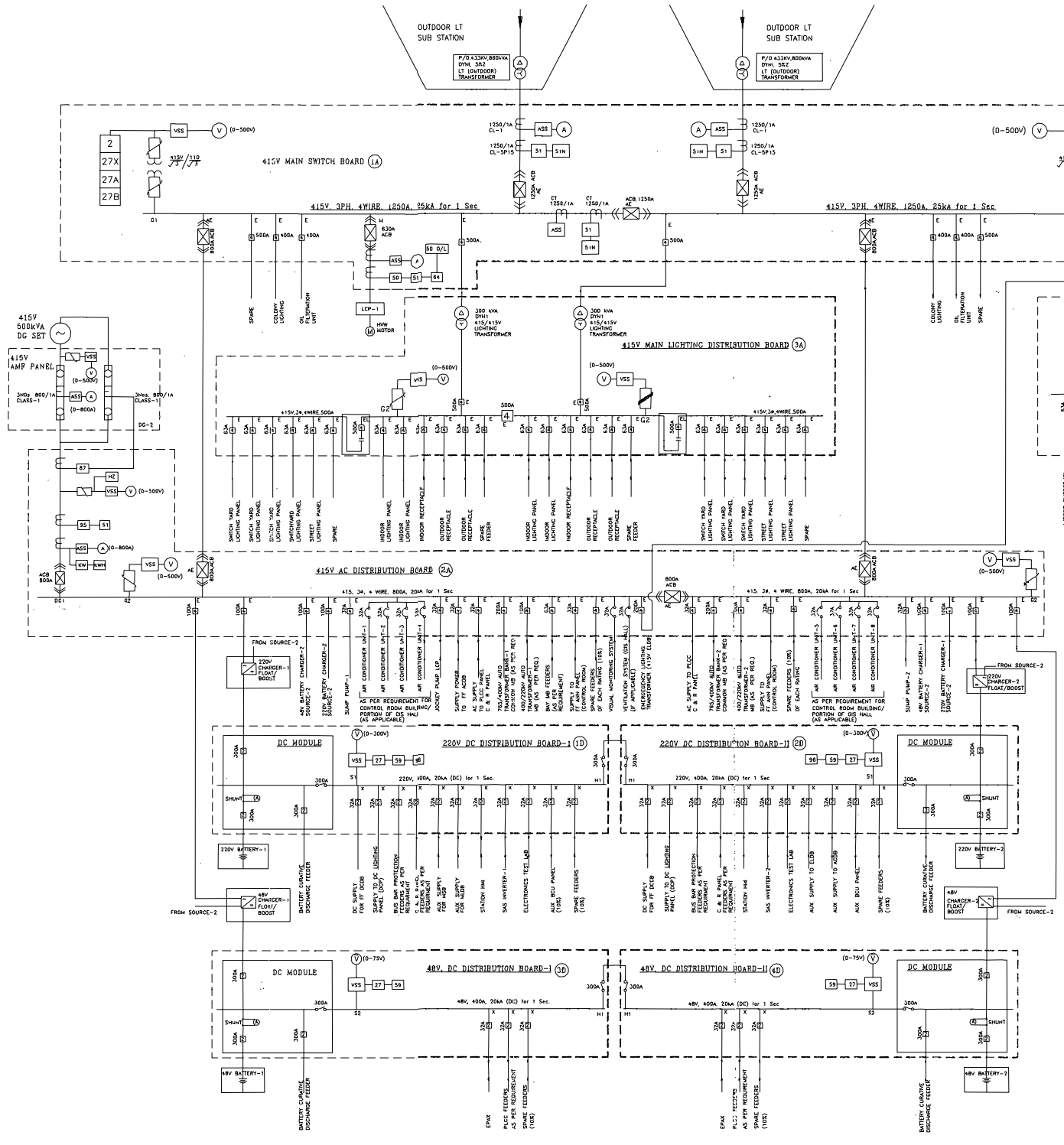
5	ONE MINUTE POWER FREQUENCY WITH STAND VOLTAGE	275kV	28kV
6	MINIMUM CREEPAGE DISTANCE 25MM/kV	3625MM	300MM

CLEARANCES:

No.	DESCRIPTION	132kV SYSTEM	11kV SYSTEM
1	PHASE TO PHASE	1300MM	110MM
2	PHASE TO EARTH	1300MM	110MM
3	SECTIONAL CLEARANCE	4000MM	2500MM

Note: 1.The solid line ——— under present scope
the dashed line- - - -is future project.
2.Two optional bay considers cable outlets bay

PROPOSED LAYOUT



LEGEND

- 2 POLE MCCB
- FOUR POLE MCCB
- AIR CIRCUIT BREAKER
- 2 POLE MCB
- AIR BREAK SWITCH

SPR- SWITCHYARD PANEL ROOM

P- PROJECT SPECIFIC PRIMARY VOLTAGE OF LT TRANSFORMER

NOTES

1. NO TWO AC SOURCE SHALL BE PARALLED AT ANY STAGE
2. DG SET SHALL BE AUTO START TYPE
3. EACH BAY MB & TRANSFORMER MB SHALL BE FED BY ATLEAST ONE SOURCE FROM 415V ACDB SECOND SOURCE SHALL BE LOOPED FROM NEAREST BAY MB & TRANSFORMER MB RESPECTIVELY, WHICH SHALL BE FED FROM ANOTHER SOURCE FROM 415V ACDB
4. NUMBER OF FEEDERS SHALL BE INCREASED IN EACH BOARD AS PER REQUIREMENT OF SUB-STATION FOR PRESENT & FUTURE BAYS AS SHOWN IN SUBSTATION SLD.
5. ONE DC 'X' TYPE MODULE IN EACH 220V DCDB SHALL BE PROVIDED FOR EACH LINE, TRANSFORMER, BUS REACTOR, TBC, BC & BUS SECTION BAY FOR PRESENT & FUTURE BAYS AS SHOWN IN SUBSTATION SLD
6. ONE DC 'X' TYPE MODULE IN EACH 48V DCDB SHALL BE PROVIDED FOR EACH LINE BAY FOR PRESENT & FUTURE BAYS AS SHOWN IN SUBSTATION SLD
7. RATING OF BUS BARS/ FEEDERS INDICATED IN THIS DRAWING ARE MINIMUM REQUIREMENT AND MAY BE INCREASED DURING DETAILED ENGINEERING IF FOUND INADEQUATE WITH RESPECT TO OFFERED LOADS / SYSTEM.
8. MODULE TYPE X REFERRED IN THIS DRAWING IS APPLICABLE WITH DP MCCB. MAXIMUM 2NOS OF DP MCCB SHALL BE CONSIDERED IN ONE MODULE OF OFFERED PANEL
9. AE(B80A,ACB) MODULE SHALL HAVE ONLY AIR CIRCUIT BREAKER WITHOUT SEPARATE PROTECTIVE RELAYS. HOWEVER, AUX RELAYS/CONTACTORS SHALL BE INCLUDED AS PER SCHEME REQUIREMENT
10. ALL DIGITAL/ANALOGUE INPUT/OUTPUTS REQUIRED FOR SAS SYSTEM SHALL BE CONSIDERED BY THE LT SWITCHGEAR MANUFACTURER
11. THIS DRAWING SHALL BE APPLICABLE WITH REV.05 OF STANDARD TECHNICAL SPECIFICATION OF LT SWITCHGEAR

FOR TENDER REFERENCE ONLY

DESIGN AS PER REQUIREMENT

Rev.	Date	Description		Approved

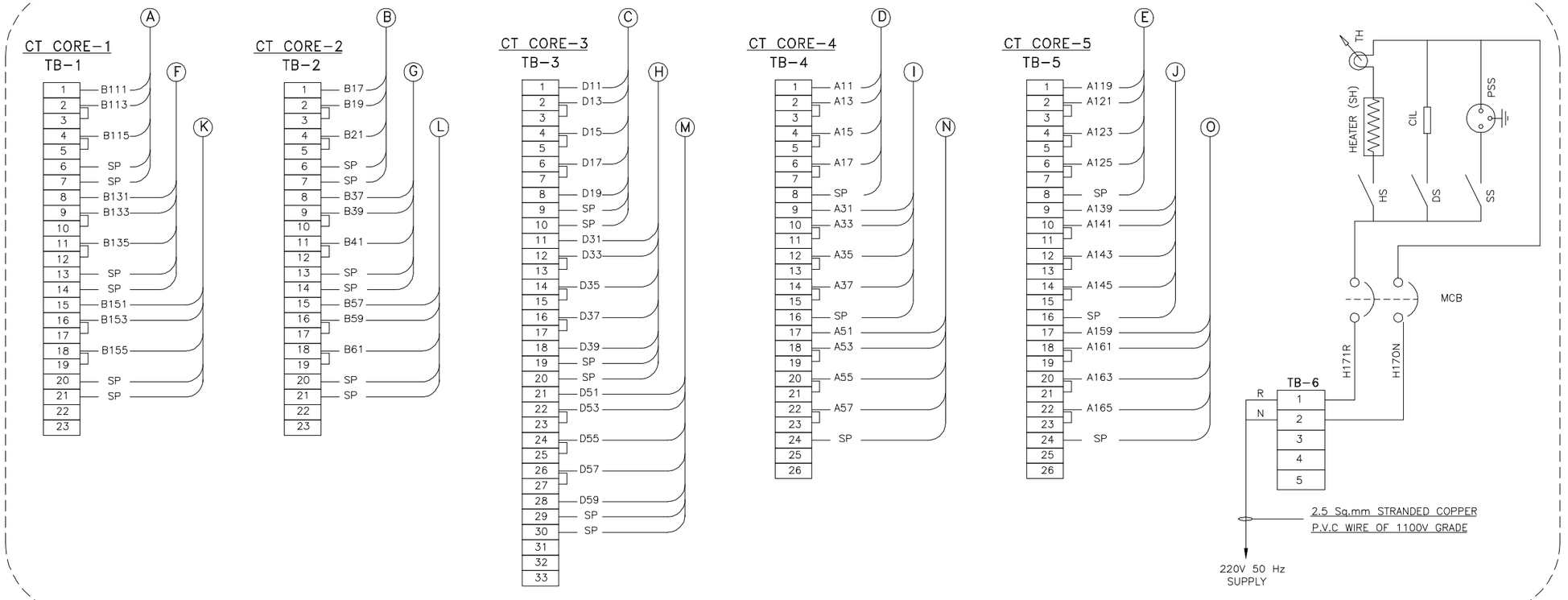
NEPAL ELECTRICITY AUTHORITY
(GoN Undertaking)

PROJECT MANAGEMENT DIRETORATE
POWER T&D EFFICIENCY ENHANCEMENT PROJECT

KATHMANDU VALLEY TRANSMISSION REINFORCEMENT PROJECT

Title
TYPICAL LYOUT MULPANI SUBSTATION

DWG. NO. KVTRP/27



CT MARSHALLING BOX

NOTES :-
1. INTERPOLE CABLING Ⓐ TO Ⓞ -2.5Sq.mm STRANDED FLEXIBLE ARMOURED COPPER CABLE OF 1100V GRADE (FROM CT SEC. TO MARSHALLING BOX)
2. TERMINAL BLOCKS SHALL BE DISCONNECTING STUD TYPE SIMILAR ELMEX MAKE CAT-DM4 OR EQUIVALENT WITH TRANSPARENT COVER
   HS-HEATER SWITCH, DS-DOOR SWITCH, SS-SOCKET SWITCH
   TH-THERMOSTAT.

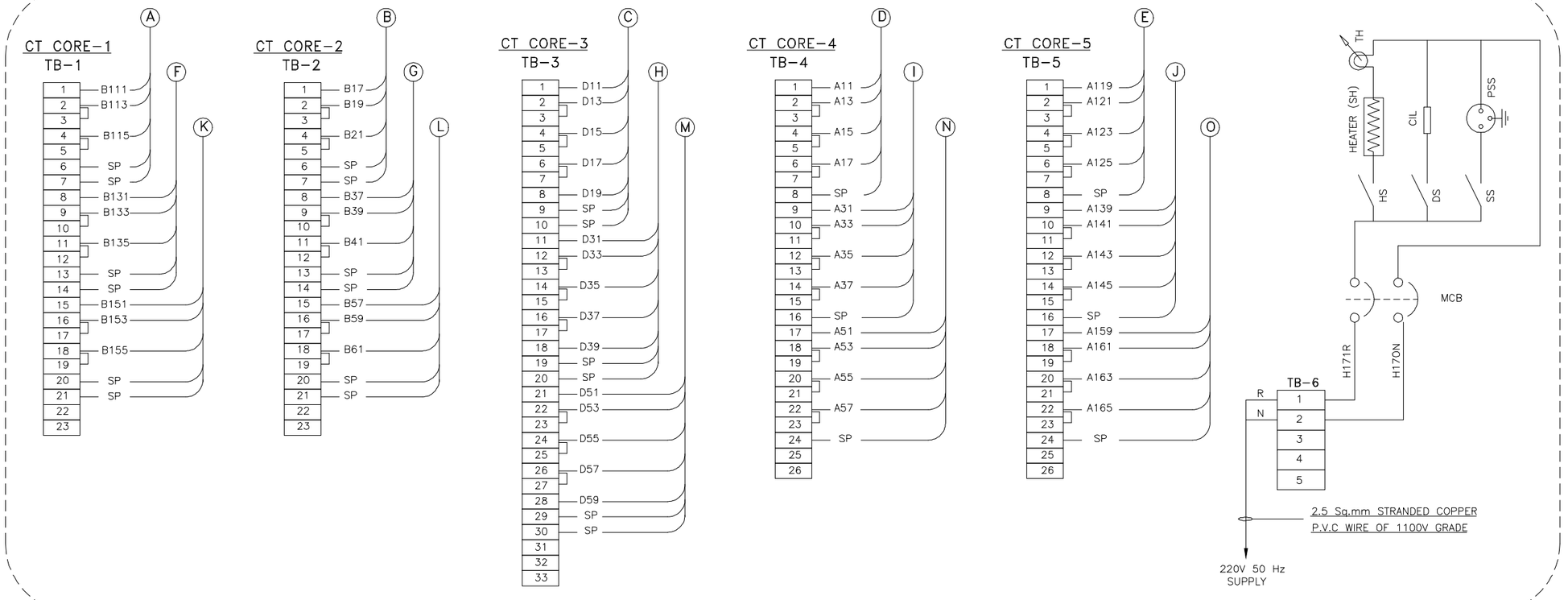
REFERENCE DRAWING. ONLY FOR TENDER PROPOSE

Rev.	Date	Description			Approved

NEPAL ELECTRICITY AUTHORITY
(GoN Undertaking)
PROJECT MANAGEMENT DIRETORATE
ELECTRICITY GRID MODERNIZATION PROJECT

MULPANI SUBSTATION CONSTRUCTION PROJECT

Title
CURRENT TRANSFORMER MARSHALING BOXCONNECTION



CT MARSHALLING BOX

NOTES :-

1. INTERPOLE CABLING (A) TO (O) -2.5Sq.mm STRANDED FLEXIBLE ARMOURED COPPER CABLE OF 1100V GRADE (FROM CT SEC. TO MARSHALLING BOX)
2. TERMINAL BLOCKS SHALL BE DISCONNECTING STUD TYPE SIMILAR ELMEX MAKE CAT-DM4 OR EQUIVALENT WITH TRANSPARENT COVER

HS-HEATER SWITCH, DS-DOOR SWITCH, SS-SOCKET SWITCH
TH-THERMOSTAT.

REFERENCE DRAWING. ONLY FOR TENDER PROPOSE

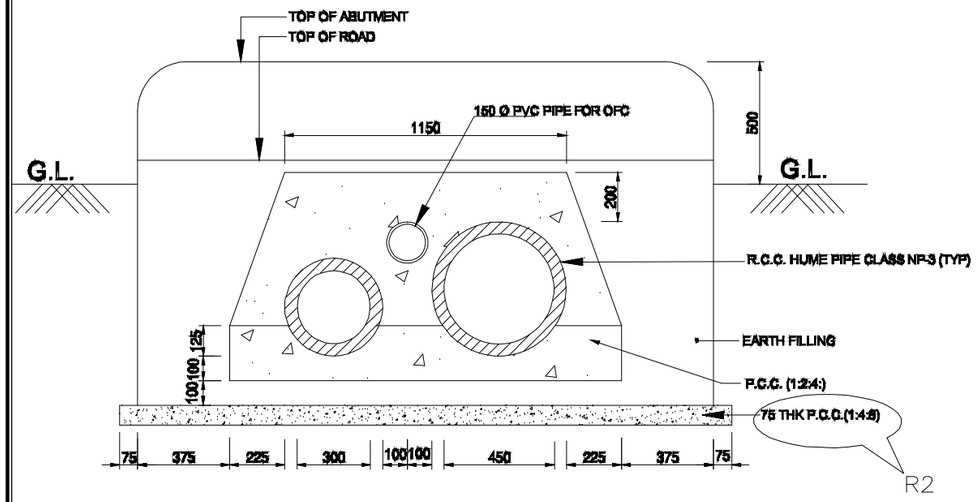
Rev.	Date	Description			Approved

NEPAL ELECTRICITY AUTHORITY
(GoN Undertaking)

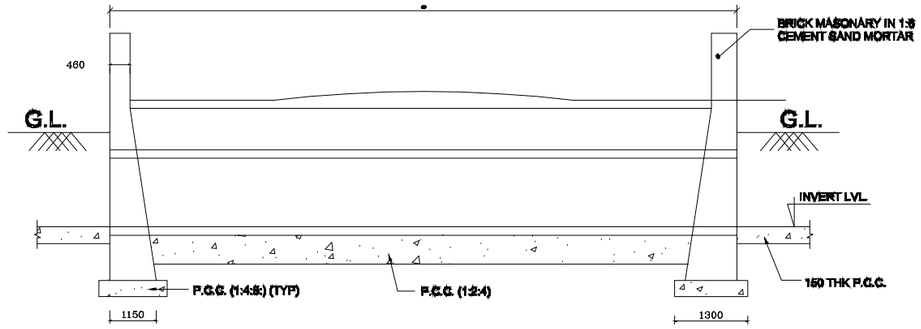
PROJECT MANAGEMENT DIRETORATE
ELECTRICITY GRID MODERNIZATION PROJECT

MULPANI SUBSTATION CONSTRUCTION PROJECT

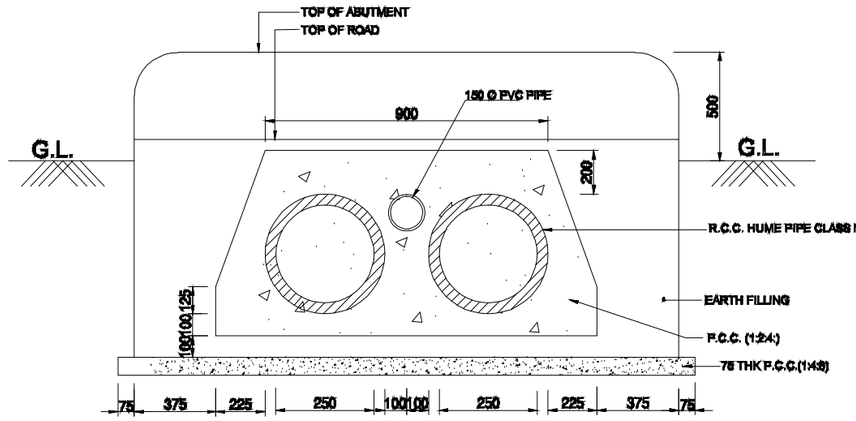
Title
CVT MARSHALING BOX CONNECTION



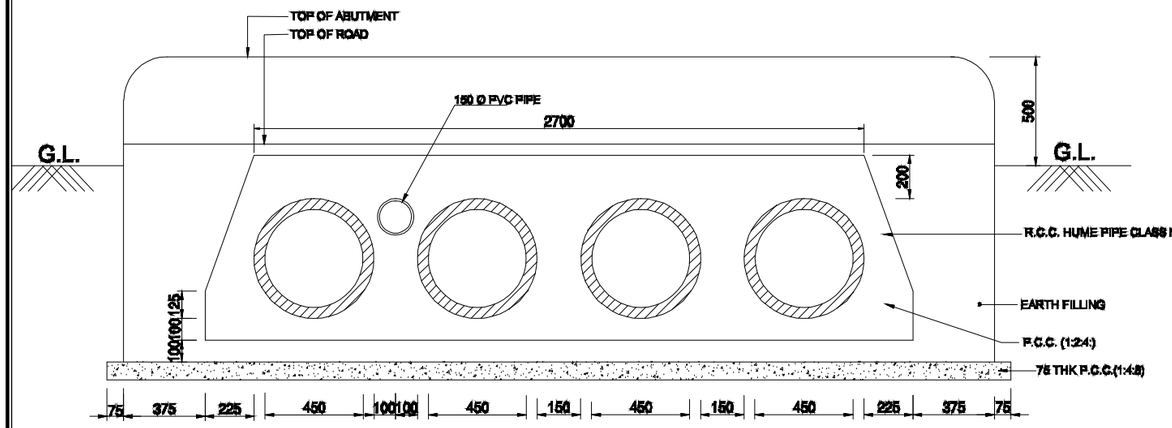
CABLE TRENCH SECTION 2-2 CROSSING ROAD



LONGITUDUNAL SECTION THROUGH CABLE TRENCH CROSSING ROAD



CABLE TRENCH SECTION 3-3 CROSSING ROAD



APPROVED BY E.D.ENGG-S/Stn & T/L VIDE NOTE SHEET
Ref:- C/ENGG/CIVIL/STD/CT-CROSSING Dated 11/06/2012

General Notes

1. ALL DIMENSIONS ARE IN MM. UNLESS NOTED OTHERWISE
2. DO NOT SCALE THE DRAWING, ONLY WRITTEN DIMENSIONS TO BE FOLLOWED
3. F.G.L. DENOTES FINISHED GROUND LEVEL.
4. CLASS 75 BRICKS SHALL BE USED
5. CONCRETE MIX FOR COVERING RCC PIPE SHALL BE 1:2:4 (1 CEMENT; 2 COARSE SAND: 4 COARSE AGGREGATE)
6. RCC HUME PIPE SHALL BE OF GRADE NP3
7. ALL LEAN CONCRETE SHALL BE OF GRADE 1:4:8 (1 CEMENT; 4 COARSE SAND: 8 COARSE AGGREGATE)
8. BRICK MASONRY SHALL BE DONE USING CEMENT MORTAR 1:6 (1 CEMENT; 6 FINE SAND)

REFERENCE DRAWING. ONLY
FOR
TENDER PROPOSE

Rev.	Date	Description			Approved

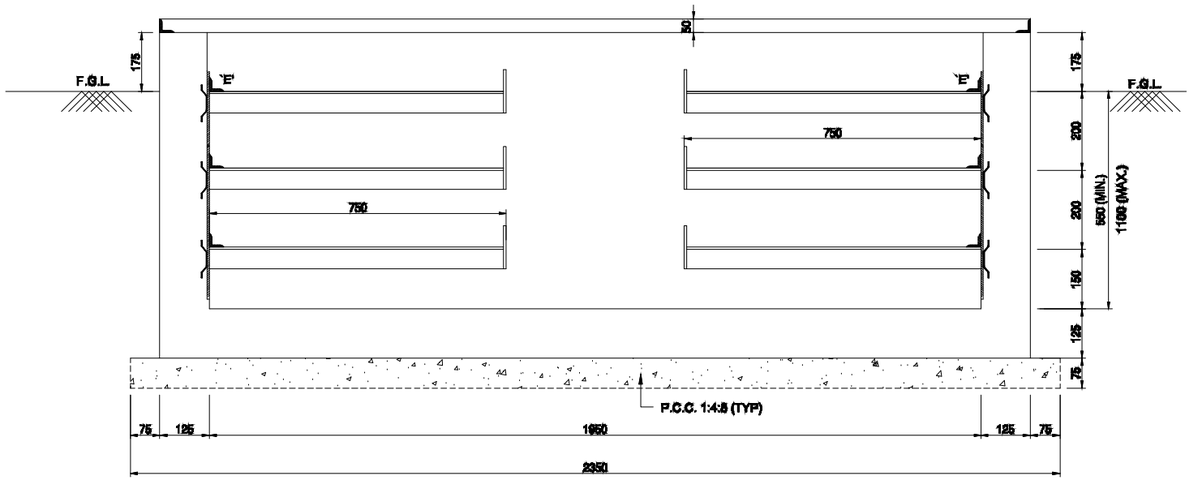
NEPAL ELECTRICITY AUTHORITY
(GoN Undertaking)
PROJECT MANAGEMENT DIRETORATE
Electricity Grid Modernization Project

MULPANI SUBSTATION CONSTRCUTION PROJECT

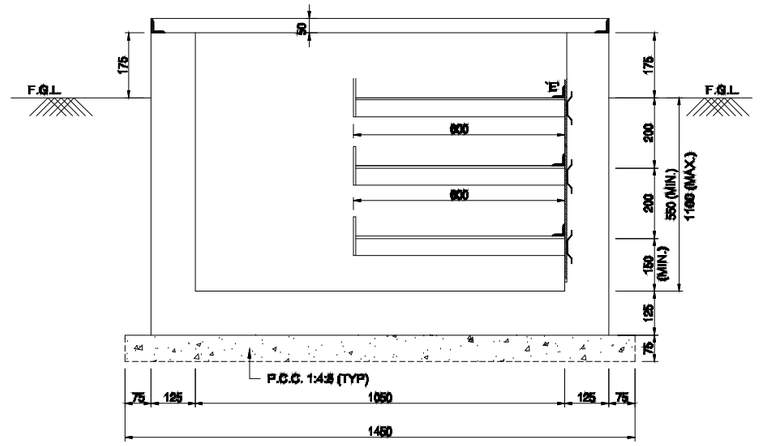
Title
CABLE TRENCH CROSSING

C:\SAMA\OM\SS-DWG-NEW

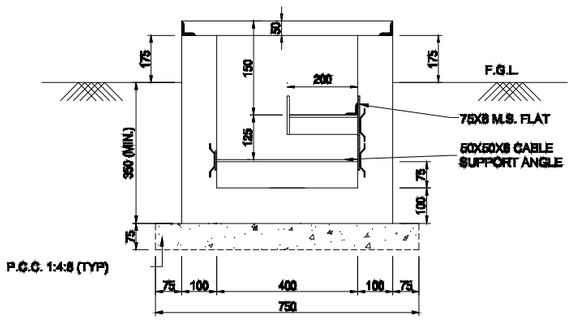
PLOT PROFILE SCALE 1:1



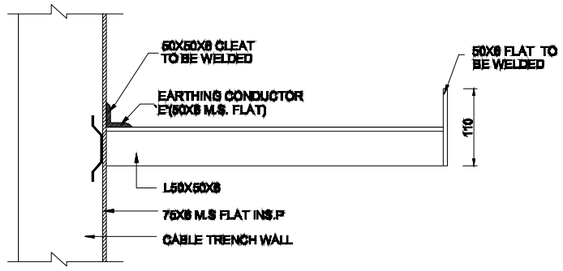
SECTION 1-1



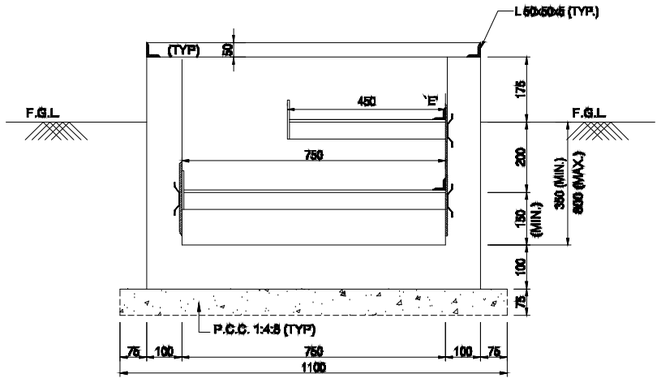
SECTION 2-2



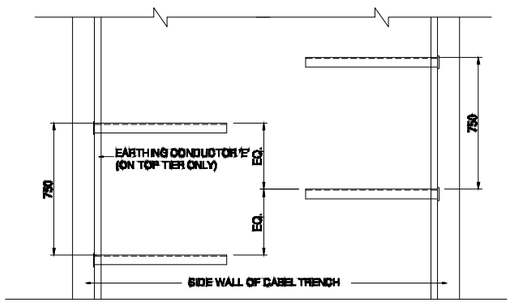
SECTION 4-4



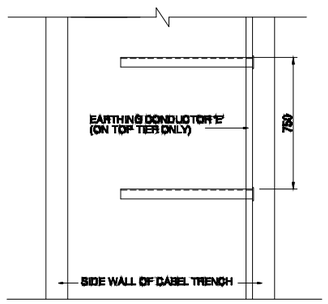
TYPICAL CABLE SUPPORT



SECTION 3-3



PLAN
CABLE TRAY SUPPORT FOR SECTION 1-1



PLAN
CABLE TRAY SUPPORT FOR SECTION 2-2 & 3-3

General Notes

1. ALL DIMENSIONS ARE IN MM. UNLESS NOTED OTHERWISE
2. DO NOT SCALE THE DRAWING, ONLY WRITTEN DIMENSIONS TO BE FOLLOWED
3. LAP LENGTH SHALL BE 47 TIMES DIA OF BAR.
4. PROVIDE CLEAR COVER TO REINF.AS UNDER.
   * 25mm FOR TOP SIDE OF BOTTOM SLAB.
   * 50mm FOR OUTER SIDE OF WALL
5. ALL R.C.C SHALL BE OF GRADE M25 UNLESS NOTED OTHERWISE.
6. LIFTING HOOK SHALL BE PROVIDED IN EVERY TENTH COVER SLAB.
7. NECESSARY OPENINGS SHALL BE PROVIDED AT APPROPRIATE LOCATIONS TO TAKE OUT CABLES.
8. FOR ACTUAL DEPTH OF TRENCHES REFER APPROVED CABLE TRENCH LAYOUT
9. F.G.L. DENOTES FINISHED GROUND LEVEL.
10. ALL CABLE TRENCHES SHALL HAVE A SLOPE OF 1:1000 IN THE DIRECTION OF MAIN RUN AWAY FROM THE BUILDING.
11. EARTHING CONDUCTOR 'E' 50x6 M.S. FLAT SHALL BE WELDED TO THE CABLE SUPPORTING STRUCTURE BEFORE INSTALLATION OF CABLE
12. ALL STEEL STRUCTURES PLATES SHALL BE PAINTED WITH ANTI-CORROSIVE PAINT OVER A COAT OF SUITABLE PRIMER BEFORE INSTALLATION OF CABLES, EARTHING CONDUCTOR SHALL BE PAINTED RED.
13. CONSTRUCTION JOINT SHALL BE PROVIDED AT 30M OR AS PER SITE REQUIREMENT BUT NOT EXCEEDING 30M.
14. ALL SUPPORT ANGLES SHALL BE 50x50x6
15. ANCHORING FLAT (75x6) SHALL BE PROVIDED AT EACH SUPPORT ANGLE POINT.
16. EARTHING CONDUCTOR 'E' SHALL BE PROVIDED ON THE TOP TIER OF EACH CABLE TRENCH SECTION.
17. INCASE EXPANSIVE SOIL IS ENCOUNTERED AT FOUNDING LEVEL. NECESSARY TREATMENT OF SOIL SHALL BE DONE AS PER RECOMMENDATION OF SOIL CONSULTANT/REPORT BEFOR PLACING THE FOUNDATIONS.
18. ALL REINFORCEMENT STEEL BARS (Φ) SHALL CONFORM TO IS:1786-1985 OF GRADE Fe500

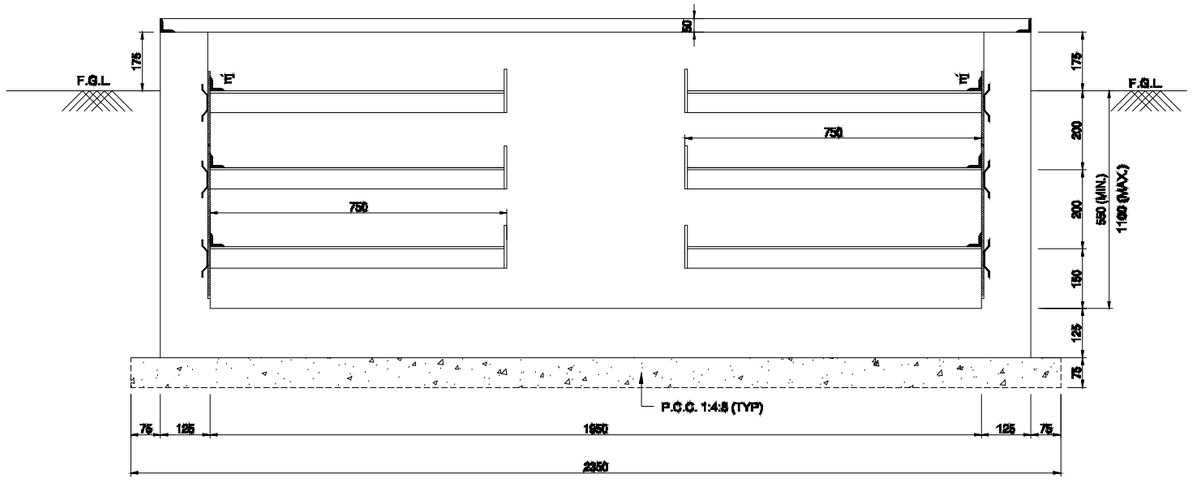
REFERENCE DRAWING. ONLY
FOR
TENDER PROPOSE

Rev.	Date	Description			Approved

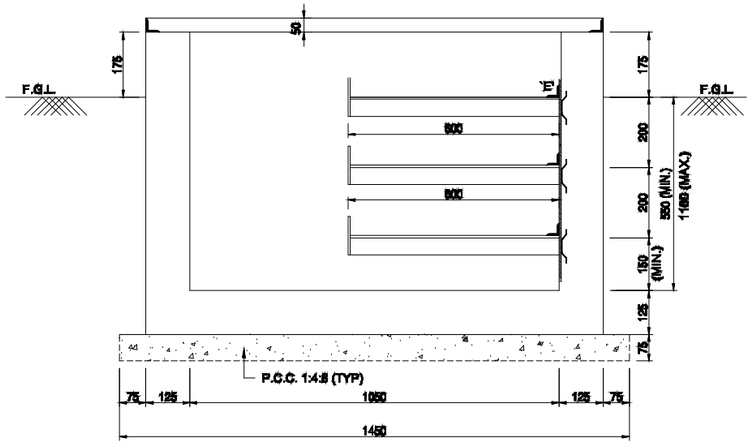
NEPAL ELECTRICITY AUTHORITY
(GoN Undertaking)
PROJECT MANAGEMENT DIRETORATE
Electricity Grid Modernization Project

MULPANI SUBSTATION CONSTRCUTION PROJECT

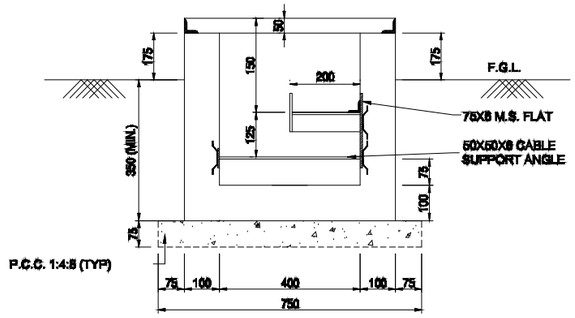
Title
CABLE TRENCH DETAIL



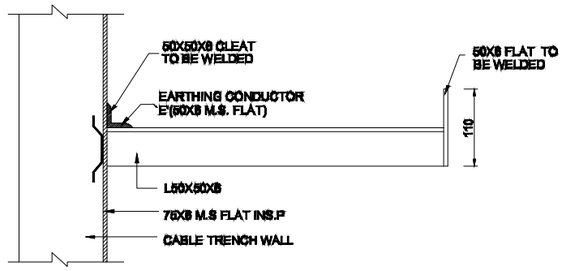
SECTION 1-1



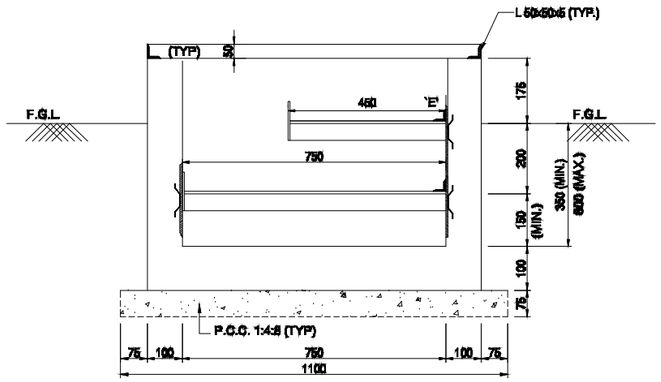
SECTION 2-2



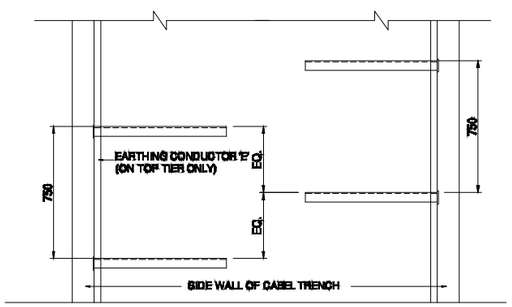
SECTION 4-4



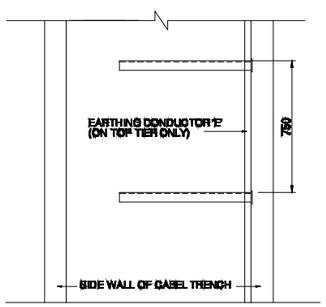
TYPICAL CABLE SUPPORT



SECTION 3-3



PLAN
CABLE TRAY SUPPORT FOR SECTION 1-1



PLAN
CABLE TRAY SUPPORT FOR SECTION 2-2 & 3-3

General Notes

1. ALL DIMENSIONS ARE IN MM. UNLESS NOTED OTHERWISE
2. DO NOT SCALE THE DRAWING, ONLY WRITTEN DIMENSIONS TO BE FOLLOWED
3. LAP LENGTH SHALL BE 47 TIMES DIA OF BAR.
4. PROVIDE CLEAR COVER TO REINF.AS UNDER.
   * 25mm FOR TOP SIDE OF BOTTOM SLAB.
   * 50mm FOR OUTER SIDE OF WALL
5. ALL R.C.C SHALL BE OF GRADE M25 UNLESS NOTED OTHERWISE.
6. LIFTING HOOK SHALL BE PROVIDED IN EVERY TENTH COVER SLAB.
7. NECESSARY OPENINGS SHALL BE PROVIDED AT APPROPRIATE LOCATIONS TO TAKE OUT CABLES.
8. FOR ACTUAL DEPTH OF TRENCHES REFER APPROVED CABLE TRENCH LAYOUT
9. F.G.L. DENOTES FINISHED GROUND LEVEL.
10. ALL CABLE TRENCHES SHALL HAVE A SLOPE OF 1:1000 IN THE DIRECTION OF MAIN RUN AWAY FROM THE BUILDING.
11. EARTHING CONDUCTOR 'E' 50x6 M.S. FLAT SHALL BE WELDED TO THE CABLE SUPPORTING STRUCTURE BEFORE INSTALLATION OF CABLE
12. ALL STEEL STRUCTURES PLATES SHALL BE PAINTED WITH ANTI-CORROSIVE PAINT OVER A COAT OF SUITABLE PRIMER BEFORE INSTALLATION OF CABLES, EARTHING CONDUCTOR SHALL BE PAINTED RED.
13. CONSTRUCTION JOINT SHALL BE PROVIDED AT 30M OR AS PER SITE REQUIREMENT BUT NOT EXCEEDING 30M.
14. ALL SUPPORT ANGLES SHALL BE 50x50x6
15. ANCHORING FLAT (75x6) SHALL BE PROVIDED AT EACH SUPPORT ANGLE POINT.
16. EARTHING CONDUCTOR 'E' SHALL BE PROVIDED ON THE TOP TIER OF EACH CABLE TRENCH SECTION.
17. INCASE EXPANSIVE SOIL IS ENCOUNTERED AT FOUNDING LEVEL. NECESSARY TREATMENT OF SOIL SHALL BE DONE AS PER RECOMMENDATION OF SOIL CONSULTANT/REPORT BEFOR PLACING THE FOUNDATIONS.
18. ALL REINFORCEMENT STEEL BARS (Ø) SHALL CONFORM TO IS:1786-1985 OF GRADE Fe500

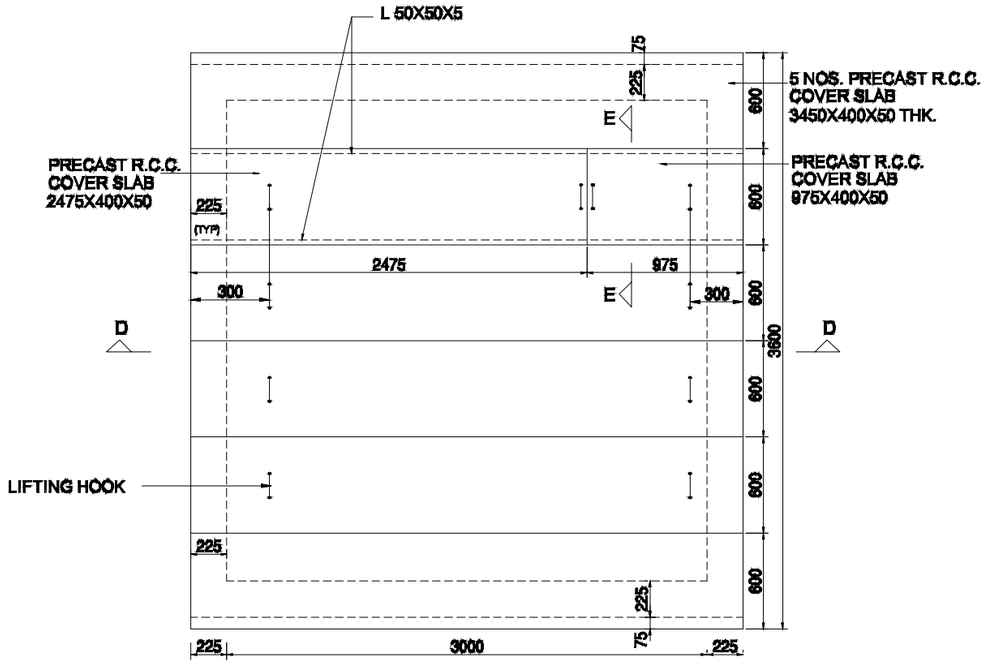
REFERENCE DRAWING. ONLY FOR TENDER PROPOSE

Rev.	Date	Description			Approved

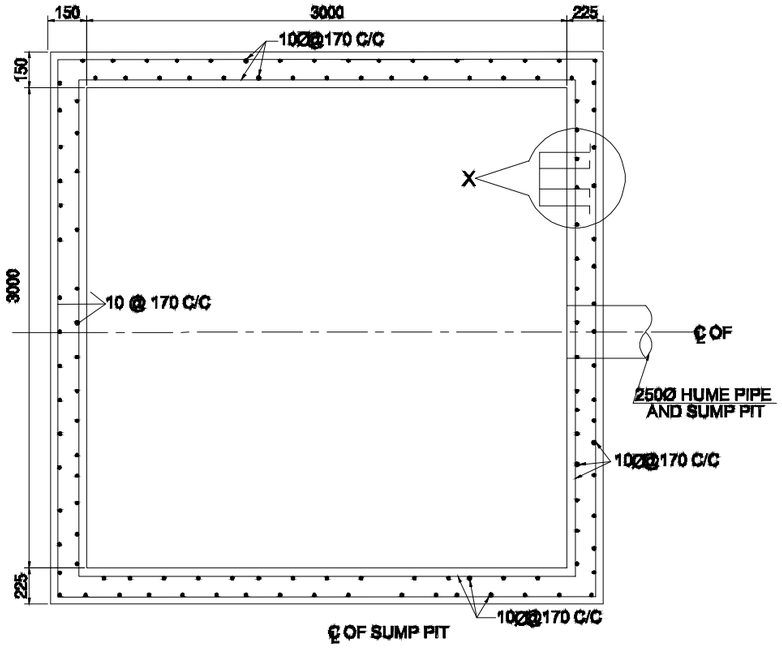
NEPAL ELECTRICITY AUTHORITY
(GoN Undertaking)
PROJECT MANAGEMENT DIRETORATE
Electricity Grid Modernization Project

ELECTRICITY GRID MODERNIZATION PROJECT

Title
RCC DETAILS CABLE TRENCH



TOP PLAN OF SUMP PIT



SECTION 3-3

General Notes

1. ALL DIMENSIONS ARE IN MM. UNLESS NOTED OTHERWISE
2. DO NOT SCALE THE DRAWING, ONLY WRITTEN DIMENSIONS TO BE FOLLOWED
3. LAP LENGTH SHALL BE 47 TIMES DIA OF BAR.
4. PROVIDE CLEAR COVER TO REINF.AS UNDER.
   * 25mm FOR TOP SIDE OF BOTTOM SLAB.
   * 50mm FOR OUTER SIDE OF WALL
5. ALL R.C.C SHALL BE OF GRADE M25 UNLESS NOTED OTHERWISE.
6. LIFTING HOOK SHALL BE PROVIDED IN EVERY TENTH COVER SLAB.
7. NECESSARY OPENINGS SHALL BE PROVIDED AT APPROPRIATE LOCATIONS TO TAKE OUT CABLES.
8. FOR ACTUAL DEPTH OF TRENCHES REFER APPROVED CABLE TRENCH LAYOUT
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10. ALL CABLE TRENCHES SHALL HAVE A SLOPE OF 1:1000 IN THE DIRECTION OF MAIN RUN AWAY FROM THE BUILDING.
11. EARTHING CONDUCTOR 'E' 50x6 M.S. FLAT SHALL BE WELDED TO THE CABLE SUPPORTING STRUCTURE BEFORE INSTALLATION OF CABLE
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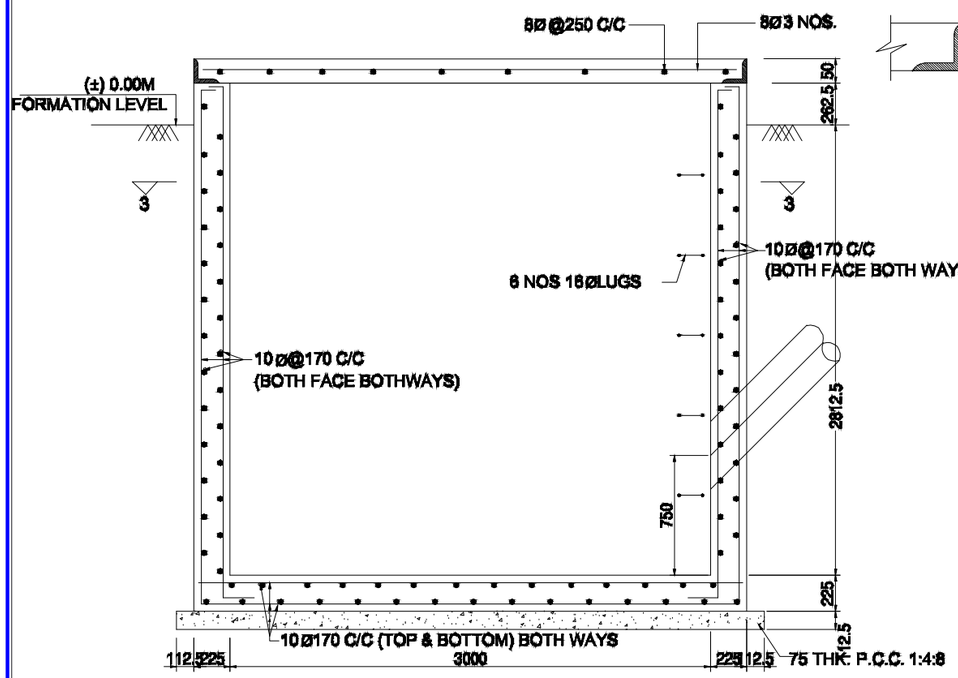
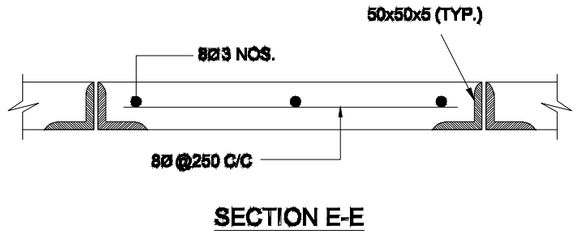
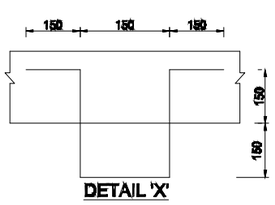
18. ALL REINFORCEMENT STEEL BARS (T) SHALL CONFORM TO IS:1786-1985 OF GRADE Fe500



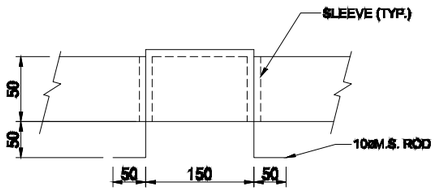
SECTION D-D



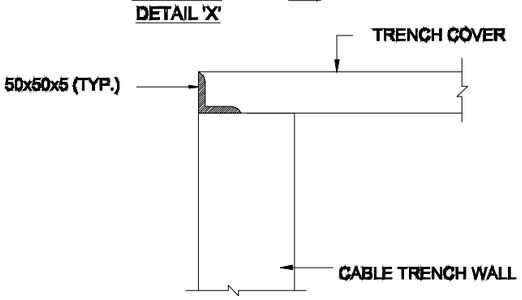
SECTION E-E



DETAIL 'X'



DETAIL OF LIFTING HOOK



TYPICAL DETAIL OF SLAB SUPPORT

REFERENCE DRAWING. ONLY FOR TENDER PROPOSE

Rev.	Date	Description		Approved

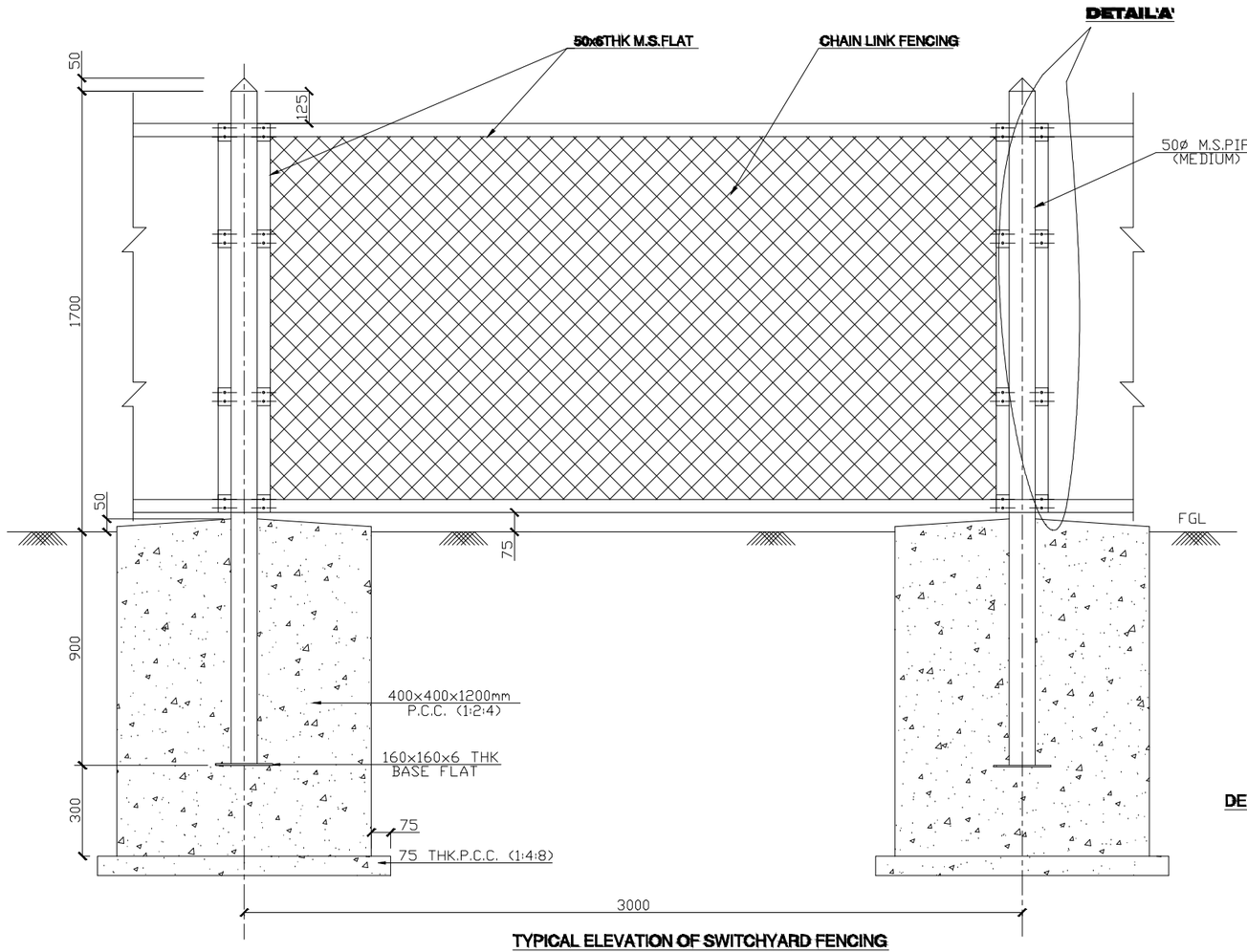
NEPAL ELECTRICITY AUTHORITY
(GoN Undertaking)
PROJECT MANAGEMENT DIRETORATE
MULPANI SUBSTATION CONSTRUCTION PROJECT

MULPANI SUBSTATION CONSTRUCTION PROJECT

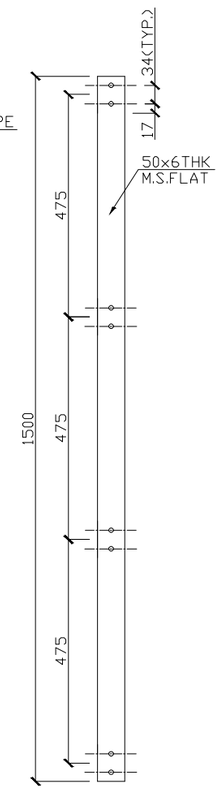
Title
DETILS OF SUMP PIT

C:\SAMA\OM\SS-DWG-NEW

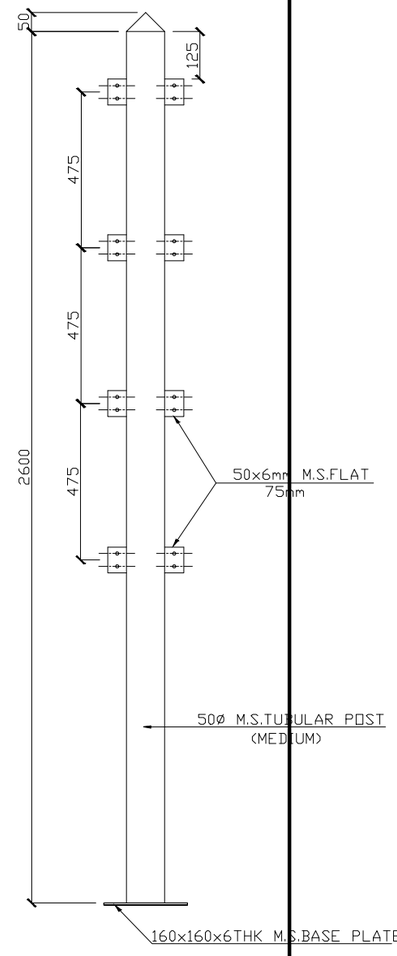
PLOT SCALE 1:1



TYPICAL ELEVATION OF SWITCHYARD FENCING



DETAIL VERTICAL M.S. FLAT 'A'



DETAIL OF TUBULAR POST

RELEASED FOR TENDER & CONSTRUCTION.

NOTES:

1. ±0.00 SHALL DENOTE SWITCHYARD FINISHED FORMATION LEVEL
2. CHAIN LINK FENCING SHALL HAVE 3.15 mm DIAMETER WIRE AS PER IS 2721 WITH 75x75 mm MESH SIZE AND PAINTED
3. TUBULAR POST SHALL BE PLACED @ 3.0m CENTRE TO CENTRE AND SHALL REST IN WELL COMPACTED EARTH
4. CORNER TUBULAR POST SHALL BE PROVIDED CLEATS IN FOUR SIDES SUITING TO REQUIREMENT
5. TUBES/PIPES OF POST SHALL BE GALVANIZED
6. CONCRETE GRADE FOR P.C.C. SHALL CONFORM IS 456: LATEST
7. EXPOSED SURFACE OF CONCRETE PAD (P.C.C.) SHALL BE PLASTERED WITH 12mm THICK CEMENT PLASTER (1:6)

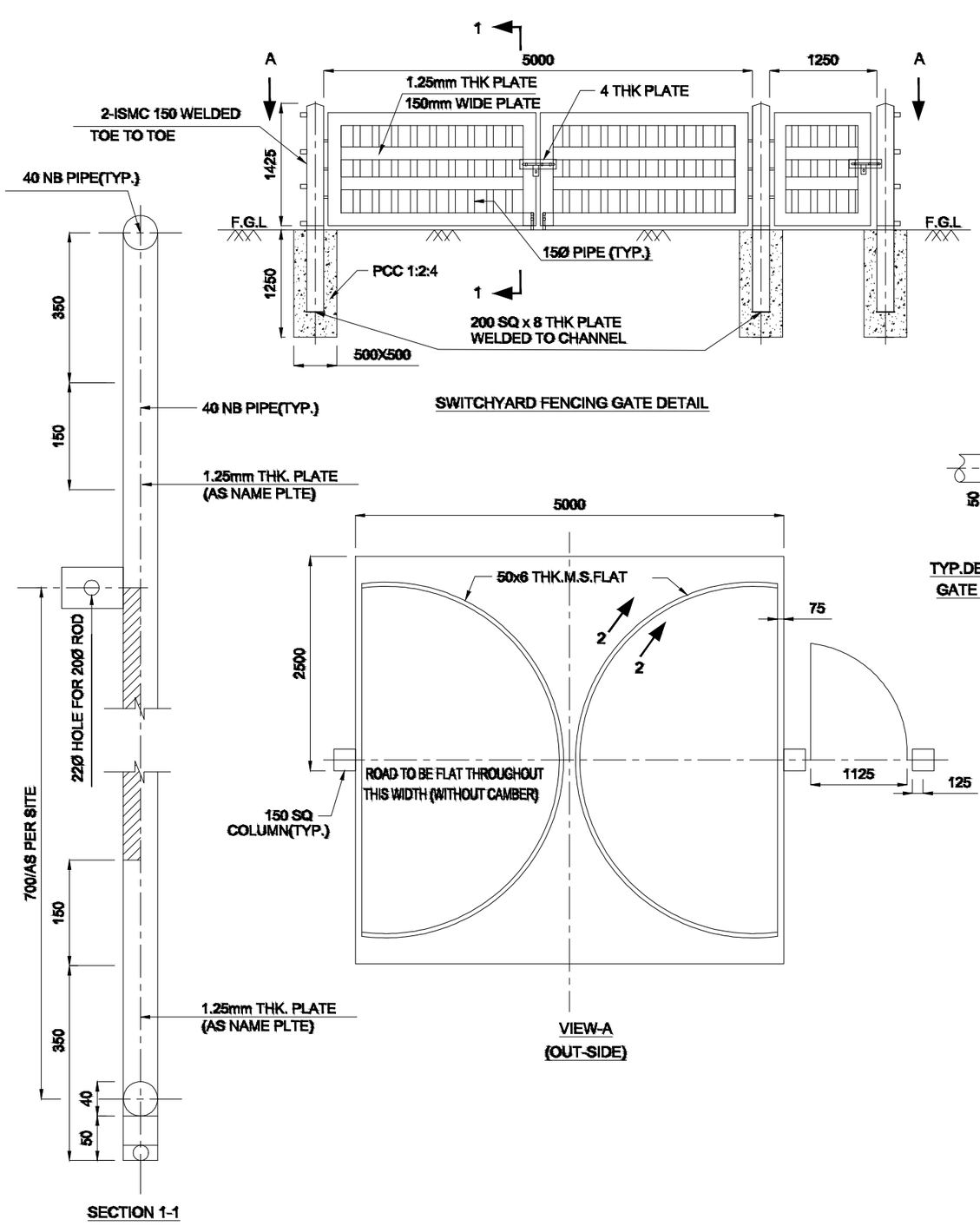
REFERENCE DRAWING. ONLY FOR TENDER PROPOSE

Rev.	Date	Description			Approved

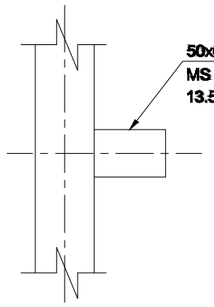
NEPAL ELECTRICITY AUTHORITY
(GoN Undertaking)
PROJECT MANAGEMENT DIRETORATE
ELECTRICITY GRID MODERNIZATION PROJECT

MULPANI SUBSTATION CONSTRUCTION PROJECT

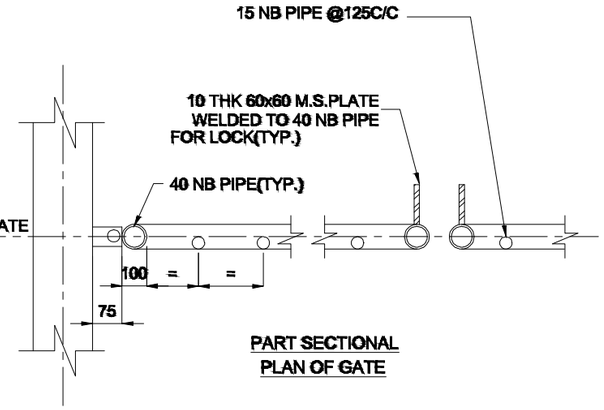
Title
DETAILS CHAINLINK FENCE



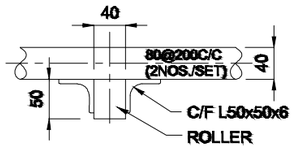
SWITCHYARD FENCING GATE DETAIL



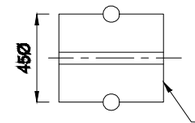
DETAIL -B



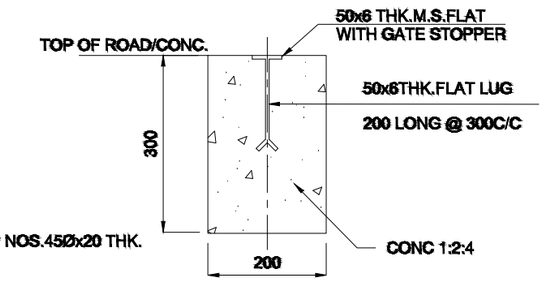
PART SECTIONAL
PLAN OF GATE



TYP.DETAIL OF
GATE ROLLER



DETAIL -A
(ROLLER BEARING)



SECTION 2:2

NOTES:

1. ALL DIMENSIONS ARE IN MM & ELEVATION ARE IN METER UNLESS NOTED OTHERWISE
2. ALL LEAN CONC. SHALL BE PCC (1:4:8)UNLESS NITED OTHERWISE.
3. UNLESS NOTED OTHERWISE LAP/ANCHOR LENGTH SHALL BE 50 TIMES THE DIA OF BARS
4. ALL STRUCTURAL STEEL CONFORM TO IS:2062 &SHALL PAINTED WITH A COAT OF APPROVED STEEL PRIMER &TWO COATS OF SYNTHETIC ENAMEL. PAINT UNLESS NOTED OTHERWISE.
5. DROP BOLTS SHOULD BO PROVIDED ON THE FAR SIDE ONLY.
6. ALL WELDS ARE 6MM THK. FILLET WELDS UNLESS NOTED OTHERWISE.
7. GATE & M.S.HOOKS TO BE PAINTED WITH ONE COAL APPROVED STEEL PRIMER BEFORE ERECTION &TWO COAT OF SYNTHETIC PAINTS AFTER ERECTION.
8. STRUCTURAL PIPES SHALL BE MEDIUM TYPE CONFORMING TO IS 1161/806

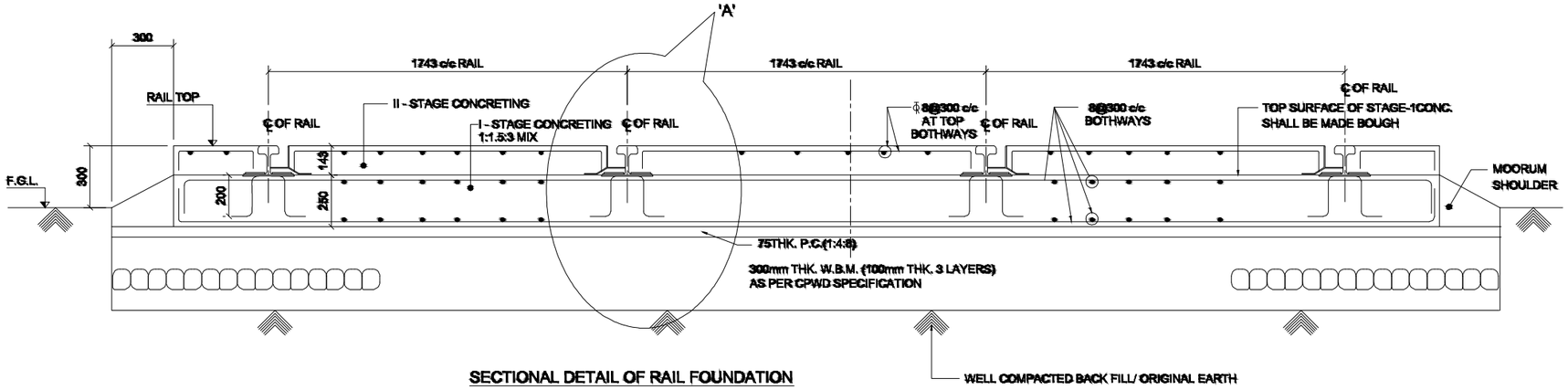
REFERENCE DRAWING. ONLY FOR TENDER PROPOSE

Rev.	Date	Description			Approved

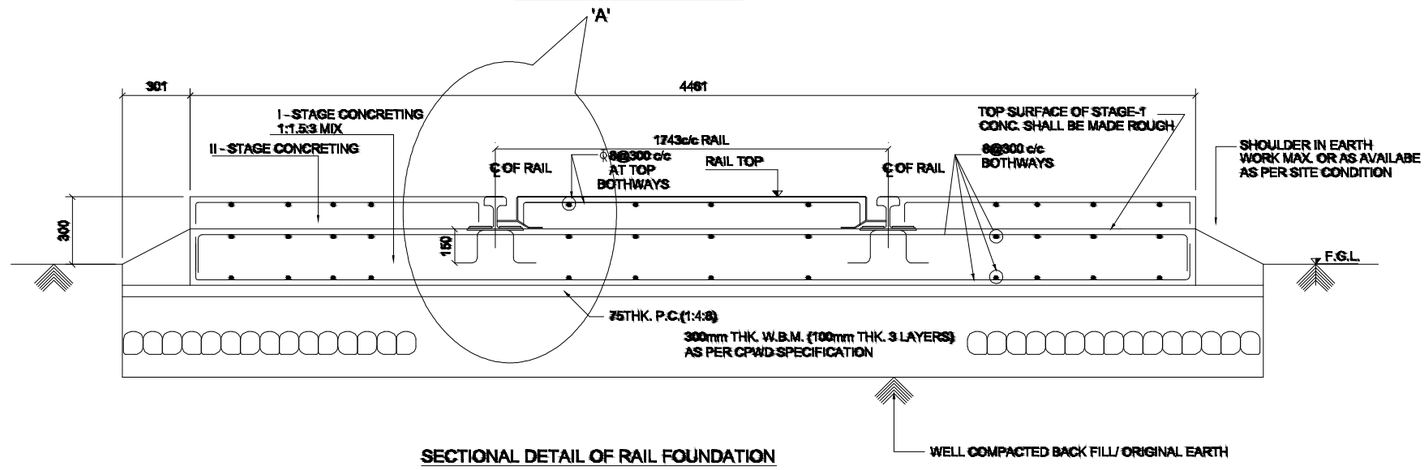
NEPAL ELECTRICITY AUTHORITY
(GoN Undertaking)
PROJECT MANAGEMENT DIRETORATE
ELECTRICITY GRID MODERNIZATION PROJECT

MULPANI SUBSTATION CONSTRUCTION PROJECT

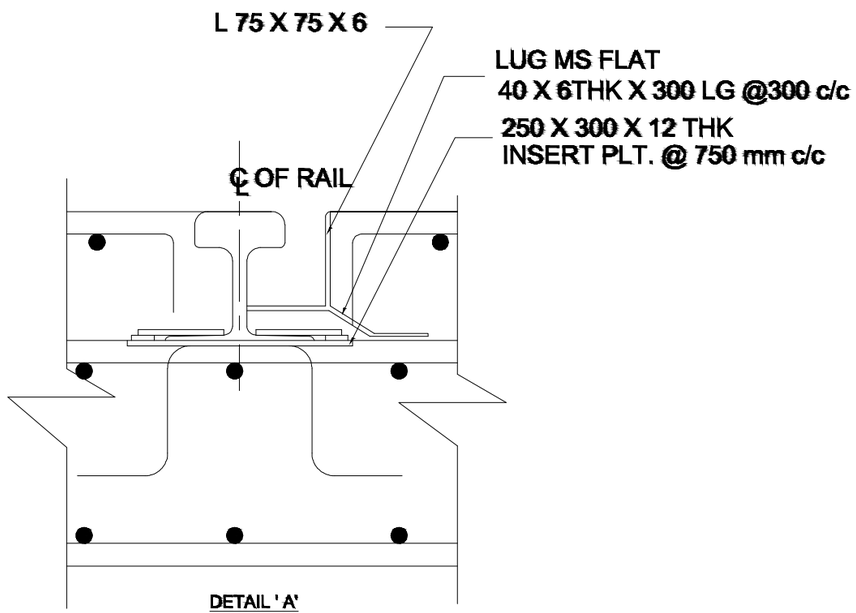
Title
SWITCHYARD GATE



SECTIONAL DETAIL OF RAIL FOUNDATION
FOR 315MVATRASFORMER



SECTIONAL DETAIL OF RAIL FOUNDATION



DETAIL 'A'

NOTES:-

1. ALL DIMENSIONS ARE IN MM. & ELEVATIONS ARE IN METRE UNLESS NOTED OTHERWISE.
2. ALL STRUCTURAL CONC. SHALL BE 1:1.5:3 (1 CEMENT:1.5COARSE SAND: 3 GRADED STONE AGGREGATE OF 20MM NOMINAL SIZE)
3. ALL LEAN CONC. SHALL BE 75MM. THK. AND OF GRADE 1:4:8 (1 CEMENT:4 COARSE SAND: 8 GRADED STONE AGGREGATE OF 40MM NOMINAL SIZE)
4. ALL REINFORCEMENT STEEL BARS (DENOTED AS Ø)SHALL CONFORM TO IS:1786-1985 OF GRADE Fe 415 OR TMT BARS OF EQUAL GRADE.
5. UNLESS NOTED OTHERWISE LAP/ANCHOR LENGTH SHALL BE 50 TIMES THE DIA. OF BARS.
6. THE DRAWING SHALL NOT BE USED FOR CONSTRUCTION IF EXPANSIVE SOIL IS MET
7. SECOND STAGE CONCRETE SHALL BE DONE AFTER RAILS ARE FIXED IN POSITION.

REFERENCE DRAWING. ONLY FOR TENDER PROPOSE

Rev.	Date	Description			Approved

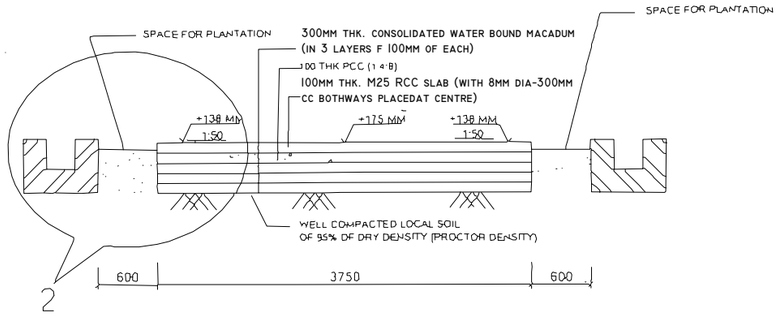
NEPAL ELECTRICITY AUTHORITY
(GoN Undertaking)
PROJECT MANAGEMENT DIRETORATE
MULPANI SUBSTATION CONSTRUCTION PROJECT

MULPANI SUBSTATION CONSTRUCTION PROJECT

Title
RAIL CUM ROAD

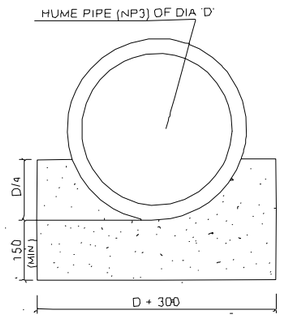
C:\SAMA\OM\SS-DWG-NEW

PLOT SCALE 1:1

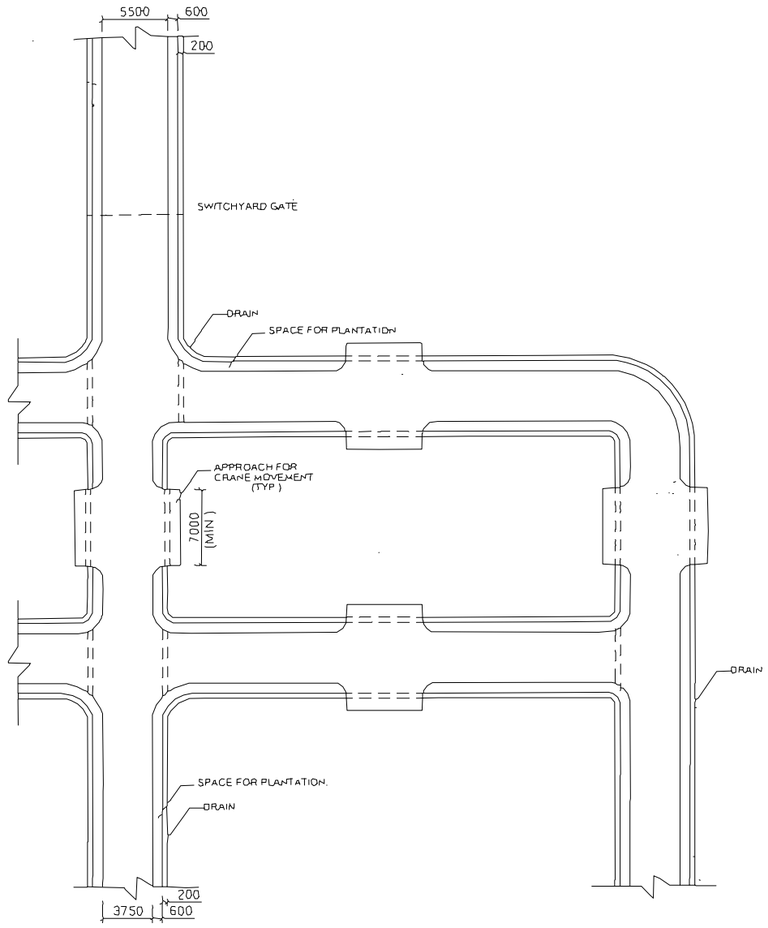


2

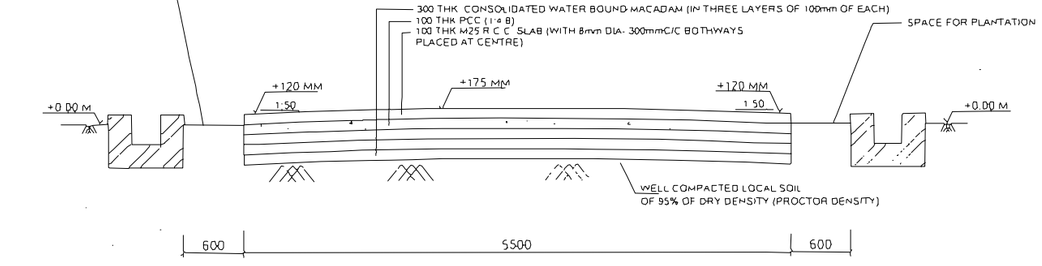
TYP. CROSS SECTION OF ROAD
(VALID FOR INTERNAL ROAD



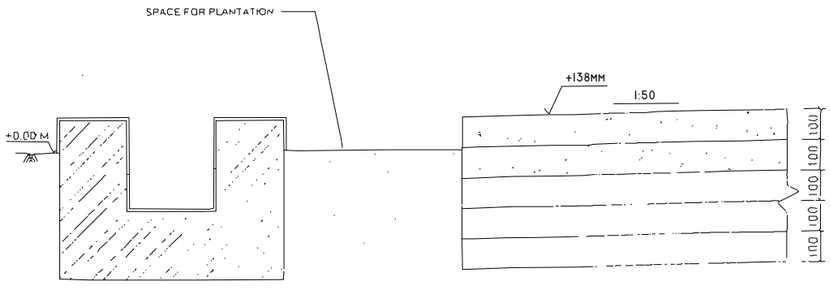
BEDDING FOR HUME PIPE



TYP. SWICHYARD ROAD AND DRAIN LAYOUTPLAN



TOP CROSS SECTION OF ROAD
(VALID FOR APPROACH TO SWITCHYARD)



DETIAL - 2

NOTES:

1. ALL DIMENSION IN MM.
2. CAMPER OF 1:50 SHALL BE PROVIDED.
3. EXPANSION JOINT 12MM THICK SHALL BE PROVIDEDEVERY 8.0M AND AT THE CENTRE.
4. POLYTHENE SHEET OF 125 MICRON SHALL BE PLACED BETWEEN PCC AND RCC SLAB (TOP SLAB).
5. 100MM DIA RCC HUME PIPE (NP3) SHALL BE PLACED ACROSS THE ROAD AT EVERY 100M INTERVAL ALONG THE ROAD,
6. FINISHED TOP OF ROAD CREST SHALL BE 175MM (MIN) ABOVE FGL.
7. IF EXPANSIVE SOIL IS ENCOUNTERED AT FOUNDATION LVL. IT SHALL BE REPLACED BY WELL COMPACTED (3 LAYER) LOCALLY AVAILABLE CNS MATERIAL.

1:50

REFERENCE DRAWING. ONLY FOR TENDER PROPOSE

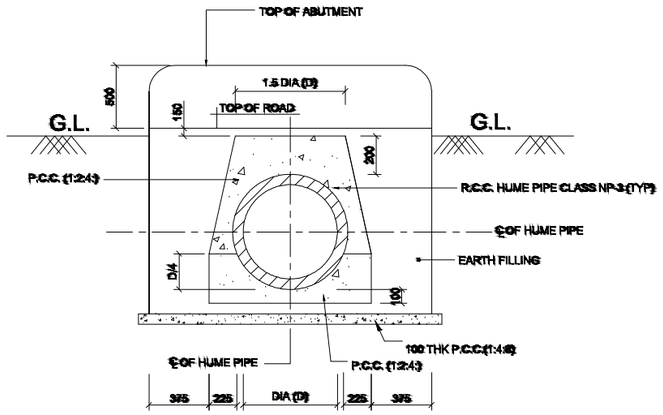
Rev.	Date	Description			Approved

NEPAL ELECTRICITY AUTHORITY
(GoN Undertaking)

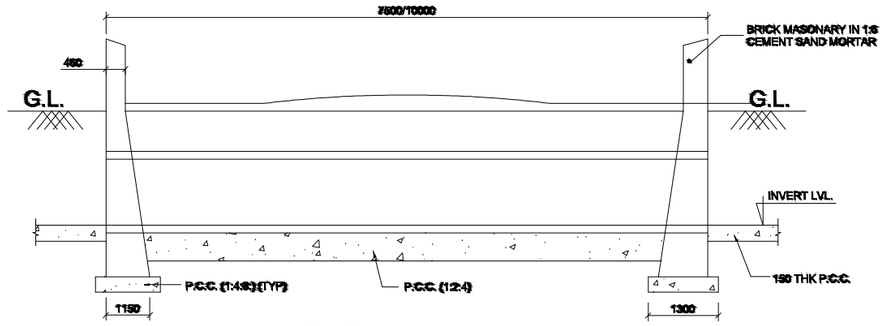
PROJECT MANAGEMENT DIRETORATE
ELECTRICITY GRID MODERNIZATION PROJECT

MULPANI SUBSTATION CONSTRUCTION PROJECT

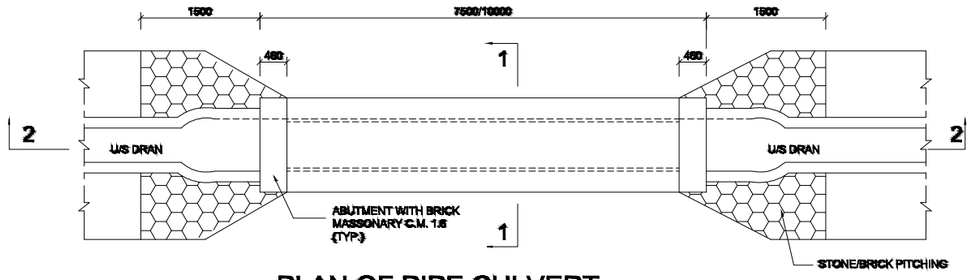
Title
CONCRETE ROAD IN SWITCHYARD AREA



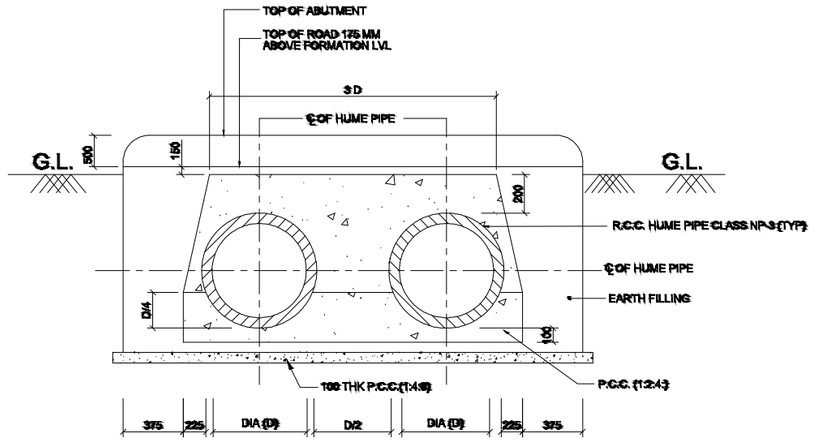
SECTION 1-1 FOR SINGLE PIPE



SECTION 2-2



PLAN OF PIPE CULVERT



SECTION 1-1 FOR DOUBLE PIPE CULVERT

NOTES:-

1. ALL DIMENSIONS ARE IN MM.
2. DO NOT SCALE THE DRG.
3. WORK SHALL BE DONE AS PER C.P.W.D. SPECIFICATION.

REFERENCE DRAWING. ONLY FOR TENDER PROPOSE

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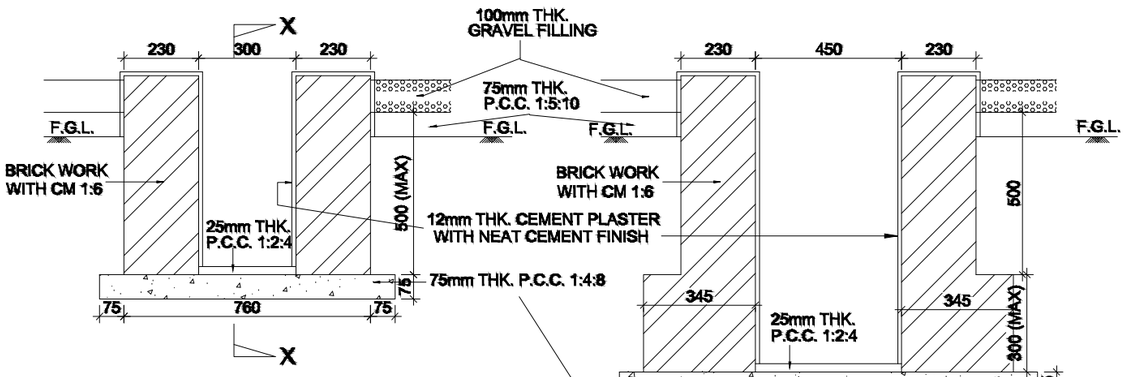
NEPAL ELECTRICITY AUTHORITY
(GoN Undertaking)
PROJECT MANAGEMENT DIRETORATE
ELECTRICITY GRID MODERNIZATION PROJECT

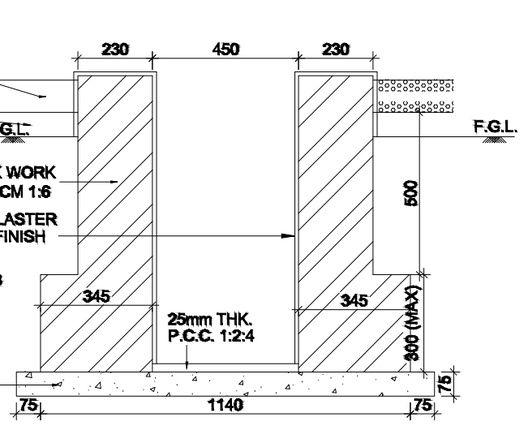
MULPANI SUBSTATION CONSTRUCTION PROJECT

Title
ROAD CULVERT



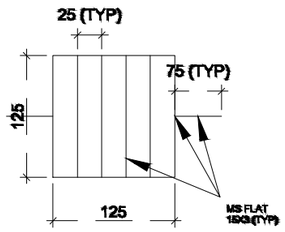
SECTION A-A

(FOR DEPTH UP TO 600 MM)

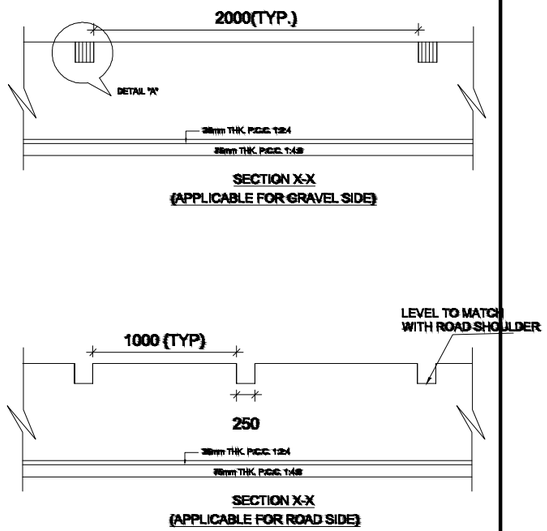


SECTION B-B

(FOR DEPTH FROM 600 TO 900 MM)

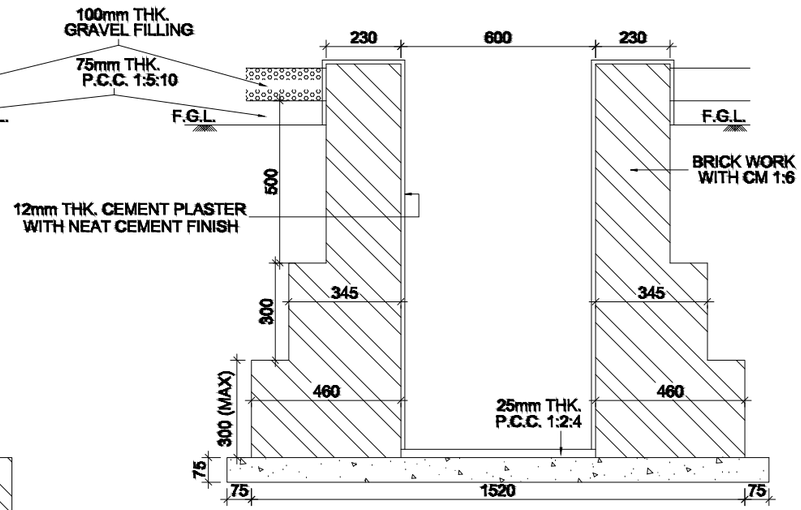


DETAIL "A"



SECTION D-D

(FOR DEPTH FROM 1200 TO 1500 MM)



SECTION C-C

(FOR DEPTH FROM 900 TO 1200 MM)

NOTES:-

1. ALL DIMENSIONS ARE IN MM. & ELEVATIONS ARE IN METRE UNLESS NOTED OTHERWISE.
2. ALL DRAINS SHALL BE GIVEN A MINIMUM SLOPE OF 1: 1000 IN THE LONGITUDINAL DIRECTION
3. MINIMUM DEPTH OF DRAIN SHALL BE 300MM BELOW FGL.
4. WHERE EVER TWO SECTIONS ARE MEETING A TRANSITION ZONE SHALL BE CONSTRUCTED HAVING LENGTH 1000mm.
5. 75X75mm WEEP HOLE SHALL BE PROVIDED AT SPACING OF 1500mm HORIZONTALY & 300mm VERTICALLY IN STAGGERED MANER.
6. DEPTH OFF DRAIN IS TAKEN AS HEIGHT FROM TOP OF DRAIN TO INVERT OF DRAIN
7. LAYOUT OF DRAIN WILL BE ISSUED DURING EXECUTION STAGE

REFERENCE DRAWING. ONLY FOR TENDER PROPOSE

Rev.	Date	Description			Approved

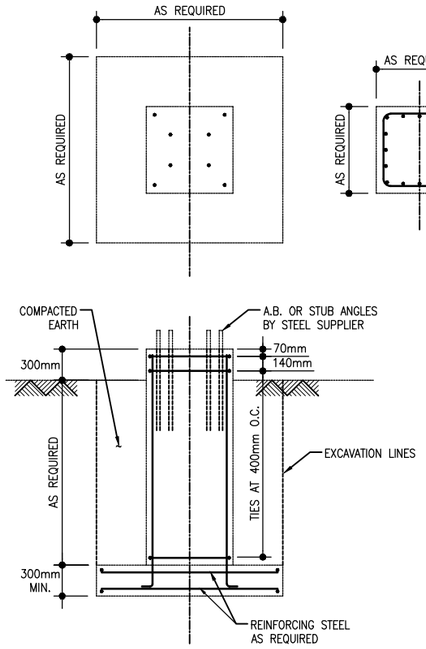
NEPAL ELECTRICITY AUTHORITY
(GoN Undertaking)
PROJECT MANAGEMENT DIRETORATE
ELECTRICITY GRID MODERNIZATION PROJECT

MULPANI SUBSTATION CONSTRUCTION PROJECT

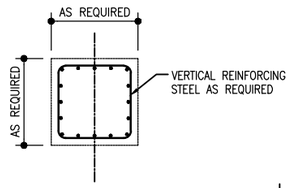
Title
DRAIN DETAIL

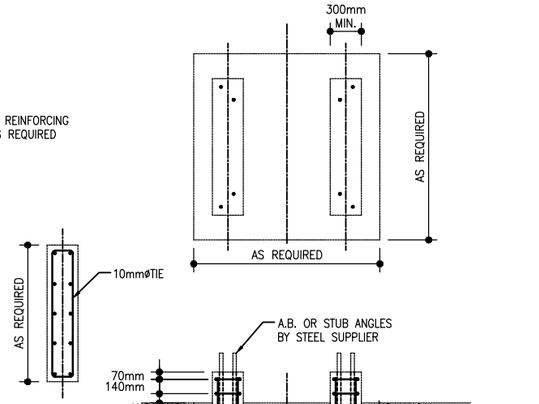
C:\SAMA\OM\SS-DWG-NEW

PLOT SCALE 1:1

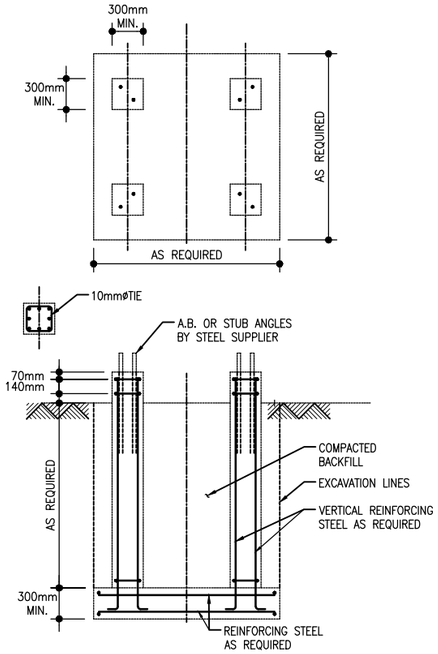


TYPICAL SINGLE PIER SPREAD FOOTING FOR 132kV EQUIPMENT AND EQUIPMENT SUPPORT STRUCTURES





TYPICAL SPREAD FOOTING FOUNDATION WITH TWO PIERS FOR EQUIPMENT AND EQUIPMENT SUPPORT STRUCTURES



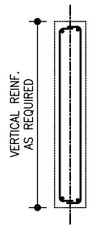
TYPICAL SPREAD FOOTING FOUNDATION WITH FOUR PIERS FOR EQUIPMENT AND EQUIPMENT SUPPORT STRUCTURES

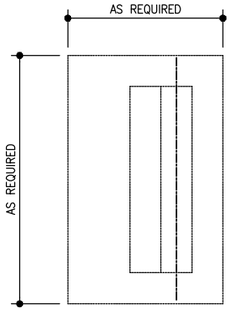
GENERAL NOTES

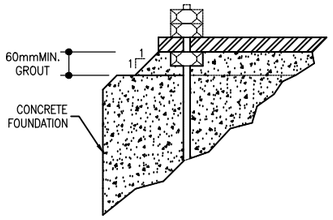
1. FOUNDATIONS OUTLINES AND DETAILS ILLUSTRATED ON THIS DRAWING ARE CONCEPTUAL ONLY AND ARE NOT RESTRICTED BEYONDTHE GENERAL OUTLINE CONFIGURATION AND MINIMUM DIMENSIONS.
2. FINAL FOUNDATION DESIGN SHALL BE BASED ON THE DESIGN PARAMETERS GIVEN IN THE SPECIFICATIONS.
3. FOR LOCATIONS AND LENGTH OF CABLE TRENCHES SEE GENERAL SUNSTATION LAYOUT DRAWINGS.

CONCRETE NOTES

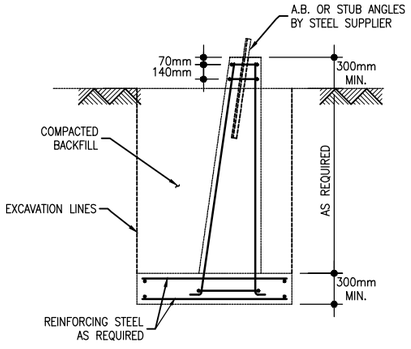
1. CONCRETE SHALL HAVE A 28 DAY MINIMUM COMPRESSIVE DESIGN STRENCTH OF 210kg/sq.cm.
2. ALL REINFORCING BARS SHALL BE DEFORMED NEW BILLET STEEL BAR CONFORMING TO ASTM A615 GRADE 60.
3. REINFORCING STEEL SHALL BE DETAILED AND FABRICATED IN ACCORDANCE WITH MANUAL OF STANDARD PRACTICE OF THE CONCETE REINFORCING STEEL INSTITUTE.
4. MINIMUM COVER FOR REINFORCING STEEL SHALL BE
   a. CONCRETE CAST AGAINST EARTH 75mm
   b. ALL OTHER CONCRETE 50mm
5. CONCRETE FOUNDATIONS SHALL HAVE THE FOLLOWING MINIMUM STEEL.
   a. FOUNDATION PIERS–0.003 GROSS AREA
   b. FOUNDATION FOOTINGS–0.003 AVERAGE GROSS AREA
6. ALL EXPOSED CONCRETE SHALL HAVE 20x20mm CHAMFER EDGES.



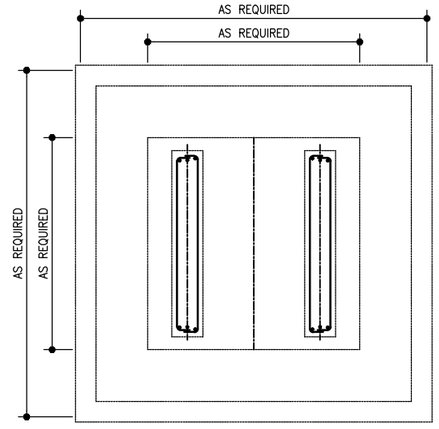


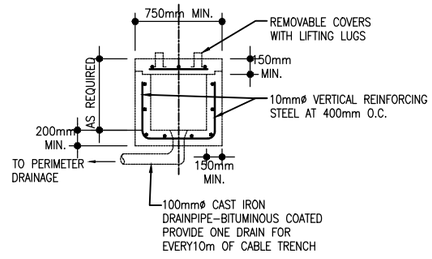


TYPICAL BASEPLATE AND GROUT DETAIL

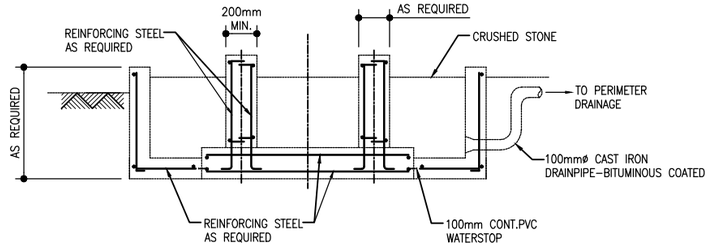


TYPICAL SPREAD FOOTING FOR 132kV GANTRY TOWER





TYPICAL CABLE TRENCH DETAIL
SLOPE TO DRAINAWAY FROM CONTROL BUILDING



132kV TRANSFORMER FOUNDATION WITH OIL CONTAINMENT

REFERENCE DRAWING. ONLY FOR TENDER PROPOSE

Rev.	Date	Description			Approved

NEPAL ELECTRICITY AUTHORITY
(GoN Undertaking)
PROJECT MANAGEMENT DIRETORATE
ELECTRICITY GRID MODERNIZATION PROJECT

MULPANI SUBSTATION CONSTRUCTION PROJECT

Title
TYPICAL EQUIPMENT FOUNDATION

Reference drawing only for tender proposes

Nepal electricity authority

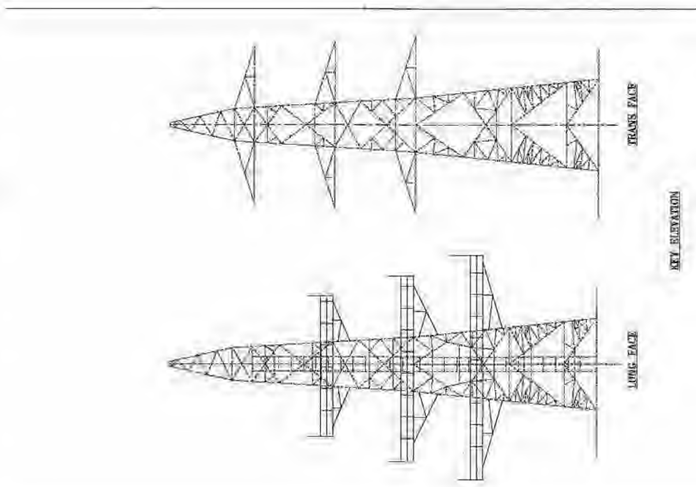
(GoN Undertaking)

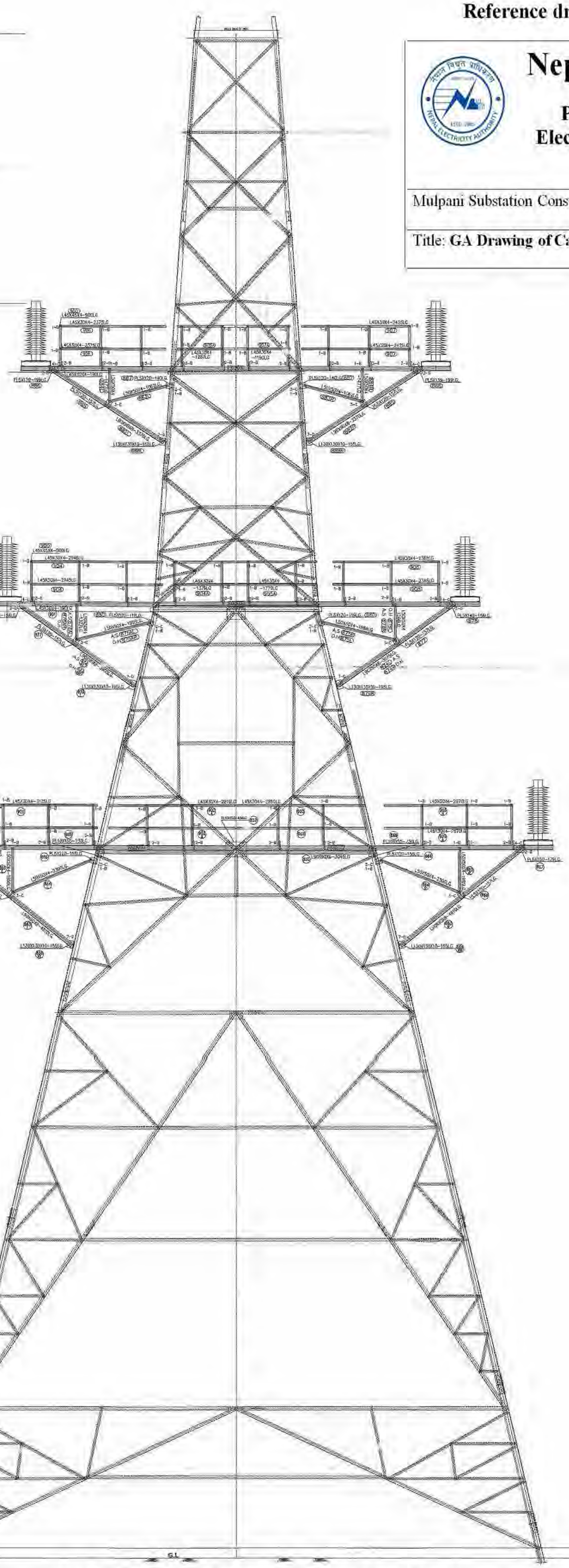
Project Management Directorate

Electricity Grid Modernization Project

Mulpani Substation Construction Project

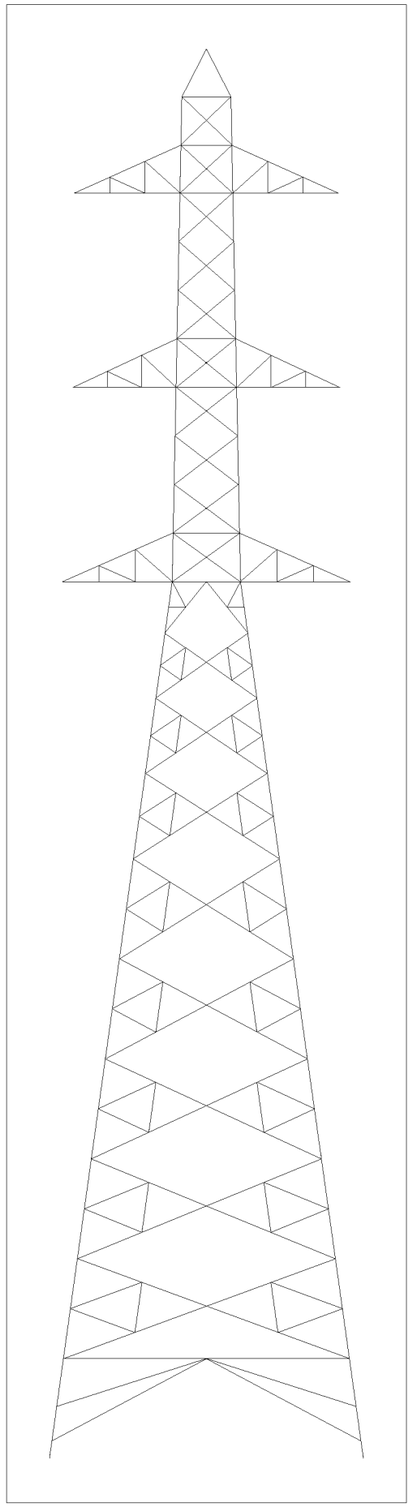
Title: **GA Drawing of Cable Termination & LA Mounting Long Face**

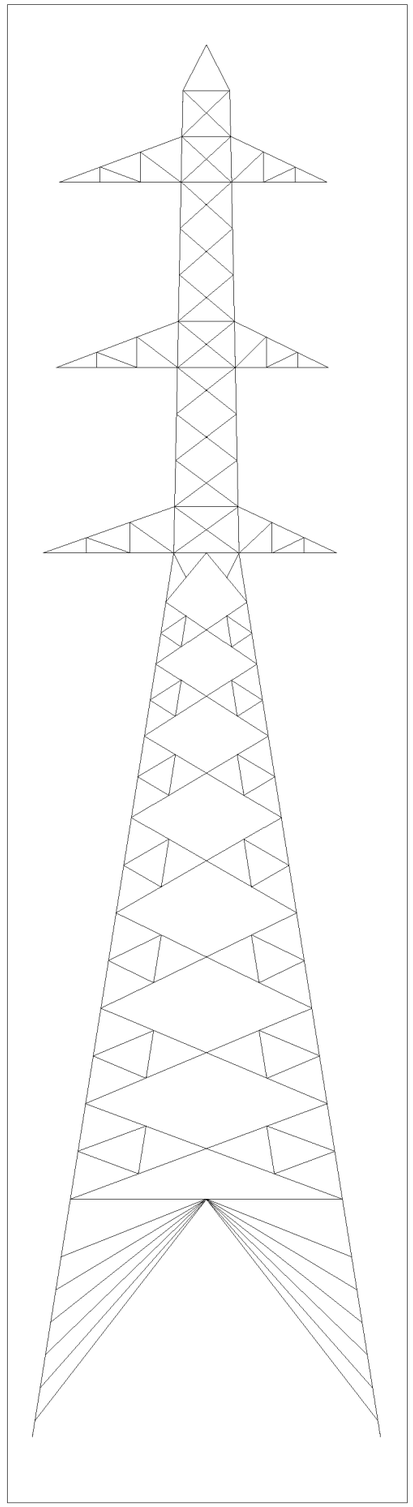




GA DRAWING OF CABLE TERMINATION & LA MOUNTING

LONG. FACE





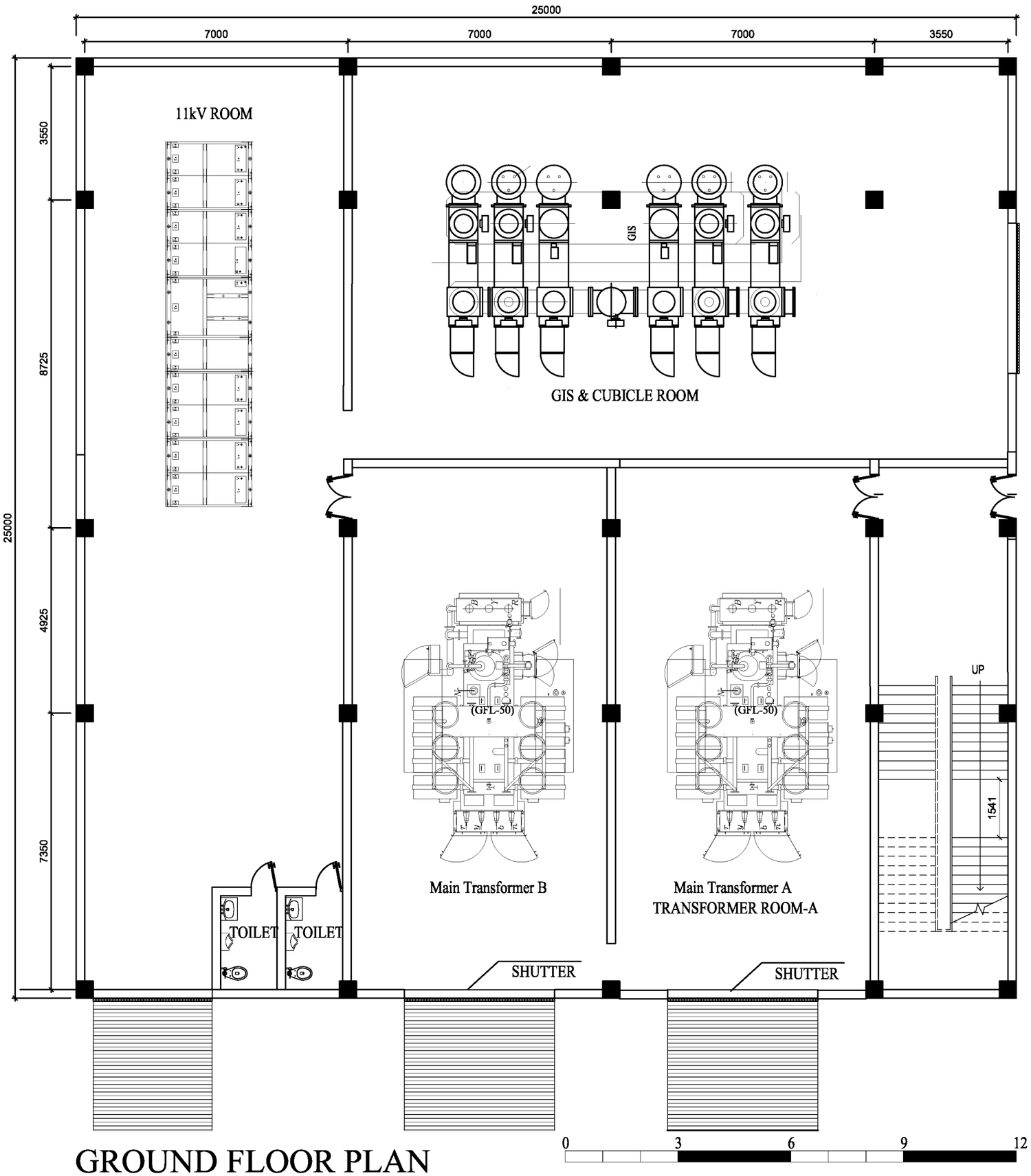
REFERENCE DRAWING. ONLY FOR TENDER PROPOSE

Rev.	Date	Description			Approved

NEPAL ELECTRICITY AUTHORITY
(GoN Undertaking)
PROJECT MANAGEMENT DIRETORATE
ELECTRICITY GRID MODERNIZATION PROJECT

MULPANI SUBSTATION CONSTRUCTION PROJECT

Title
TYPICAL DEAD END TOWER



GROUND FLOOR PLAN

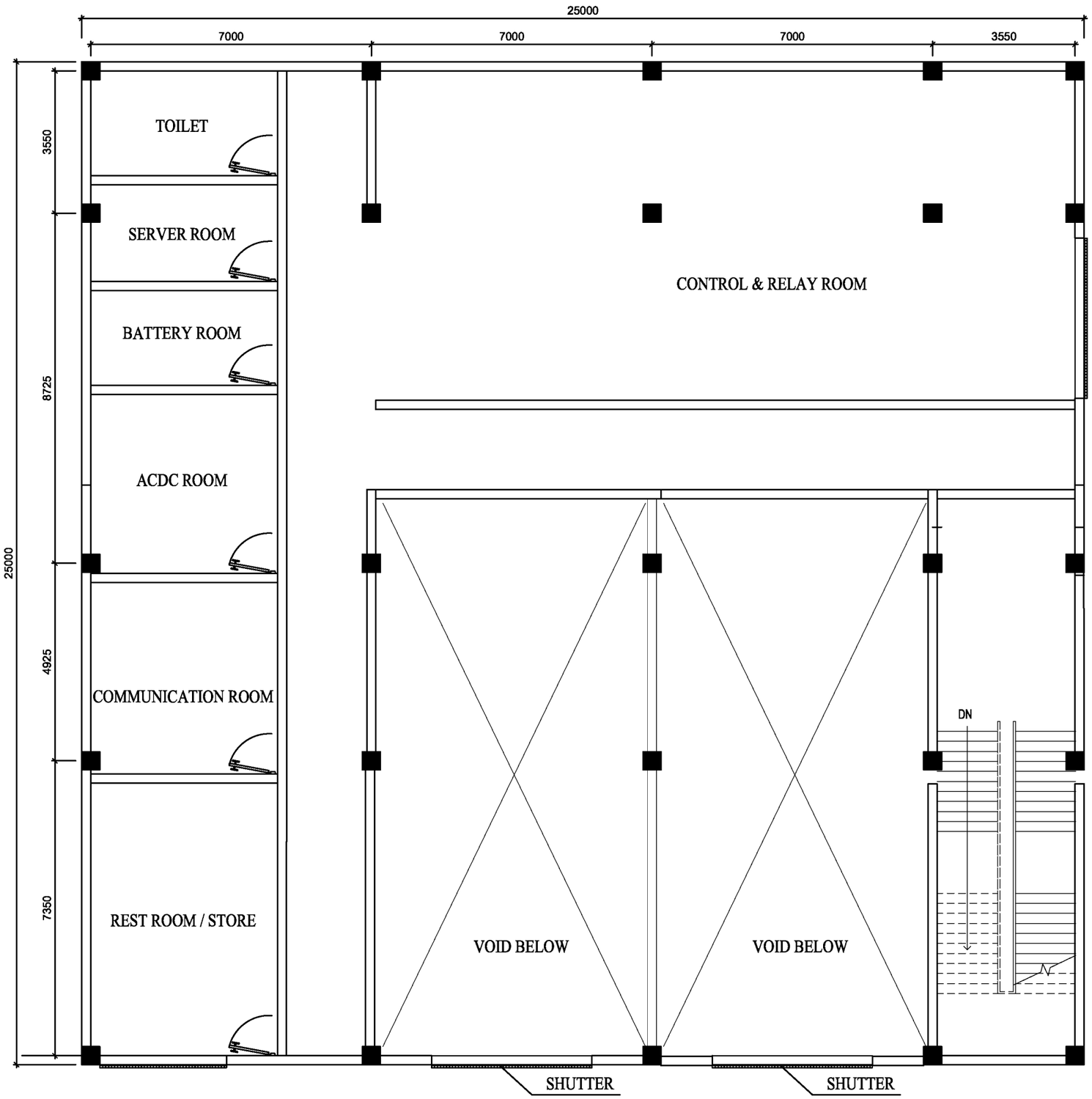
REFERENCE DRAWING. ONLY FOR CONCEPT

Reference drawing only for tender proposes

Nepal electricity authority
(GoN Undertaking)
Project Management Directorate
Electricity Grid Modernization Project

Mulpani Substation Construction Project

Title: Control building (Ground Level Plan)



FIRST FLOOR PLAN

0 3 6 9 12

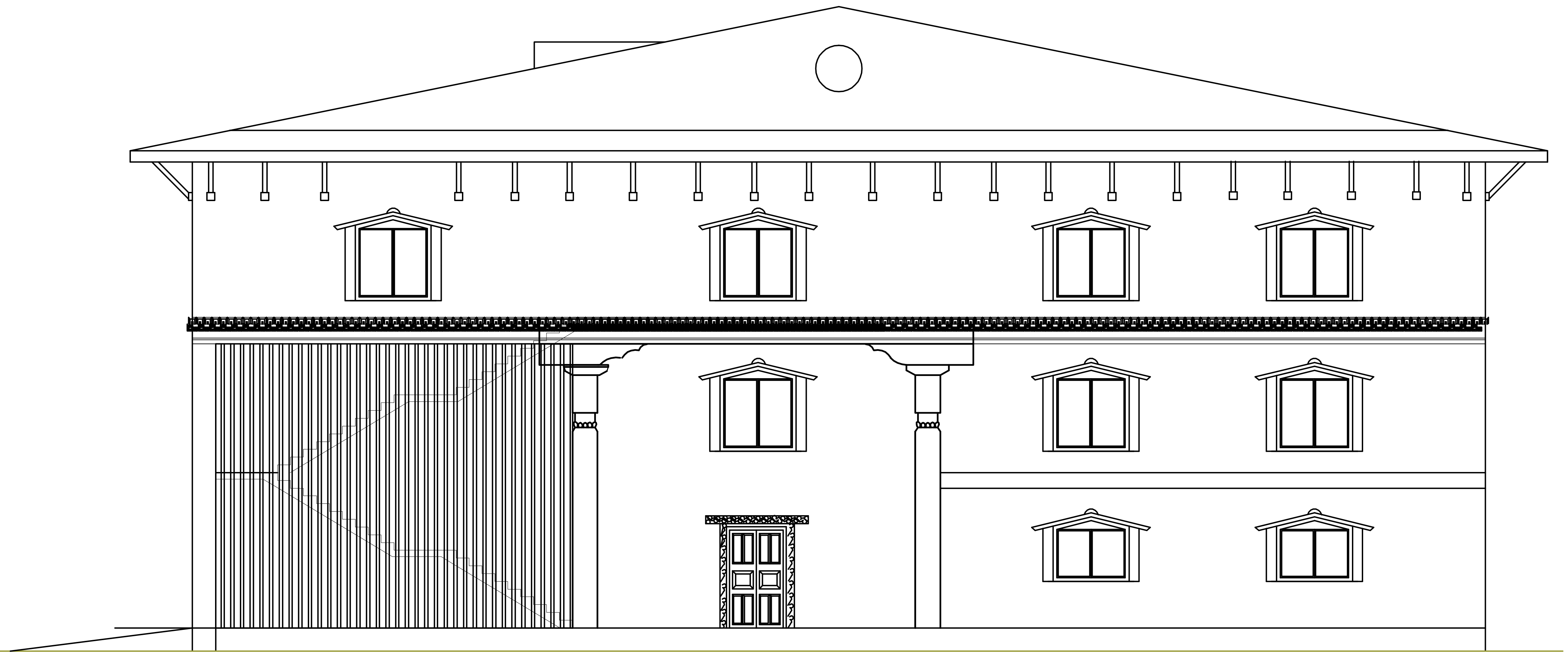
REFERENCE DRAWING. ONLY FOR CONCEPT

Reference drawing only for tender proposes

Nepal electricity authority
(GoN Undertaking)
Project Management Directorate
Electricity Grid Modernization Project

Mulpani Substation Construction Project

Title: Control building (First Level Plan)



EAST ELEVATION

0 3 6 9 12

REFERENCE DRAWING, ONLY FOR CONCEPT
DETAIL DRAWING SHALL BE PROVIDED LATER

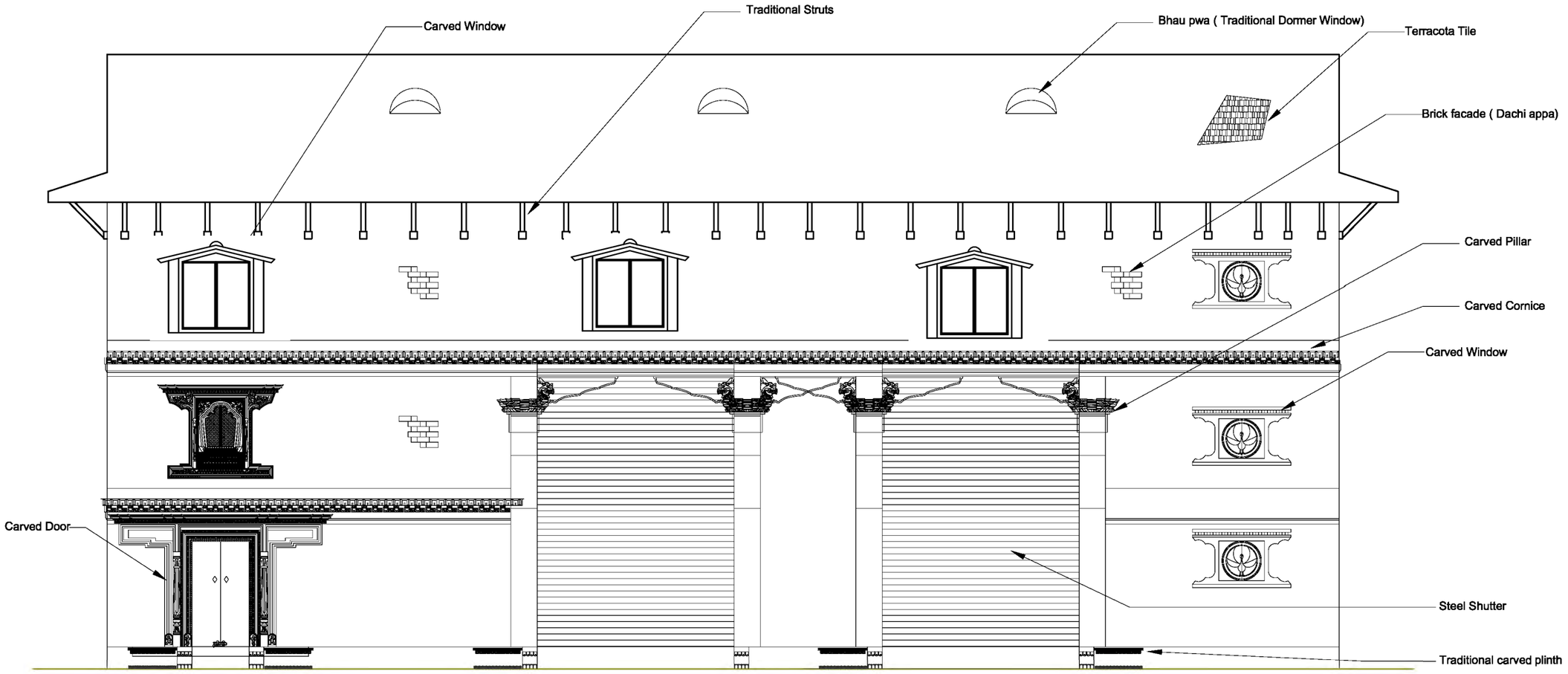
FOR TENDER PURPOSE ONLY.

Reference drawing only for tender proposes

Nepal electricity authority
(GoN Undertaking)
Project Management Directorate
Electricity Grid Modernization Project

Mulpani Substation Construction Project

Title: Control building (Front Elevation)



SOUTH ELEVATION

0 3 6 9 12

REFERENCE DRAWING. ONLY FOR CONCEPT

Rev.	Date	Description	Approved

Reference drawing only for tender proposes

Nepal electricity authority
(GoN Undertaking)
Project Management Directorate
Electricity Grid Modernization Project

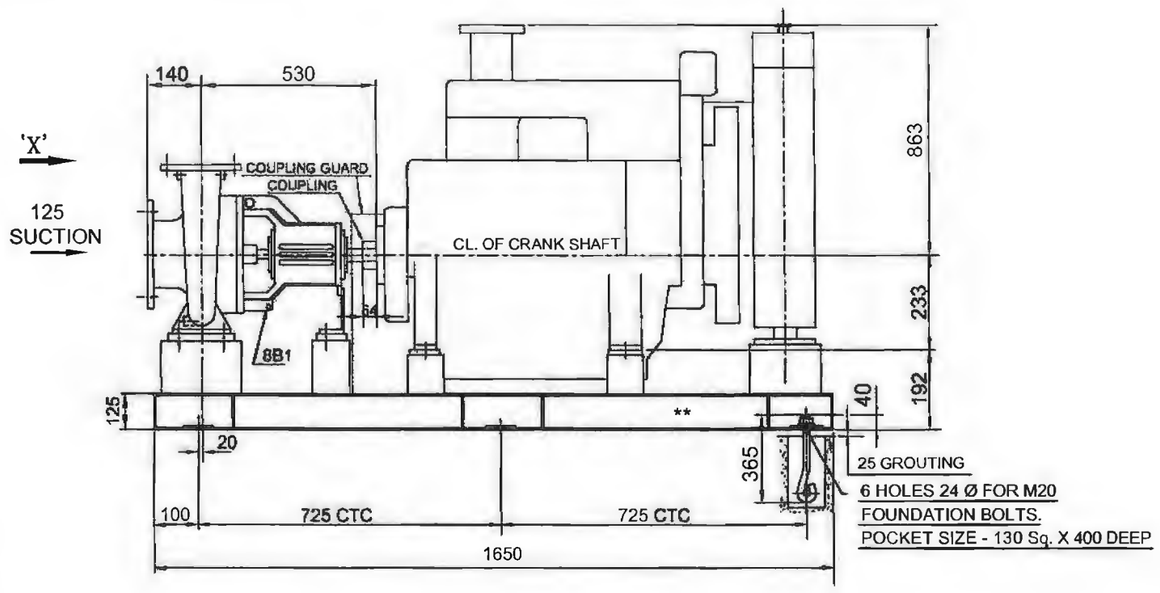
Mulpani Substation Construction Project

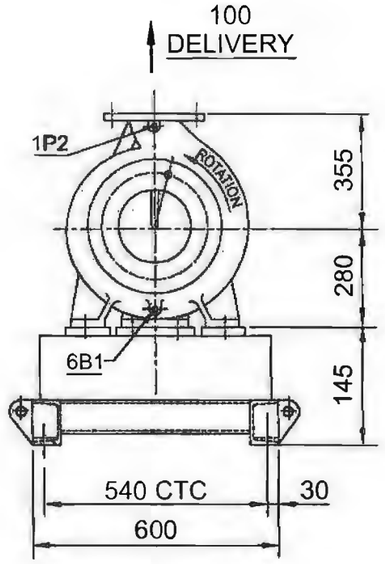
Title: Control building (Front Elevation)

DRG. No. AIL/PGCIL/BR/EL/GA/PU/24/R0

QUOTATION NO:- 81064207 / 10

TAG NO. ENGINE DRIVEN HYDRANT PUMP.





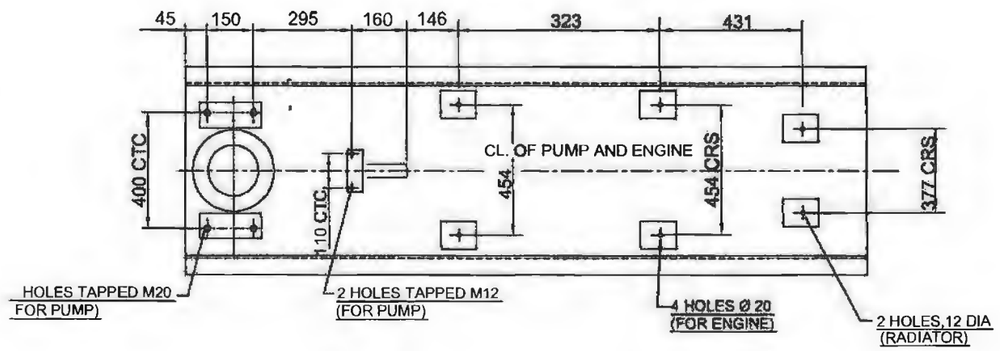
VIEW FROM ARROW `X'
ONLY FOR PUMP

NOTE

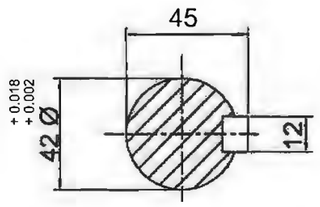
ALL CONNECTIONS ARE PLUGGED EXCEPT 8B1

BEARING - ANTIFRICTION , GREASE SHIELDED BEARING

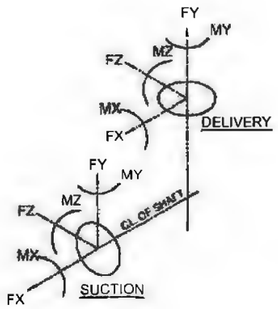
*NOTE:- GROUTING TO BE DONE INSIDE THE BASEPLATE & UPTO THE TOP OF BASE CHANNEL



PLAN VIEW OF BED PLATE.



DETAILS OF PUMP SHAFT
COUPLING END.



PUMP FLANGE DRILLING DETAILS AS PER ANSI B 16.1 CLASS125 FF

BRANCH NOM.SIZE IN MM.	O/D	P.C.D.	NO & SIZE OF HOLES OFF CLS.	THICK	R F. FLANGE		COMP. FLANGE	
					R.F. DIA	R.F. THK.	I/DIA.	THK
SUCTION DIA.125	254	216	8 - DIA 22	24	-	-	-	-
DELIVERY DIA.100	229	191	8-M16	24	-	-	-	-

MAXIMUM ALLOWABLE NOZZLE LOADS

BRANCH	FORCES IN KG.			MOMENTS IN KG.M.		
	FX	FY	FZ	MX	MY	MZ
SUCTION 125	254	165	200	180	140	105
DELIVERY 100	145	182	127	136	103	70

CONNECTIONS			
ITEM	DESCRIPTION	SIZE	QTY
1P2	PRESSURE GAUGE FOR DELIVERY.	3/8" BSP	1
6B1	CASING DRAIN.	3/4" BSP	1
8B1	GLAND DRAIN.	1/2" BSP	1

APPROXIMATE WEIGHTS IN Kgs.	
PUMP	150
ENGINE	380
BED PLATE	150
COUPLING & GUARD	25
TOTAL WEIGHT	1050
LOAD DETAILS IN KGS.	
STATIC LOAD OF PUMPSETS.	1050
DYNAMIC LOAD OF PUMPSETS.	1310

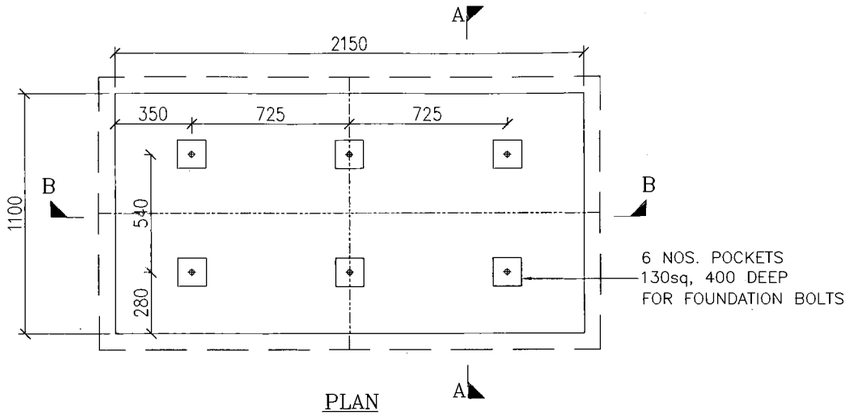
Reference drawing only for tender proposes

Nepal electricity authority
(GoN Undertaking)
Project Management Directorate
Electricity Grid Modernization Project

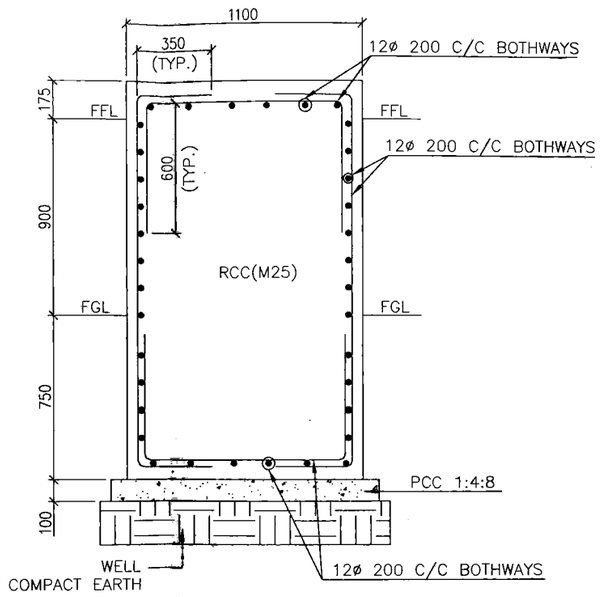
Mulpani Substation Construction Project

Title: **General Arrangement Drawing for Pump**

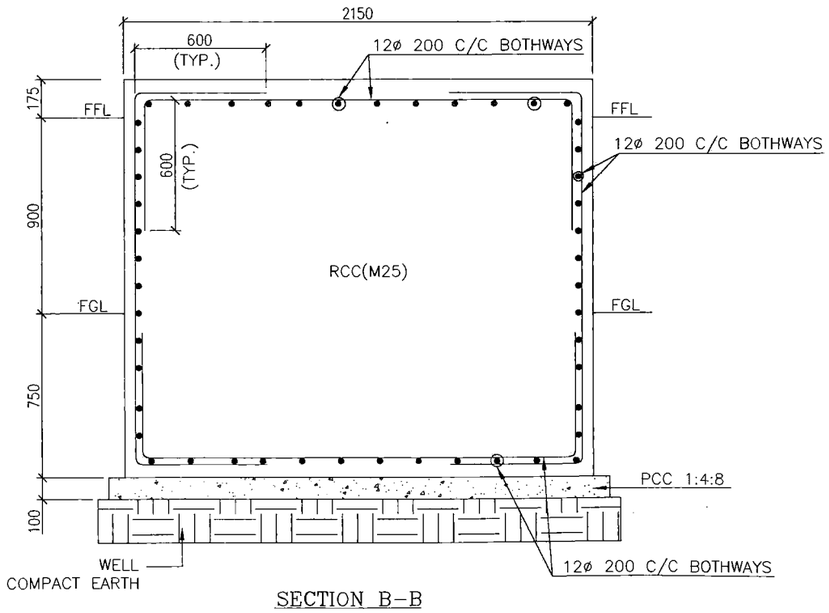
A1 SHEET - 841x594mm



PLAN



SECTION A–A



SECTION B–B

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES AND LEVELS ARE IN METRES.
2. GRADE OF STRUCTURAL CONCRETE SHALL BE–M25, P.C.C(1:4:8).
3. REINFORCEMENT BARS SHALL BE HIGH BOND HIGH YIELD STRENGTH DEFORMED CORROSION RESISTANT RIBBED TMT BARS OF GRADE Fe500 CONFORMING TO INTERNATIONAL STANDARDS.
4. CLEAR COVER TO MAIN REINFORCEMENT SHALL BE AS FOLLOWS:
   a) FOUNDATION–50 M.M.
5. ALL BOND LENGTH & LAP LENGTH SHALL BE 50XDIA. OF BAR.

Reference drawing only for tender proposes

Nepal electricity authority

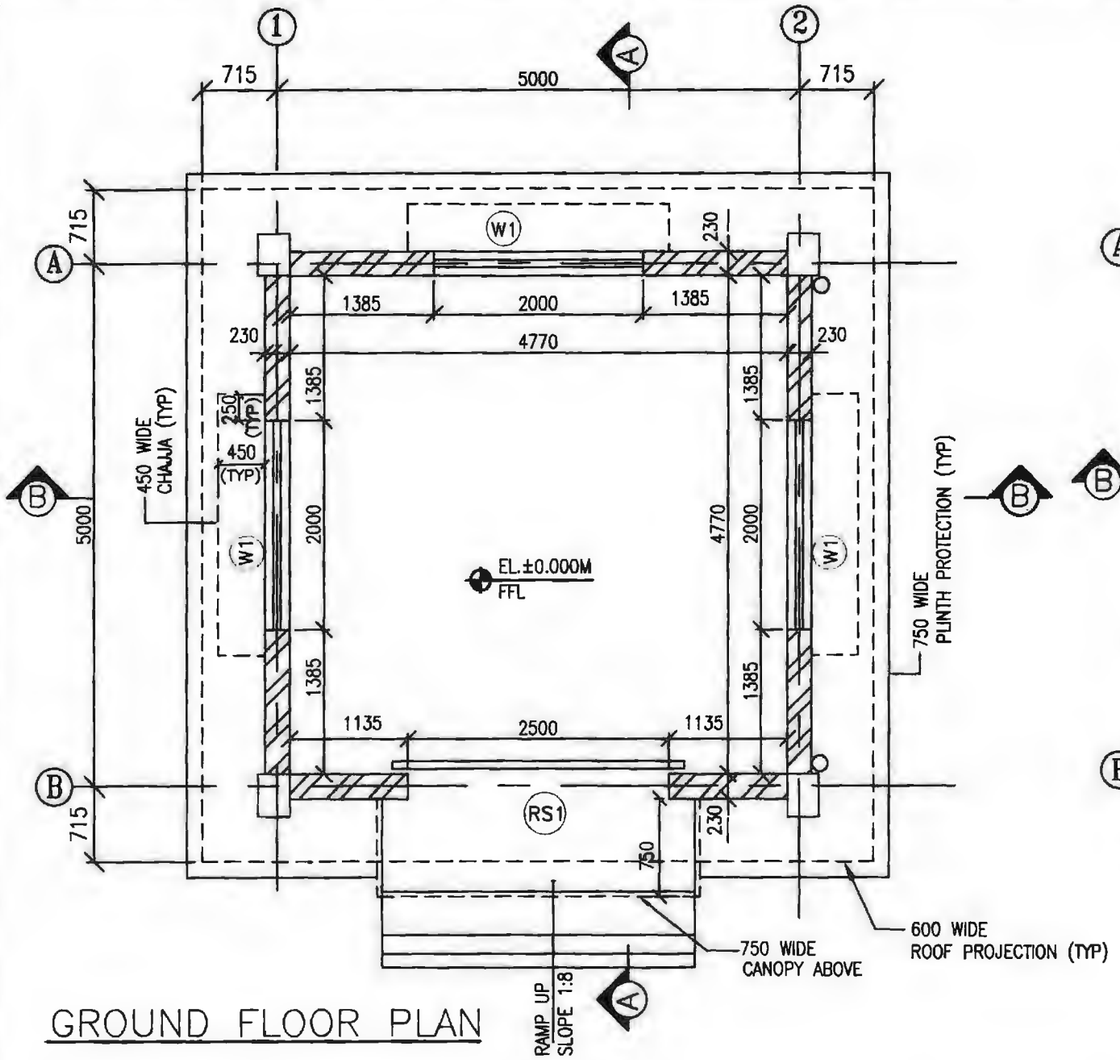
(GoN Undertaking)

Project Management Directorate

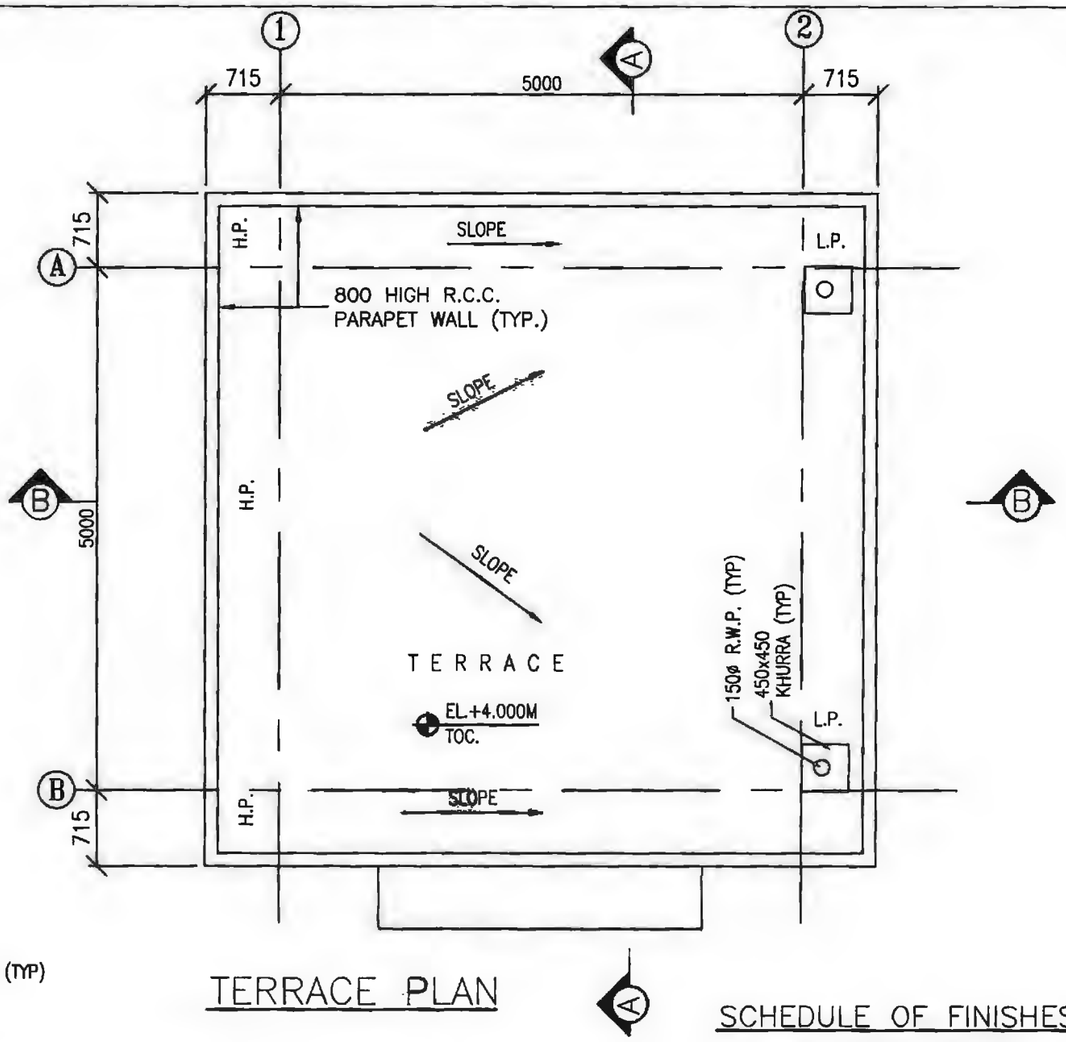
Electricity Grid Modernization Project

Mulpani Substation Construction Project

Title: **Pump Foundation Plan And Section Substation**



GROUND FLOOR PLAN



TERRACE PLAN

SCHEDULE OF FINISHES

1.0 BRICK WORK:

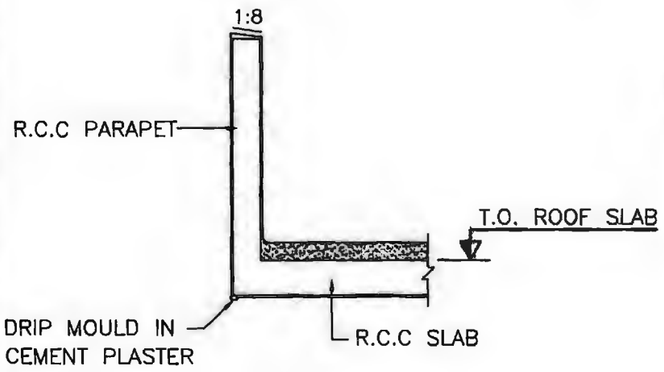
1.1 230mm THK. BRICK MASONARY IN C.M. (1:6)

2.0 FLOORING:

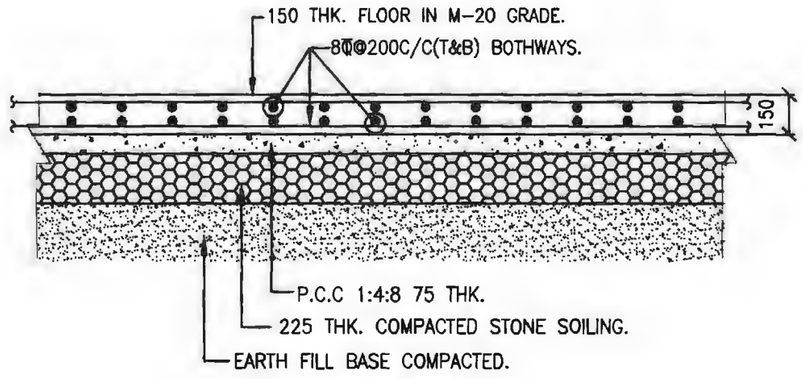
3.1 HARDCRETE FLOORING

3.2 SKIRTING:
150 HIGH SKIRTING MATCHING WITH THE FLOOR SHALL BE PROVIDED.

3.0 PLASTERING & FINISHING DETAILS SHALL BE AS PER SPECIFICATION



TYP. DETAIL OF PARAPET



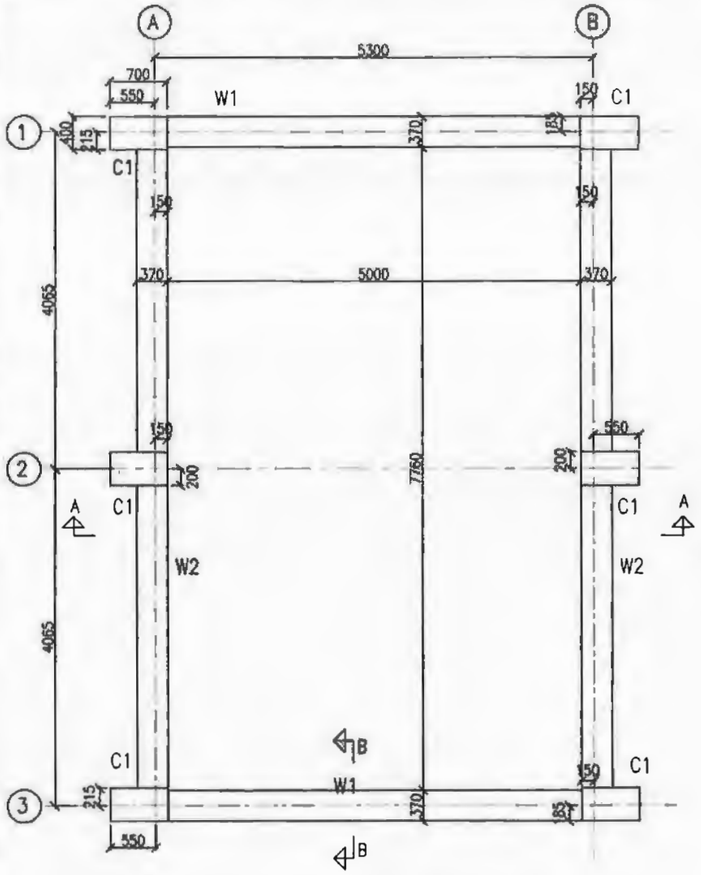
DETAIL OF GRADE SLAB

Reference drawing only for tender proposes

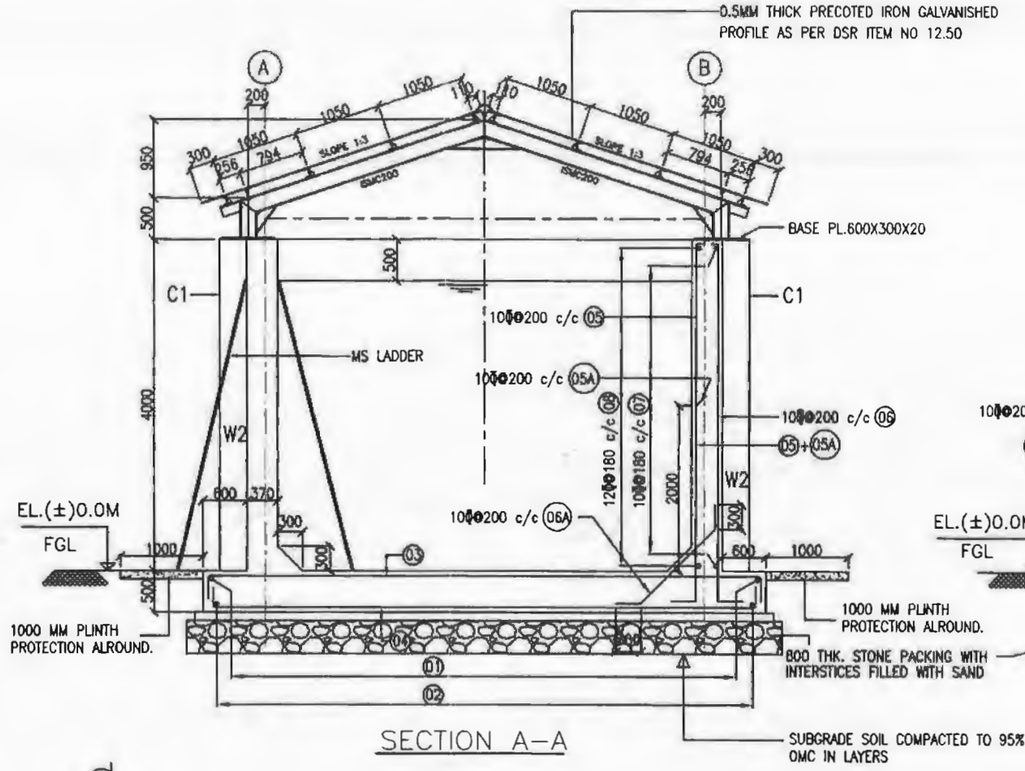
Nepal electricity authority
(GoN Undertaking)
Project Management Directorate
Electricity Grid Modernization Project

Mulpani Substation Construction Project

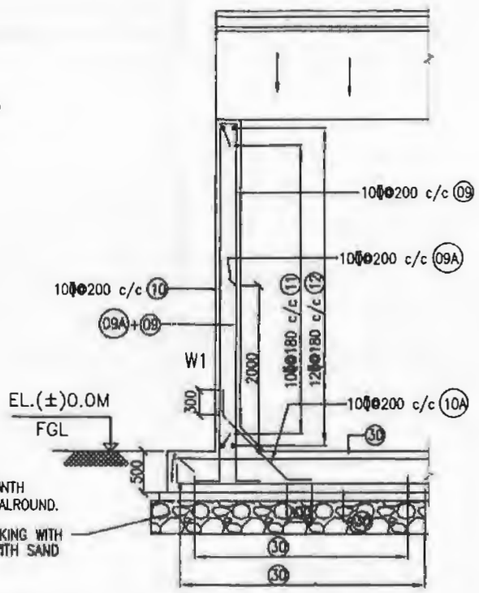
Title: **Fire Control House Arch. Plan, Elevations, Sections And Details**



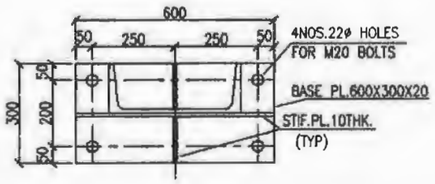
PLAN AT TOP OF TANK



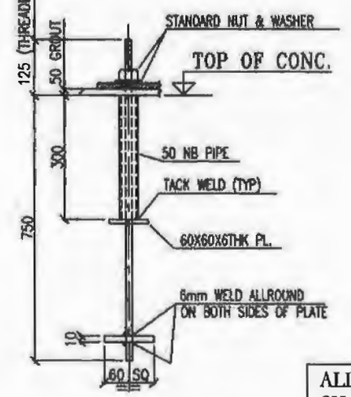
SECTION A–A



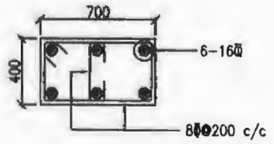
SECTION B–B



DETAIL OF BASE PLATE



TYP. DET. OF M20Φ BOLTS



COL. C1

ALL THE INSERT NOZZLES, FIRE SLEEVES ETC. SHALL BE AS PER APPROVED DESIGN OF FIRE FIGHTING SYSTEM.

FOR TENDER REFERENCE ONLY

Reference drawing only for tender proposes

Nepal electricity authority

(GoN Undertaking)

Project Management Directorate

Electricity Grid Modernization Project

Mulpani Substation Construction Project

Title: **Fire Control House, Water Tank Details**