# Nepal Electricity Authority

(A Government of Nepal Undertaking)

## Transmission Directorate

## Grid Development Department

**Burtibang Paudi-Amarai Tamghas Sandhikharka Gorushinge 132kv Transmission Line Project**

**Bidding Document**
**For**
**"Design, Supply, Construction, Testing And Commissioning of Motipur and Sandikharka 132/33/11 kV, Substation"**

**International Competitive Bidding (ICB)**
**(Single Stage, Two Envelope Bidding Procedure)**

**IFB No: BPTSG-074/75-02**

**Employer: Nepal Electricity Authority**

**Burtibang Paudi-Amarai Tamghas Sandhikharka Gorushinge 132kv Transmission Line Project**

**VOLUME II-A OF III**

**Date: November 2017**

# Abbreviations

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

# BIDDING DOCUMENT

## TECHNICAL BID

## PROCUREMENT OF WORKS
## International Competitive Bidding (ICB)
## Single Stage two Envelope Bidding

**"Design, Supply, Construction, Testing And Commissioning of Motipur and Sandikharka 132/33/11 kV, Substation."**

**Issued on:**

**Bid Document issued to:**

**Contract Identification No:** BPTSG-074/75-02

**Project Name :** *Burtibang Paudi-Amarai Tamghas Sandhikharka Gorushinge 132kV Transmission Line Project*

**Office Name :** *Nepal Electricity Authority*

**Office Address:** *Kharipati, Bhaktapur, Nepal*

Financing Agency: Government of Nepal (GoN), Nepal

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# CHAPTER 1-PROJECT SPECIFIC REQUIREMENT

## 1.0 GENERAL

**1.1.1** Nepal Electricity Authority is establishing new 132/33/11 kV Substation at Motipur Danda of Kapivastu District and Futbang, Sandhikharka of Arghakhachi District under Burtibang Paudi-Amarai Tamghas Sandhikharka Gorushinge 132kV Transmission Line Project. The above project is being implemented by Nepal Electricity Authority funded from Government of Nepal, as part of the above Transmission Line project.

*Design, engineering, drawing and construction of works shall satisfy the general technical requirements specified in the Specification or* ***implied as per relevant IEC/IEEE/ IS/ASTM/British standard codes (B S Codes)/ equivalent International Standards****.*

### 1.1.2 Associated Transmission System:

The following transmission system is envisaged under Burtibang Paudi-Amarai Tamghas Sandhikharka Gorushinge 132kV Transmission Line Project as per present scope.

**Transmission lines**

1. Burtibang Paudi-Amarai Tamghas Sandhikharka Gorushinge 132 kV D/C Lines: 36.31 km (along with OPGW)

**Substations**

1. Construction of 132/33/11kV New substation at Motipur Danda
2. Construction of 132/33/11kV New substation at Futbang Sandhikharka.

## 2.0 SCOPE

**2.1** The scope of this specification covers the following package for substation works associated with under BPTSG 132kV Transmission Line Project.

**A. Construction of a new 132/33/11kV substation at Motipur Danda with the provision of following bays as per Single Line Diagram:**

i. 132 kV bays, 6 nos. for LILO of 132 kV Butwal-Chanauta Existing D/C Line & proposed 132kV Motipur-Sandhikharka D/C Lines.

ii. 132 kV bays, 1 nos. for 132/33 KV, 24/27/30 MVA, Power Transformer.

iii. 132kV Bay, 1 No for Bus Coupler.

iv. 33 kV Bays, 4 Nos. for 33kV Outgoing Lines.

v. 33kV Bay, 1 Nos. for 33/11 kV, 16 MVA Power transformers.

vi. 11kV Indoor Switchgear comprising of 3 nos. 11kV line bays, 01 no. transformer incomer bays from 16MVA, 33/11kV transformer.

vii. Supply, erection, testing and commissioning of transformers 24/27/30 MVA, 132/33 kV and 16 MVA 33/11 kV Power Transformer.

**B. Construction of a new 132/33/11kV substation at Sandhikharka with the provision of following bays as per Single Line Diagram:**

i. 132 kV bays, 4 nos. for proposed 132kV Motipur-Sandhikharka & Sandhikharka-Tamghas D/C Lines.

ii. 132 kV bays, 1 nos. for 132/33 KV, 24/27/30 MVA, Power Transformer.

iii. 132kV Bay, 1 No for Bus Coupler.

iv. 33 kV Bays, 4 Nos. for 33kV Outgoing Lines.

v. 3kV Bay, 1 Nos. for 33/11 KV, 16 MVA Power transformers.

vi. 11kV Indoor Switchgear comprising of 3 nos. 11kV line bays, 01 no. transformer incomer bays from 16MVA, 33/11kV transformer.

vii. Supply, erection, testing and commissioning of transformers 24/27/30 MVA, 132/33 kV and 16 MVA 33/11 kV Power Transformer.

**C. Supply, Installation, testing & commissioning of communication equipment's (Fibre Optic based) for Burtibang Paudi-Amarai Tamghas Sandhikharka Gorushinge 132kV Transmission Line Project, as per Technical specification for Fibre Optics Based Communication Equipment's is included in the present scope of work.**

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

**Substation Package associated with Burtibang Paudi-Amarai Tamghas Sandhikharka Gorushinge 132kV Transmission Line Project**

**(A) 132/33/11kV Substation (New) at Motipur Substation**

(i) Design, engineering, manufacture, testing at manufacturer's works, transportation, unloading and delivery at site including insurance & storage, erection, testing and commissioning at Site, complete in all respect for the above mentioned power transformers.

(ii) Design, engineering, manufacture, testing, supply on for destination site basis including transportation & insurance, storage, erection, testing and commissioning of the following equipment's/items, complete in all respects.

(a) 132kV, 33kV & 11kV circuit breakers, isolators, earth switches, current transformers, capacitor voltage transformers, PT and surge arresters.

(b) 200KVA, 33/0.4kV Distribution transformer along with associated equipment i.e. surge arrester & 33kV power fuse etc.

(c) Complete Relay & Protection System as per of Chapter - C & R Panels of the Technical Specifications.

(d) Complete Substation automation including hardware and software for remote control station along with associated equipment's for following bays (bay as defined in technical specification, Sec.-Substation Automation):

| S.No. | Description | At Motipur |
|---|---|---|
| 1. | **132 kV bays** | 06 |
| 2. | **132/33 kV Transformer bay** | 01 |
| 2. | **33 kV bays** | 04 |
| 3. | **11 kV bays** | 04 |

The contractor shall also supply necessary BCU for monitoring and control of auxiliary supply including operation of Isolators associated with Auxiliary transformer.

(e) For existing 132kV Motipur-Butwal and Motipur-Chanauta D/C Lines, Digital Protection Coupler (2 Nos. at each end, *i.e. 2 Nos. at Motipur and Butwal substation for Motipur-Butwal D/C lines and 2 Nos. at Motipur and Chanauta Substation for Motipur-Chanauta D/C lines*) and for proposed Motipur-Sandhikharka D/C Lines Digital Protection Coupler 2 Nos. at Motipur substation end shall be used for protection application. Each DPC shall be equipped with 4 commands. The above DPC shall have communication port matching to that being provided in the FO communication SDH panel and all accessories, cabling etc. required to interface with SDH/MUX telecommunication terminal equipment (located in the Control Room) for its commissioning is in present scope of Project. 48volt power supply cable, Control Cable from DPC to relay panel shall be laid as per location of DPC panel. The specification for the digital protection coupler shall be as per **Annexure I.**

(f) Air Conditioning System

(g) LT switchgear (AC/DC Distribution boards).

(h) Batteries & Battery Chargers

(i) 600V grade Power & Control cables along with complete accessories. Auxiliary Power supply and control cables from control room/ switchyard panel room and RTCC panel to common marshalling box of transformer/ reactor are also in present scope of work. HV cable from substation boundary to the LT yard as per requirement.

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

(k) Bus Post Insulators, insulator strings and hardware, clamps & connectors, Equipment terminal connectors including for 11 kV XLPE Power Cable, Conductors, Aluminum tubes, Bus bar and earthing materials, Bay marshalling box, spacers, cable supporting angles/channels, Cable trays & covers, Junction box, buried cable trenches.

(l) Complete lighting and illumination for the switchyard including street Lightning, Control Room cum administrative building etc.

(n) Earthing and lightning protection system

(o) 33 and 11 kV Cable extension as per approved layout.

(p) Mandatory Spares.

(q) Any other equipment/material required to complete the specified scope.

(iii) Design, engineering, manufacture, testing, supply on destination site basis including transportation & insurance, storage at site of mandatory spares.

(iv) Installation, testing and commissioning of complete in all respect for the above mentioned equipment's.

(v) **Civil Works** - The scope of work shall include but shall not be limited to the following based on design and drawings to be developed by the contractor:-

a) Foundations of Power Transformers along with jacking pad and pylon supports, rail track and fire resistant wall between Transformers whenever applicable.

b) Foundation for all towers, equipment's support structures and LT Transformers.

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

d) All roads including culverts as approved by project office. Roads within boundary wall shall be flexible type i.e. asphalt concrete. The approach road along with culvert between main boundary wall of substation and adjoining Main road shall also be constructed by the contractor with culverts, crossings, and other structures wherever required.

e) Antiweed treatment, PCC and Stone spreading in switchyard area.

f) Control cum administrative building.

g) Drains along with crossings with cable trenches. Drain layout shall be developed by the contractor.

h) Fencing for switchyard with gates.

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

j) Surveying, Soil investigation, contouring, leveling and filling. The leveling and filling (to an approximate depth as per requirement) in the area under present scope

of work inside substation is to be carried out to achieve finished ground level. The finished ground level shall be provided during detail engineering.

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

(l) Employer's quarters, Guard House and Store buildings.

(m) Cutting and clearing of trees and bushes in yard if any.

**(B) 132/33/11kV Substation (New) at Sandhikharka Substation**

(i) Design, engineering, manufacture, testing at manufacturer's works, transportation, unloading and delivery at site including insurance & storage, erection, testing and commissioning at Site, complete in all respect for the above mentioned power transformers.

(ii) Design, engineering, manufacture, testing, supply on for destination site basis including transportation & insurance, storage, erection, testing and commissioning of the following equipment's/items, complete in all respects.

(a) 132kV, 33kV & 11kV circuit breakers, isolators, earth switches, current transformers, capacitor voltage transformers, PT and surge arresters.

(b) 200KVA, 33/0.4kV Distribution transformer along with associated equipment i.e. surge arrester & 33kV power fuse etc.

(c) Complete Relay & Protection System as per of Chapter - C & R Panels of the Technical Specifications.

(d) Complete Substation automation including hardware and software for remote control station along with associated equipment's for following bays (bay as defined in technical specification, Sec.-Substation Automation):

| S.No. | Description | At Sandhikharka |
|---|---|---|
| 1. | **132 kV bays** | 04 |
| 2. | **132/33 kV Transformer bay** | 01 |
| 2. | **33 kV bays** | 04 |
| 3. | **11 kV bays** | 04 |

The contractor shall also supply necessary BCU for monitoring and control of auxiliary supply including operation of Isolators associated with Auxiliary transformer.

(e) For proposed Sandhikharka-Motipur D/C Lines and Sandikharka-Tamghas D/C Lines Digital Protection Coupler (2 Nos. for both line) at Sandhikharka substation end shall be used for protection application. Each DPC shall be equipped with 4 commands. The above DPC shall have communication port matching to that being provided in the FO communication SDH panel and all accessories, cabling etc.

required to interface with SDH/MUX telecommunication terminal equipment (located in the Control Room) for its commissioning is in present scope of Project. 48volt power supply cable, Control Cable from DPC to relay panel shall be laid as per location of DPC panel. The specification for the digital protection coupler shall be as per **Annexure I.**

(f) Air Conditioning System
(g) LT switchgear (AC/DC Distribution boards).
(h) Batteries & Battery Chargers
(i) 600V grade Power & Control cables along with complete accessories. Auxiliary Power supply and control cables from control room/ switchyard panel room and RTCC panel to common marshalling box of transformer/ reactor are also in present scope of work. HV cable from substation boundary to the LT yard as per requirement.
(j) Lattice or pipe structures (galvanized): 132/33kV Towers/gantry structures, Beams and equipment support structure, support structure for 33 and 11 kV XLPE power cable termination shall be provided as per design and drawings to be developed by the contractor. However the supply of support structure for circuit breaker is under scope of CB manufacturer.
(k) Bus Post Insulators, insulator strings and hardware, clamps & connectors, Equipment terminal connectors including for 11 kV XLPE Power Cable, Conductors, Aluminum tubes, Bus bar and earthing materials, Bay marshalling box, spacers, cable supporting angles/channels, Cable trays & covers, Junction box, buried cable trenches.
(l) Complete lighting and illumination for the switchyard including street Lightning, Control Room cum administrative building etc.
(n) Earthing and lightning protection system
(o) 33 and 11 kV Cable extension as per approved layout.
(p) Mandatory Spares.
(q) Any other equipment/material required to complete the specified scope.

(iii) Design, engineering, manufacture, testing, supply on destination site basis including transportation & insurance, storage at site of mandatory spares.

(iv) Installation, testing and commissioning of complete in all respect for the above mentioned equipment's.

(v) **Civil Works** - The scope of work shall include but shall not be limited to the following based on design and drawings to be developed by the contractor:-

a) Foundations of Power Transformers along with jacking pad and pylon supports, rail track and fire resistant wall between Transformers whenever applicable.
b) Foundation for all towers, equipment's support structures and LT Transformers.
c) Cable trenches along with covers, road/rail crossings, sump pits and cable trench crossings with roads or drains etc.
d) All roads including culverts as approved by project office. Roads within boundary wall shall be flexible type i.e. asphalt concrete. The approach road along with

culvert between main boundary wall of substation and adjoining Main road shall also be constructed by the contractor with culverts, crossings, and other structures wherever required.

e) Antiweed treatment, PCC and Stone spreading in switchyard area.

f) Control cum administrative building.

g) Drains along with crossings with cable trenches. Drain layout shall be developed by the contractor.

h) Fencing for switchyard with gates.

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

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

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

(l) Employer's quarters, Guard House and Store buildings.

(m) Cutting and clearing of trees and bushes in yard if any.

**2.3** The bidders are advised to visit the substation sites and acquaint themselves with the topography, infrastructure and also the design philosophy. Before proceeding with the construction work of the new Sub-stations and existing substations, the Contractor shall fully familiarize himself with the site conditions and General arrangements & scheme etc. Though the Owner shall endeavor to provide the information, it shall not be binding for the Owner to provide the same. The bidder shall be fully responsible for providing all equipment, materials, system and services specified or otherwise which are required to complete the construction and successful commissioning, operation & maintenance of the substation in all respects. All materials required for the Civil and construction/installation work shall be supplied by the Contractor. The cement and steel shall also be supplied by the Contractor.

The complete design **(unless specified otherwise in specification elsewhere)** and detailed engineering shall be done by the Contractor based on conceptual tender drawings. Drawings enclosed with tender drawings are for information only. Drawings shall be developed by the contractor as per his design and has to be approved by the project office.

The Contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the equipment. The dimension of the equipment shall be such that when packed for transportation, it will comply with the requirements of loading and clearance restrictions for the selected route. It shall be the responsibility of the contractor to coordinate the arrangement for transportation of the Transformers for all the stages from the manufacturer's work to site.

The conditions of roads, capacity of bridges, culverts etc. in the route shall also be assessed by the bidders. The scope of any necessary modification/ extension/ improvement to existing road, bridges, culverts etc. shall be included in the scope of the bidder. The contractor shall carry out the route survey along with the transporter and submit the detail proposal and methodology for transportation of transformers for approval of Employer within three months from the date of award.

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

**2.5** Design of substation and its associated electrical & mechanical auxiliaries systems includes preparation of single line diagrams and electrical layouts including layout arrangement for foundation layout, cable trench layout, earthmat layout, erection key diagrams, electrical and physical clearance diagrams, design calculations for earthing and lightening protection system (including Direct Stroke Lighting Protection), control and protection schematics, wiring and termination schedules, civil designs **(as applicable)** and drawings, air conditioning system, indoor/outdoor lighting/illumination and other relevant drawings & documents required for engineering of all facilities within the fencing to be provided under this contract, are covered under the scope of the Contractor.

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

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

## 3.0 PHYSICAL AND OTHER PARAMETERS

The Motipur Substation and Sandhikharka substation of Nepal Electricity Authority are located in western region of Nepal and at Kapilvastu and Arghakhachi District.

### 3.1 Meteorological data :-

a) Altitude above sea level : 118(Motipur) & 930 m (Sandhikharka)

b) Ambient Air Temperature : 40$^{o}$C(max)/10$^{o}$C(min) for Motipur, 35$^{o}$C(max)/0$^{o}$C(min) for Sandhikharka.

c) Average Humidity (in %) : 80(max),20(min)

d) The substation locations are lying in the zone with wind speed: 33m/s.

e) Seismic Requirement for Substations: 0.3g (Horizontal peak acceleration value). The above specification are applicable for all the equipment and structures.

3.2 The fault level of 31.5kA for 1 Sec for all equipment to be supplied under present scope. The details system parameter is given hereunder:

| S.N | Description of parameters | 132 kV System |
|---|---|---|
| 1. | System operating voltage | 132kV |
| 2. | Maximum operating voltage of the system(rms) | 145kV |
| 3. | Rated frequency | 50Hz |
| 4. | No. of phase | 3 |
| 5. | Rated Insulation levels | |
| i) | Full wave impulse withstand voltage (1.2/50 microsec.) | 650 kVp |
| ii) | One minute power frequency dry and wet withstand voltage (rms) | 275kV |
| 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 | 500micro-volt |
| 8. | Minimum creepage distance (25mm/kV) | 3625 mm |
| 9. | Min. Clearances | |
| i. | Phase to phase | 1300 mm |
| ii. | Phase to earth | 1300 mm |
| iii | Sectional clearances | 4000 mm |
| 10. | Rated short circuit current | 31.5 kA for 1 Sec |
| 11. | System neutral earthing | 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 above MSL necessary altitude correction factor shall be applicable as per IEC or part thereof. Bidders shall furnish the suitable value after taking altitude correction factor in Chapter 22: Technical Data Sheet (Guaranteed Technical Particulars) separately for each items as applicable.

2. The insulation and RIV levels of the equipment's shall be as per values given in the respective chapter of the equipment's.

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

| S.N. | Parameters | **132 kV** |
|---|---|---|
| (a) | Max. System voltage Um(kV) | 145 |
| (b) | Impulse withstand voltage (dry & wet) (kVp) | ± 650 |
| (c) | Power frequency withstand voltage (dry and wet) (kV rms) | 275 |
| (d) | Total creepage distance (min) (mm) | 3625 |

## 4.0 SCHEDULE OF QUANTITIES

The requirement of various items/equipment's and civil works are indicated in Schedules of Rates and Prices.

All equipments/items and civil works for which bill of quantity has been indicated in Schedules of Rates and Prices, shall be payable on unit rate basis/quoted rate basis. During actual execution, any variation in such quantities shall be payable as per relevant clauses incorporated in Letter of award.

Wherever the quantities of items/works are not indicated and quantified and given in lot, the bidder is required to estimate the quantity required for entire execution and completion of works and incorporate their price in respective Schedules of Rates and Prices. For erection hardware items, Bidders shall estimate the total requirement of the works and indicate module-wise lump sum price bay wise and include the same in relevant Schedules of Rates and Prices. For module identification, Bidder may refer typical drawings enclosed with the specifications. Any material/works for the modules not specifically mentioned in the description in Schedules of rates and prices, as may be required shall be deemed to be included in the module itself.

The quantities specified in the Schedules of Rates and Prices are only estimates. As soon as practicable, the Contractor shall complete all survey, design and investigation works and accordingly revise the quantities and the Schedules of rates and Prices based on the unit/lump sum prices quoted in the Schedules of rates and Prices to complete the Facilities in accordance with the Technical Specifications and submit for Employer's approval. The revised price adjustment due to variation of quantities shall be limited to ±15% of the initial contract amount for the total amount of the respective schedules.

Bidder should include all such items in the bid proposal sheets, which are not specifically mentioned but are essential for the execution of the contract. Item which explicitly may not appear in various schedules and required for successful commissioning of substation shall be considered included in the bid price and shall be provided at no extra cost to Owner.

## 5.0 BASIC REFERENCE DRAWINGS

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

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.

**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
2. Chapter 2 : General Technical Requirement
3. Chapter 3 : Disconnecting Switch
4. Chapter 4 : Power Transformer
5. Chapter 5 : Circuit Breaker
6. Chapter 6 : Surge Arrester
7. Chapter 7 : Instrument Transformer
8. Chapter 8 : Battery and Battery Charger
9. Chapter 9 : Lighting System
10. Chapter 10: Power and Control Cable
11. Chapter 11 : AC Distribution Board
12. Chapter 12 : Air Conditioning System
13. Chapter 13 : Substation Structure
14. Chapter 14 : Control & Relay and Protection Panel
15. Chapter 15 : Substation Automation
16. Chapter 16 : LT Transformer
17. Chapter 17: Fibre Optic Based Communication
18. Chapter 18: 11kV Switchgear & 11kV OH Line Equipment
19. Chapter 19: Switchyard Erection
20. Chapter 20: Civil Works
21. Chapter 21: Inspection, Testing and Commissioning
22. Chapter 22: Technical Data Sheet

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.

## 6.0 SPARES Mandatory Spares

The Mandatory Spares shall be included in the bid proposal by the bidder. The prices of these spares shall be given by the Bidder in the relevant schedule of Schedules of Rates and Prices 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.

## 7.0 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 Schedules of Rates and Prices. 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**.**

## 9.0 FACILITIES TO BE PROVIDED BY THE OWNER

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

9.2 Owner shall make available construction water supply at a single point in the substation as far as possible. All further distribution for the same shall be made by the Contractor. In case of non-availability or inadequate availability of water for construction work, the contractor shall make his own arrangement at his own cost and the Owner

shall in no case be responsible for any delay in works because of non-availability or inadequate availability of water.

## 10.0 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 132,33kV ,11 kV bays under present scope at all 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 above activities shall be carried out as appropriate, in all stations in the route of data communication and the Load Dispatch Centre. The manufacturers of the existing SCADA system are:-

LDC facilities: Siemens Germany

RTU facilities: ABB, Germany

The details of existing RTU installed at existing substations and Data acquisition principles (types of analogue /digital data ) for control, monitoring of substation is enclosed at **Annexure II**. The existing communication protocol used for SCADA at LDC Kathmandu is IEC 101/104. **For the present scope of work no RTU is envisaged for new substation and the Data for SCADA purpose shall be obtained from the Substation Automation System (based on IEC 61850) using Gateway port with communication protocol IEC 101/104 as per requirement being provided at substations under present Contract**.

d. Augmentation and integration work related to Communication System

The existing FO communication link exists between Butwal-Kaligandaki-Lekhnath-Damauli-Marsyangdi Substations. Data and voice communications from various substations and power houses flow to LDC in the direction in the same direction as specified above to Siuchatar. The scope of work for supply, installation of approach optical fibre (as per requirement from JB to ODF box), Optical Line Termination Equipment, Digital Multiplexer, hardware accessories etc at Motipur and Sandhikharka Substation and its integration work (at existing Butwal Substation, Chanauta Substation & LDC Kathmandu) for onward transmission of Data and Voice communication upto LDC Kathmandu is included in the contract.

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

f. Erection, testing and commissioning of Circuit breaker, Isolators, Substation automation system, Control and protection Panels 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 Schedules of Rates and Prices.

g. The lighting fixtures for switchyard lighting shall be mounted on LMs wherever LMs are provided. Where LMs are not available, the fixtures may be mounted on Gantry structures or on lighting poles to be provided by the contractor. Also, for illumination in switchyard panel room average Lux level at ground level shall be 300 lux**.**

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

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

j. Sufficient number portable fire extinguisher (CO2 type) of 4.5 kg shall be provided for control room as per Bid proposal sheet (Schedules of Rates and Prices).

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

l. Design, engineering, drawing and construction of works shall satisfy the general technical requirements specified in the Specification or implied as per relevant IEC/IEEE/ IS/ASTM/British standard codes (B S Codes)/ equivalent International Standards.

m. Non CFC refrigerant shall be utilized for Air conditioning system, offered for Control room building and switchyard panel room is under the scope of contract.

## 11. 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.'

## Annexure-I

## 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, Inter tripping and Blocking protection schemes of EHV lines.

The protection signalling equipment shall communicate to the remote end interfacing with SDH terminal equipment at its 2Mbps port. It shall provide suitable interfaces for protective relays, which operate at 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 signalling equipment. Proper tripping signal shall always take the priority over the test procedure.
The high speed digital protection signalling equipment shall be designed and provided with following features.

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

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

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

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

**i) General equipment interface tests:**

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

**ii) <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 |

v) Alarm Contact

| | | |
|---|---|---|
| Rated voltage | : | 250 volts DC |
| Rated current | : | 0.1 A DC |
| Other parameters | : | As per IEC-255-0-20 |

vii) Digital communication interface: G 703(E1)

# ANNEXURE-II

## EXISTING SCADA & ITS DATA ACQUISITION

### 1.0 GENARAL INFORMATION

### 1.1 Remote Terminal Units and Substation Automation System

The Load Dispatch Centre (LDC) at Kathmandu controls and monitors the network of Integrated Nepal Power System (INPS) via RTU and SASs located at its various substations. Manufacturers of existing SCADA system are:
LDC facilities: SINAUT Spectrum V.4.3, SIEMENS, Germany

### 1.2 Data acquisition principles for existing Substation

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

**Remote Control**

- Remote control of all 132/33/11kV circuit breakers.

**Status indications**

- Status indications of all 132kV circuit breakers, bus bar and line isolators.
- Status indications of all 33/11kV line feeders.

### 1.3 Integration of SCADA of existing Substation

The existing communication protocol used for SCADA at LDC Kathmandu is IEC 60870- 5-101. For the present scope of work for new Motipur and Sandhikharka Substations 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 and 104 as per requirement being provided at two substations (i.e. Motipur and Sandhikharka) under present contract. The details of substation automation system is included in the separate chapter Substation Automation.

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

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

**Measurements**

- Busbar voltages (separate for each busbar and section) of all 132/33/11 kV Busbars.
- Active/reactive power for
  - All 132kV Line feeders and 132kV Transformer feeders.
- Single phase current measurements for all 33/11kV lines participating in load shedding Scheme.

# Annexure-III

## Specification for Revenue Meter & Metering (Instrument) Transformer

### General

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

### Energy Meter

The Energy Meter shall have the following minimum requirement

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

# Chapter 2: General Technical Requirement

## 1.0 FOREWORD

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

## 2.0 GENERAL REQUIREMENT

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

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

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

## 3.0 STANDARDS

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

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

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

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

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

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

## 4.0 SERVICES TO BE PERFORMED BY THE EQUIPMENT BEING FURNISHED

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

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

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

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

4.5 The equipment shall also comply with the following:

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

b) All piping, if any between equipment control cabinet and 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

**132kV, 33kV & 11kVSystem**

| SL No | Description of parameters | 132 kV System | 33 kV System | 11 kV System |
|---|---|---|---|---|
| 1. | System operating voltage | 132kV | 33kV | 11kV |
| 2. | Maximum operating voltage of the system(rms) | 145kV | 36kV | 12kV |
| 3. | Rated frequency | 50Hz | 50Hz | 50Hz |
| 4. | No. of phase | 3 | 3 | 3 |

| SL No | Description of parameters | 132 kV System | 33 kV System | 11 kV System |
|---|---|---|---|---|
| 5. | Rated Insulation levels | | | |
| i) | Full wave impulse withstand voltage (1.2/50 microsec.) | 650 kVp | 170 kVp | 75 kVp |
| ii) | One minute power frequency dry and wet withstand voltage (rms) | 275kV | 70kV | 28 kV |
| 6. | Corona extinction voltage | 105kV | - | - |
| 7. | Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 92KV rms for 132KV system | 500 micro-volt | - | - |
| 8. | Minimum creepage distance (25mm/kV) | 3625 mm | 900 mm | 265 mm |
| 9. | Min. Clearances | | | |
| i. | Phase to phase | 1300 mm | 320 mm | 127 mm |
| ii. | Phase to earth | 1300 mm | 320 mm | 127 mm |
| iii) | Sectional clearances | 4000 mm | 3000 mm | - |
| 10. | Rated short circuit current | 31.5 kA for 1 Sec | 25 kA for 3 Sec | 25 kA for 3 Sec |
| 11. | System neutral earthing | Effectively earthed | Effectively earthed | Effectively earthed |

Note :

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

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

**132kV, 33kV & 11kV System**

| S.N. | Parameters | 132 kV | 33kV | 11kV |
|---|---|---|---|---|
| (a) | Max. System voltage Um(kV) | 145 | 36 | 12 |
| (b) | Impulse withstand voltage (dry & wet) (kVp) | ± 650 | ± 170 | ± 75 |
| (c) | Power frequency withstand voltage (dry and wet) (kV rms) | 275 | 75 | 28 |
| (d) | Total creepage distance (min) (mm) | 3625 | 900 | 265 |

## 5.0 ENGINEERING DATA AND DRAWINGS

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

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

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

### 5.3 Drawings

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

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

5.3.3 The review of these data by the 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.

5.4 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 Employer shall not relieve the contractor of any of his responsibilities and liabilities under the Contract.

5.5 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.

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

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

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

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

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

## 6.2 Provisions for Exposure to Hot and Humid climate

Outdoor equipment supplied under the specification shall be suitable for service and storage under tropical conditions of high temperature, high humidity, heavy rainfall and environment favorable to the growth of fungi and mildew. The indoor 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, reactors, CB, CT, CVT, SA, Isolators, C & R panels and Communication equipments shall be provided with English inscriptions.

## 6.4 FIRST FILL OF CONSUMABLES, OIL AND LUBRICANTS

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

## 7.0 DESIGN IMPROVEMENTS / COORDINATION

7.1 The bidder shall note that the equipment offered by them 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 will be called upon to attend design co-ordination meetings with the Project Manager/Engineer of the Purchaser (if any) during the period of Contract. The Contractor shall attend such meetings at his own cost at Owner's Corporate Centre, Nepal or at mutually agreed venue as and when required and fully cooperate with such persons and agencies involved during those discussions.

## 8.0 QUALITY ASSURANCE PROGRAMME

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

(a) Their organization structure for the management and implementation of the proposed quality assurance programme:

(b) Documentation control system;

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

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

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

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

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

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

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

(j) System for quality audits;

(k) System for authorizing release of manufactured product to the Purchaser.

(l) System for maintenance of records;

(m) System for handling storage and delivery; and

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

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

**8.2 Quality Assurance Documents**

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

**9.0 TYPE TESTING, INSPECTION, TESTING & INSPECTION CERTIFICATE**

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

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

The test reports submitted shall be of the tests conducted within last 15 (fifteen) years prior to the originally Scheduled date of bid opening. In case the test reports are of the test conducted earlier than 15 (fifteen) years prior to the originally Scheduled date of bid opening, the contractor shall repeat these test(s) at no extra cost to the purchaser.

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

i) Lightning Impulse Test

ii) Switching Impulse Test

iii) Multiple Chopped Impulse Test (For CT)

iv) Chopped Impulse Test (For CVT )

In case the test reports are of these tests (equipment / material) as mentioned above are conducted earlier than 10 (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.

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

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

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

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

9.4 The Contractor shall give the Purchaser /Inspector fifteen (15) days written notice for on-shore and six (6) weeks' notice for off-shore material being ready for joint testing including contractor and ***Purchaser.*** Such tests shall be to the Contractor's account except for the expenses of the Inspector. The Purchaser /inspector, unless witnessing of the tests is virtually waived, will attend such tests within fifteen (15) days of the date of which the equipment is notified as being ready for test/inspection, failing which the Contractor may proceed alone with the test which shall be deemed to have been made in the Inspector's presence and they shall forthwith forward to the Inspector duly certified copies of tests in triplicate.

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

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

9.7 In all cases where the Contract provides for tests whether at the premises or at the works of the Contractor or of any Sub-Contractor, the Contractor except where

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

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

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

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

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

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

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

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

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

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

## 12.3 PAINTING

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

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

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

12.3.4 The exterior and interior color 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 color inside the equipments /boards /panels/junction boxes is also acceptable. The exterior color 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 along with the Bids for Purchaser's review & approval.

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

## 13.0 HANDLING, STORING AND INSTALLATION

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

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

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

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

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

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

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

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

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

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

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

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

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

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

13.13 Equipment Bases

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

## 14.0 TOOLS AND TACKLES

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

## 15.0 AUXILIARY SUPPLY

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

| Normal Voltage | Variation in Voltage | Frequency in HZ | Phase/ Wire | Neutral connection |
|---|---|---|---|---|
| 400V | $\pm$ 5 | 50 $\pm$ 2.5% | 3/4 Wire | Solidly Earthed. |
| 230V | $\pm$ 5 | 50 $\pm$ 2.5% | 1/2 Wire | Solidly Earthed. |
| 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 $\pm$ 10%.

## 16.0 SUPPORT STRUCTURE

16.1 All equipment support structures shall be supplied along with brackets, angles, stools etc. for attaching the operating mechanism, control cabinets & marshalling box (wherever applicable) etc.

16.2 Support structure shall meet the following mandatory requirements:

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

## 17.0 CLAMPS AND CONNECTORS INCLUDING TERMINAL CONNECTORS

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

| | |
|---|---|
| For connecting, ACSR conductors | Aluminum alloy casting conforming to BS:1490/ Equivalent International Standard |
| For connecting Equipment terminals made of copper with ACSR conductors | Bimetallic connectors made from aluminum alloy casting conforming to BS: 1490/ Equivalent International Standard with 2mm thick bimetallic liner. |
| For connecting GI | Galvanized mild shield wire |
| i) Bolts nuts and plain washers | Electro galvanized for sizes Plain, washers below M12, for theirs hot dip galvanized. |
| 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 galvanized. Copper alloy liner of minimum 2 mm thickness shall be cast integral with aluminum body or 2 mm thick bi-metallic strips shall be provided for Bi-metallic clamps.

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

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

17.8 Clamp shall be designed to carry the same current as the conductor and the temperature rise shall be equal or less than that of the conductor at the specified ambient temperature. The rated current for which the clamp/connector is designed

with respect to the specified reference ambient temperature, shall also be indelibly marked on each component of the clamp/connector, except on the hardware.

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

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

**17.11 Tests**

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

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

ii) Short time current test

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

iv) Resistance test and tensile test

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

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

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

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

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

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

18.6 All boxes/cabinets shall be designed for the entry of cables from bottom by means of weather proof and dust-proof connections. Boxes and cabinets shall be designed

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

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

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

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

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

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

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

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

i) Check for wiring

ii) Visual and dimension check

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

## 19.0 TERMINAL BLOCKS AND WIRING

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

19.2 Terminal blocks shall be 650V grade and have continuous rating to carry the maximum expected current on the terminals and non-breakable type. These shall be of moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Screw clamp, overall insulated, insertion type, rail mounted terminals can be used in place of stud type terminals. But preferably the terminal blocks shall be non-disconnecting stud type of Elmex or Phoenix or Wago or equivalent make.

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

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

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

19.6 The terminal blocks shall be of extensible design.

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

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

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

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

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

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

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

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

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

## 20.0 LAMPS & SOCKETS

20.1 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.

20.2 Hand Lamp:

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

20.3 Switches and Fuses:

20.3.1 Each panel shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of DC and AC supplies for various control, signaling, 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.

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

**21.0 Bushings, Hollow Column Insulators, Support Insulators:**

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

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

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

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

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

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

21.6 Bushing porcelain shall be robust and capable of withstanding the internal pressures likely to occur in service. The design and location of clamps and the shape and the strength of the porcelain flange securing the bushing to the tank shall be such that there is no risk of fracture. All portions of the assembled porcelain enclosures and supports other than gaskets, which may in any way be exposed to the atmosphere shall be composed of completely non hygroscopic material such as metal or glazed porcelain.

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

21.8 Tests

In bushing, hollow column insulators and support insulators shall conform to type tests and shall be subjected to routine tests in accordance with relevant international standard.

## 22.0 MOTORS

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

### 22.1 Enclosures

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

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

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

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

### 22.2 Operational Features

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

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

### 22.3 Starting Requirements:

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

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

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

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

e) The locked rotor withstand time under hot condition at 110% of rated voltage shall be more than starting time with the driven equipment of minimum permissible voltage by at least two seconds or 15% of the accelerating time whichever is greater. In case it is not possible to meet the above requirement, the Bidder shall offer centrifugal type speed switch mounted on the motor shaft which shall remain closed for speed lower than 19% and open for speeds above 19% of the rated speed. The speed switch shall be capable of withstanding 120% of the rated speed in either direction of rotation.

**22.4 Running Requirements:**

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

b) The double amplitude of motor vibration shall be within the limits specified in relevant International Standard. Vibration shall also be within the limits specified by the relevant standard for the driven equipment when measured at the motor bearings.

c) All the induction motors shall be capable of running at 80% of rated voltage for a period of 5 minutes with rated load commencing from hot condition.

**22.5 TESTING AND COMMISSIONING**

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

(a) Insulation resistance.

(b) Phase sequence and proper direction of rotation.

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

# ANNEXURE - A
# LIST OF SPECIFICATIONS
# GENERAL STANDARDS AND CODES

| | | |
|---|---|---|
| IEC-60060 (Part 1 to P4) | - | High Voltage Test Techniques |
| IEC 60068 | - | Environmental Test |
| IEC-60117 | - | Graphical Symbols |
| IEC-60156, | - | Method for the Determination of the Electrical Strength of Insulation Oils. |
| IEC-60270, | - | Partial Discharge Measurements. |
| IEC-60376 | - | Specification and Acceptance of New Sulphur Hexafluoride |
| IEC-60437 | - | Radio Interference Test on High Voltage Insulators. |
| IEC-60507 | - | Artificial Pollution Tests on High Voltage Insulators to be used on AC Systems. |
| IEC-62271-1 | - | Common Specification for High Voltage Switchgear & Control gear Standards. |
| IEC-60815 | - | Guide for the Selection of Insulators in respect of Polluted Conditions. |
| IEC-60865 (P1 & P2) | - | Short Circuit Current - Calculation of effects. |
| ANSI-C.1/NFPA.70 | - | National Electrical Code |
| ANSI-C37.90A | - | Guide for Surge Withstand Capability (SWC) Tests |
| ANSI-C63.21, | - | Specification for Electromagnetic Noise and |
| C63.3 | - | Field Strength Instrumentation 10 KHz to 1 GHZ |
| C36.4ANSI-C68.1 | - | 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 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 |

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| CSA-Z299.3-1979h | - | Quality Verification Program Requirements |
| CSA-Z299.4-1979h | - | Inspection Program Requirements |

**TRANSFORMERS AND REACTORS**

| | | |
|---|---|---|
| IEC-60076 (Part 1 to 5) | - | Power Transformers |
| IEC-60214 | - | On-Load Tap-Changers. |
| IEC-60289 | - | Reactors. |
| IEC- 60354 | - | Loading Guide for Oil - Immersed power transformers |
| IEC-60076-10 | - | Determination of Transformer and Reactor Sound Levels |
| ANSI-C571280 | - | General requirements for Distribution, Power and Regulating Transformers |
| ANSI-C571290 | - | Test Code for Distribution, Power and Regulation Transformers |
| ANSI-C5716 | - | Terminology & Test Code for Current Limiting Reactors |
| ANSI-C5721 | - | Requirements, Terminology and Test Code for Shunt Reactors Rated Over 500 KVA |
| ANSI-C5792 | - | Guide for Loading Oil-Immersed Power Transformers upto and including 100 MVA with 55 deg C or 65 deg C Winding Rise |
| ANSI-CG,1EEE-4 | - | Standard Techniques for High Voltage Testing |

**CIRCUIT BREAKERS**

| | | |
|---|---|---|
| IEC-62271-100 | - | High-voltage switchgear and control gear - Part 100: Alternating current circuit-breakers |
| IEC-62271-101 | - | High-voltage switchgear and control gear - Part 101: Synthetic testing |
| IEC-62155 | - | Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V |
| IEC-62271-110 | - | High-voltage switchgear and control gear - Part 110: Inductive load switching |
| IEC-62271-109 | - | High-voltage switchgear and control gear - Part 110: Inductive load switching |

**CURRENT TRANSFORMERS, VOLTAGE TRANSFORMERS AND COUPLING CAPACITOR VOLTAGE TRANSFORMERS**

| | | |
|---|---|---|
| IEC-60044-1 | - | Current transformer. |
| IEC-60044-2 | - | Inductive Voltage Transformers. |

| | | |
|---|---|---|
| IEC-60044-5 | - | Instrument transformer - Part 5: Capacitor voltage transformer |
| IEC-60358 | - | Coupling capacitors and capacitor dividers. |
| IEC-60044-4 | - | Instrument Transformers: Measurement of Partial Discharges |
| IEC-60481 | - | Coupling Devices for power Line Carrier Systems. |
| ANSI-C5713 | - | Requirements for Instrument transformers |
| ANSIC92.2 | - | Power Line Coupling voltage Transformers |
| ANSI-C93.1 | - | Requirements for Power Line Carrier Coupling Capacitors |
| BUSHING | | |
| IEC-60137 | - | Insulated Bushings for Alternating Voltages above 1000V |

**SURGE ARRESTERS**

| | | |
|---|---|---|
| IEC-60099-4 | - | Metal oxide surge arrestors without gaps |
| IEC-60099-5 | - | Selection and application recommendation |
| ANSI-C62.1 | - | IEE Standards for S A for AC Power Circuits |
| NEMA-LA 1 | - | Surge Arresters |

**CUBICLES AND PANELS & OTHER RELATED EQUIPMENTS**

| | | |
|---|---|---|
| IEC-60068.2.2 | - | Basic environmental testing procedures Part 2: Test B: Dry heat |
| IEC-60529 | - | Degree of Protection provided by enclosures. |
| IEC-60947-4-1 | - | Low voltage switchgear and control gear. |
| IEC-61095 | - | Electromechanical Contactors for household and similar purposes. |
| IEC-60439 (P1 & 2) | - | Low Voltage Switchgear and control gear assemblies |
| ANSI-C37.19 | - | Switchgear Assemblies, including metal enclosed bus. |
| ANSI-C37.50 | - | Test Procedures for Low Voltage Alternating Current Power Circuit Breakers |
| ANSI-C39 | - | Electric Measuring instrument |
| ANSI-C83 | - | Components for Electric Equipment |
| NEMA-AB | - | Moulded Case Circuit and Systems |
| NEMA-CS | - | Industrial Controls and Systems |
| NEMA-PB-1 | - | Panel Boards |
| NEMA-SG-5 | - | Low voltage Power Circuit breakers |
| NEMA-SG-3 | - | Power Switchgear Assemblies |
| NEMA-SG-6 | - | Power switching Equipment |

| | | |
|---|---|---|
| NEMA-5E-3 | - | Motor Control Centers |
| 1248 (P1 to P9) | - | Direct acting indicating analogue electrical measuring instruments & their accessories. |

**Disconnecting switches**

| | | |
|---|---|---|
| IEC-62271-102 | - | High-voltage switchgear and control gear - Part 102: Alternating current disconnectors and earthing switches |
| IEC-60265 (Part 1 & 2) | - | High Voltage switches |
| ANSI-C37.32 | - | Schedule of preferred Ratings, Manufacturing Specifications and Application Guide for high voltage Air Switches, Bus supports and switch accessories |
| ANSI-C37.34 | - | Test Code for high voltage air switches |
| NEMA-SG6 | - | Power switching equipment |

**PLCC and line traps**

| | | |
|---|---|---|
| IEC-60353 | - | Line traps for A.C. power systems. |
| IEC-60481 | - | Coupling Devices for power line carrier systems. |
| IEC-60495 | - | Single sideboard power line carrier terminals |
| IEC-60683 | - | Planning of (single Side-Band) power line carrier systems. |
| CIGRE | - | Teleprotection report by Committee 34 & 35. |
| CIGRE | - | Guide on power line carrier 1979. |
| CCIR | - | International Radio Consultative Committee |
| CCITT | - | International Telegraph & Telephone Consultative Committee |
| EIA | - | Electric Industries Association |

**Protection and control equipment**

| | | |
|---|---|---|
| IEC-60051: (P1 to P9) | - | Recommendations for Direct Acting indicating analogue electrical measuring instruments and their accessories. |
| IEC-60255 (Part 1 to 23) | - | Electrical relays. |
| IEC-60297 (P1 to P4) | - | Dimensions of mechanical structures of the 482.6mm (19 inches) series. |
| IEC-60359 | - | Expression of the performance of electrical & electronic measuring equipment. |
| IEC-60387 | - | Symbols for Alternating-Current Electricity meters. |
| IEC-60447 | - | Man machine interface (MMI) - Actuating principles. |
| IEC-60521 | - | Class 0.5, 1 and 2 alternating current watt hour 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 aluminum or aluminum-Copper Overhead Conductors |

**Bus hardware and insulators**

| | | |
|---|---|---|
| IEC-60120 | - | Dimensions of Ball and Socket Couplings of string insulator units. |
| IEC-60137 | - | Insulated bushings for alternating voltages above 1000 V. |
| IEC-60168 | - | Tests on indoor and outdoor post insulators of ceramic material or glass for Systems with Nominal Voltages Greater than 1000 V. |
| IEC-62155 | - | Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V |

| | | |
|---|---|---|
| IEC-60273 | - | Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1000V. |
| IEC-61462 | - | Pressurized and un-pressurized insulator for use in electrical equipment with rated voltage greater than 1000V – Definitions, Test methods, acceptance criteria and design recommendations |
| IEC-60305 | - | Insulators for overhead lines with nominal voltage above 1000V-ceramic or glass insulator units for a.c. systems Characteristics of String Insulator Units of the cap and pin type. |
| IEC-60372 (1984) | - | Locking devices for ball and socket couplings of string insulator units: dimensions and tests. |
| IEC-60383 (P1 and P2) | - | Insulators for overhead lines with a nominal voltage above 1000 V. |
| IEC-60433 | - | Characteristics of string insulator units of the long rod type. |
| IEC-60471 | - | Dimensions of Clevis and tongue couplings of string insulator units. |
| ANSI-C29 | - | Wet process porcelain insulators |
| ANSI-C29.1 | - | Test methods for electrical power insulators |
| ANSI-C92.2 | - | For insulators, wet-process porcelain and toughened glass suspension type |
| ANSI-C29.8 | - | For wet-process porcelain insulators apparatus, post-type |
| ANSI-G.8 | - | Iron and steel hardware |
| CISPR-7B | - | Recommendations of the CISPR, tolerances of form and of Position, Part 1 |
| ASTM A-153 | - | Zinc Coating (Hot-Dip) on iron and steel hardware |

**Strain and rigid bus-conductor**

| | | |
|---|---|---|
| ASTM-B 230-82 | - | Aluminum 1350 H19 Wire for electrical purposes |
| ASTM-B 231-81 | - | Concentric - lay - stranded, aluminum 1350 conductors |
| ASTM-B 221 | - | Aluminum - Alloy extruded bar, road, wire, shape |
| ASTM-B 236-83 | - | Aluminum bars for electrical purpose (Bus-bars) |
| ASTM-B 317-83 | - | Aluminum-Alloy extruded bar, rod, pipe and structural shapes for electrical purposes (Bus Conductors) |

**Batteries and batteries charger**

**Battery**

| | | |
|---|---|---|
| IEC: 60896-21&22 | - | Lead Acid Batteries Valve Regulated types – Methods of Tests & Requirements |
| IEC: 60623 | - | Vented type nickel Cadmium Batteries |

| | | |
|---|---|---|
| IEC: 60622 | - | Secondary Cells & Batteries – Sealed Ni-Cd rechargeable single cell |
| IEC: 60623 | - | Secondary Cells & Batteries – Vented Ni-Cd rechargeable single cell |
| IEC: 60896-11 | - | Stationary Lead Acid Batteries – Vented Type – General requirements & method of tests |
| IEEE-485 | - | Recommended practices for sizing of Lead Acid Batteries |
| IEEE-1115 | - | Sizing of Ni-Cd Batteries |
| IEEE-1187 | - | Recommended practices for design & installation of VRLA Batteries |
| IEEE-1188 | - | Recommended practices for design & installation of VRLA Batteries |
| IEEE-1189 | - | Guide for selection of VRLA Batteries |

**Battery Charger**

| | | |
|---|---|---|
| IEEE-484 | - | Recommended Design for installation design and installation of large lead storage batteries for generating stations and substations. |
| IEEE-485 | - | Sizing large lead storage batteries for generating stations and substations |

**Wires and cables**

| | | |
|---|---|---|
| ASTMD-2863 | - | Measuring the minimum oxygen concentration to support candle like combustion of plastics (oxygen index) |
| IEC-60096 (part 0 to p4) | - | Radio Frequency cables. |
| IEC-60183 | - | Guide to the Selection of High Voltage Cables. |
| IEC-60189 (P1 to P7) | - | Low frequency cables and wires with PVC insulation and PVC sheath. |
| IEC-60227 (P1 to P7) | - | Polyvinyl Chloride insulated cables of rated voltages up to and including 450/750V. |
| IEC-60228 | - | Conductors of insulated cables |
| IEC-60230 | - | Impulse tests on cables and their accessories. |
| IEC-60287 (P1 to P3) | - | Calculation of the continuous current rating of cables (100% load factor). |
| IEC-60304 | - | Standard colours for insulation for low-frequency cables and wires. |
| IEC-60331 | - | Fire resisting characteristics of Electric cables. |
| IEC-60332 (P1 to P3) | - | Tests on electric cables under fire conditions. |
| IEC-60502 | - | Extruded solid dielectric insulated power cables for rated voltages from 1 kV upto to 30 kV |

| | | |
|---|---|---|
| IEC-754 (P1 and P2) | - | Tests on gases evolved during combustion of electric cables. |

**Painting**

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

**HORIZONTAL CENTRIFUGAL PUMPS**

| | | |
|---|---|---|
| API-610 | - | Centrifugal pumps for general services |
| | - | Hydraulic Institutes Standards |
| BS:599 | - | Methods of testing pumps |
| PTC-8.2 | - | Power Test Codes - Centrifugal pumps |

**DIESEL ENGINES**

| | | |
|---|---|---|
| ASME Power Test Code | - | Internal combustion engine PTC-17 |
| | - | Codes of Diesel Engine Manufacturer's Association, USA |

**PIPING VALVES & SPECIALITIES**

| | | |
|---|---|---|
| BS: 5150 | - | Specification for cast iron gate valves |

**PG Test Procedures**

| | | |
|---|---|---|
| NFPA-13 | - | Standard for the installation of sprinkler system |
| NFPA-15 | - | Standard for water spray fixed system for the fire protection |
| NFPA-12A | - | Standard for Halong 1301 Fire Extinguishing System |
| NFPA-72E | - | Standard on Automatic Fire Detectors |
| NFPA-12 | - | Standard on Carbon dioxide extinguisher systems |

Electrical generating and distributing stations code of practice

**Steel structures**

| | | |
|---|---|---|
| ANSI-B18.2.1 | - | Inch series square and Hexagonal bolts and screws |
| ANSI-B18.2.2 | - | Square and hexagonal nuts |
| ANSI-G8.14 | - | Round head bolts |
| ASTM-A6 | - | Specification for General Requirements for rolled steel plates, shapes, sheet piling and bars of structural use |
| ASTM-A36 | - | Specifications of structural steel |
| ASTM-A47 | - | Specification for malleable iron castings |
| ASTM-A143 | - | Practice for safeguarding against embilement of Hot Galvanized structural steel products and procedure for detaching embilement |

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|---|---|---|
| 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 columbium-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 |
| ANSI-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 BEAR CONDUCTOR**

| | |
|---|---|
| IEC: 437-1973 | Test on High Voltage Insulators NEMA:107-1964 |
| | CISPR |
| Part - V | Overhead Transmission Purposes |
| BS: 215(Part-II) | Aluminum 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. |

# CHAPTER – 3

# DISCONNECTING SWITCH (ISOLATOR)

## 1.1 General

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

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

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

## 1.2 Design Requirements

The disconnecting switches shall be used for the 50Hz, 3 phase system. Earth switches shall be provided on disconnecting switches wherever called for. Complete disconnecting switches with all the necessary items for successful operation shall be supplied.

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

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

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

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

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

The rating, the accessories to be furnished and the schedule of equipment are detailed in Technical Particular below.

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

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

In case of disconnecting switch with grounding switch, the grounding switch shall be capable of making to a dead short circuit without damage of the equipment or

endangering operator. It shall be provided with and interlocking with the corresponding disconnecting switch so that the earth switches can be operated only when the disconnecting switches is open and vice versa.

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

## 1.3 Construction Features

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

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

All current carrying parts shall be of non-ferrous metal or alloy. Bolts, screws and pins shall be provided with lock washers. Keys or equivalent locking facilities, if provided on current carrying parts, shall be made of copper silicon alloy or equivalent. The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces.

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

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

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

All bearings in the current path shall be shorted by flexible copper conductor of adequate size (minimum – 150 mm2) to allow the specified fault current through it without injury.

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

### 1.3.1 Main contacts

The disconnecting switches shall be provided with high pressure current carrying contacts on the hinge/ jaw ends and all contact surfaces shall be silver plated and controlled by powerful springs designed for floating and pressure point contact. The

thickness of silver plating should not be less than 25 microns. The contacts shall be accurately machined and self-aligned.

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

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

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

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

### 1.3.2 Insulators and Terminals

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

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

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

Arcing horns as required shall be furnished.

All insulators of identical ratings shall be interchangeable.

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

## 1.4 Operating Mechanism

### 1.4.1 Disconnecting Switches

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

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

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

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

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

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

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

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

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

### 1.4.2 Grounding Switches

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

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

The grounding switch shall be capable of withstanding the electrical and mechanical stresses developed by a short circuit current specified in Appendix. The cross-section

of the flexible copper connection between rotating shaft and structure shall be capable to allow specified fault through it without injury but of minimum size 150 mm2.

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

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

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

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

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

## 1.5 Tests

### 1.5.1 Routine Tests

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

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

### 1.5.2 Design Tests

The disconnecting switch design tests shall include following:

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

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

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

### 1.5.3 Field Tests

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

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

## 1.6 Drawings, Data and Manuals

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

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

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

## 1.7 Spare Parts

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

**Technical particulars of DISCONNECTING SWITCH WITH & WITHOUT GROUNDING SWITCH**

| S. No. | Description | Disconnecting switch 132 kV | Disconnecting switch 33 kV |
|---|---|---|---|
| 1. | Type | 3-poles, center break | 3-poles, three columns, center rotating ,double break or 3-poles, center break |
| 2. | Rated Voltage | 132 kV | 33 kV |
| 3. | Frequency | 50 Hz | 50 Hz |

| S. No. | Description | Disconnecting switch 132 kV | Disconnecting switch 33 kV |
|---|---|---|---|
| 4. | Insulation levels<br>a) Basic impulse level (BIL)<br>b) Power frequency withstand voltage (For1 minute) | <br>650 kV (crest)<br><br>275 kV (rms) | <br>170 kV (crest)<br><br>70 kV (rms) |
| 5. | Current ratings<br>a) Continuous current<br>b) Rated Short Time current (1 sec.) | <br>1250 A<br>31.5 kA | <br>1250A<br>31.5 kA |
| 6. | Operating mechanism of disconnecting switch | Motor operated (both local and remote operation) and manual | Local, manual Operation |
| 7. | Auxiliary power supply | | |
| | a) Space heater and cubicle | 230V,1-phase, 50Hz | 230V,1-phase, 50Hz |
| | b) Control circuit | 110 V DC | 110 V DC |
| | c) Operating motor | 230/400 V, 50 Hz | - |
| 8. | Applicable standard | IEC | IEC |
| 9. | Enclosure Protection | IP-55W | IP-55W |
| 10. | Creepage Distance | 3625 | 900 |

The above parameters are applicable for installations up to an altitude of 1000m above mean sea level. For altitude exceeding 1000m above MASL. For altitude exceeding 1000m, necessary altitude correction factor shall be applicable as per IEC or part thereof.

# CHAPTER - 4

# POWER TRANSFORMERS

## 1.1 General

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

The Contractor shall submit type test report, valid ISO 9001 certificate, necessary technical brochures, sales record, design calculations, layout and detailed drawings for the transformers to verify compliance with the Specification. In particular, the Contractor shall include dimensioned layout and section drawings and weight for those parts which influence the space availability in switchyard for transformers, transformer pits (oil soaking and waste oil-water), transportation routes, cable trenches, fencing/walls, fire walls etc.

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

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

Any material and equipments 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.

## 1.2 Design Requirement

The transformer shall be connected to three phase 50 Hz system of 132 kV and 33kV systems as specified. The transformers shall be located at the altitude as mentioned in Chapter 1, Project Specific Requirement.

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

The transformer shall be capable of operating continuously at its rated output without exceeding the temperature rise limits as specified in Technical Particular.

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

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

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

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

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

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

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

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

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

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

## 1.3 Construction Features

### 1.3.1 Tank

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

The main tank body shall be capable of withstanding a vacuum of 100.64 KN/m2 (760mm of Hg.)

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

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

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

All heavy removable parts shall be provided with mounting rails along with eye bolt for ease of handling and necessary lugs and shackles shall be provide to enable the whole transformer to be

lifted by a crane or other means. Manholes of sufficient size shall be provided for access to leads, windings, bottom terminals of bushings and taps.

### 1.3.2 Core & Coils

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

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

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

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

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

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

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

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

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

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

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

### 1.3.3 Tapping

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

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

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

### 1.3.4 On-Load Tap Changer

The on-load tap-changer (OLTC) to be equipped in the transformers and associated control gear shall be from MR Germany or ABB Sweden . Since majority of transformers in the Employer use this make and their performance is satisfactory.

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

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

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

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

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

a. Whenever over current occurs, the control circuit for commanding OLTC motor operation shall be blocked by the normally close contacts of the over current relays.

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

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

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

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

The control circuit of the transformer shall be completely designed and provision shall be made for parallel operation with another transformer. MASTER-FOLLOWER operation mode shall be provided.

The following accessories, control and selector switches and other necessary accessories shall be furnished.

a. Remote control board

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

b. In transformer control cubicle

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

c. In driving mechanism cubicle

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

### 1.3.5 Insulating Oil

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

| Sr. No. | Characteristics | Specification |
|---|---|---|
| 1. | Electric Strength (BDV) | 30 kV (min) |
| 2. | Dielectric dissipation factor | 0.01 (Max.) (Ten Delta) |
| 3. | Specific resistance (Resistivity) | 1500x10*12 (Min.) at $27^0$C (ohm-cm) |
| 4. | Flash point pensky-Mortion | $140^0$C (Min.) (Closed) |
| 5. | Inter facial tension at $27^0$C | 0.04 N/m (Min.) |
| 6. | Total activity | 0.04 mg koh/gm (Max.) |

| Sr. No. | Characteristics | Specification |
|---|---|---|
| 7. | Water Content | 50 (Max) mg/kg |

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

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

### 1.3.6 Oil Preservation System

Oil preservation shall be by means of conservator tank system.

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

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

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

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

Both compartments shall be provided with their own breather, filler cap and drain plug.
Each compartment of the conservator shall be provided with dial type level indicator visible from the ground level and fitted with low oil-level alarm contact. Plain oil level gauge shall also be provided to each compartment.

### 1.3.7 Temperature Indicators

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

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

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

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

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

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

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

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

### 1.3.9 Pressure relief device

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

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

### 1.3.10 Transformer Bushings

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

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

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

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

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

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

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

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

### 1.3.11 Marshalling Box

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

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

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

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

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

- Winding temperature high trip
- Oil temperature high trip
- Buchholz relay trip or sudden gas and sudden oil pressure relay trip
- Pressure relief device

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

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

### 1.3.12 Cable Termination

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

### 1.3.13 Terminal Blocks

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

### 1.3.14 Painting

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

### 1.3.15 Auxiliary supply

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

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

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

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

The manufacturer/contractor shall co-ordinate with illumination system supplier for his requirement of 63A convenience outlet(s) and its location in outdoor switchyard for purification of transformer oil during maintenance etc.

## 1.4 Auxiliary Equipment to Be Furnished

### 1.4.1 Bushing Current Transfer

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

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

Current transformer rating and accuracy class shall be as per Technical Particular and shall be designed to withstand the electromagnetic stresses developed during short circuit.

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

### 1.4.2 Lightning Arresters

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

### 1.4.3 Cooling Equipment

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

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

The dimension of remote tap changer control panel shall be match with transformer control panel.

## 1.5 Tests

### 1.5.1 Routine Tests

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

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

### 1.5.2 Special Tests

The following tests shall be performed on each transformer:

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

### 1.5.3 Design Tests

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

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

### 1.5.4 Tests on Miscellaneous Components

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

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

The bodies of all valves and pipe works shall withstand a hydraulic pressure of 20 psig for 15 minutes. The testing medium shall be insulating oil as per IEC Publication 296.

### 1.5.5 Test Certificates

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

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

### 1.5.6 Field Test

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

a. Construction inspection
b. Insulation oil test for

- Dielectric strength
- Acidity contain
- Dissolved gas analysis

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

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

## 1.6 Tender Evaluation and the Guaranteed Losses

### 1.6.1 Capitalization of Transformer Losses

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

| | | | |
|---|---|---|---|
| a. | No load losses | : | US$ 4684 per kW |
| b. | Load losses | : | US$ 1180 per kW |
| c. | Loss associated with cooling fan load | : | US$ 393 per kW |

After manufacturer of the transformers, losses will be measured during factory inspection test at manufacturer premises. If any of the losses are found to be more than the guaranteed losses by the contractor in Technical Data Sheet (Guaranteed Technical Particulars), the contractor will be panelized at the rate mentioned above.

### 1.6.2 Guaranteed Values Not Reached

If the individual losses of a power transformer as measured during test exceeds the values guaranteed in the Bid, then for each kilowatt of losses in excess of the losses guaranteed, an amount at the rates of twice the rates of specified in clause 1.6.1 for no load losses and load losses shall be deducted from the Contract Price of the successful Contractor.

## 1.7 Performance Guarantee

The performance figures quoted on Technical Data Sheet shall be guaranteed within the tolerances permitted by relevant standards listed under section of General Technical Specifications, and shall become a part of the successful Contractor's Contract. In case of loss capitalization, no tolerance shall be permitted for the guaranteed value. The transformer will be rejected, if the measured no-load and load losses (excluding fan loss) exceed the guaranteed value by over 15 % provided that the total losses do not exceed 10% as specified.

## 1.8 Drawings, Data & Manuals

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

### 1.8.1 Along with the bid

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

### 1.8.2 After Award of Contract

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

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

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

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

## 1.9 Name Plate

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

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

## 1.10 Spare

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

### 1.11 Transportation

The core and coils shall be completely dried before shipment and assembled with tank and with oil or dry nitrogen depending upon the size of the transformers. In order to facilitate handling and shipping, as many external accessories as practical, including bushings, shall be removed and replaced by special shipping covers. The Contractor shall give special attention to the limitation of bridge capacity in Nepal and make necessary transportation arrangements accordingly.

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

### 1.12 Transformer accessories

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

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

**Table-1: technical particulars of power transformers**

| S.No. | Description | *132/33 kV* | *33/11kV* |
|---|---|---|---|
| 1. | Rated capacity | *24/27/30 MVA* | *12.8/16 MVA* |
| 2. | Quantity required | One (1) no of three phase | One (1) no of three phase |
| 3. | Type | Outdoor, Oil-immersed | Outdoor, Oil-immersed |
| 4. | Type of cooling | *ONAN//ONAF/ONAF (24/27/30 MVA)* | *ONAN/ONAF (12.8/16 MVA)* |
| 5. | Temperature rise above 40 degree C ambient temperature | | |

| S.No. | Description | *132/33 kV* | *33/11kV* |
|---|---|---|---|
| | a) In oil by thermometer | 50 degree C | 50 degree C |
| | b) In winding by resistance | 55 degree C | 55 degree C |
| 7. | Number of phases | 3(three) | 3(three) |
| 8. | Maximum voltage (line to line) | | |
| | a) Primary | 145 kV | 36 kV |
| | b) Secondary | 36 kV | 12 kV |
| 9. | Rated Voltage (line to line) | | |
| | a) Primary | *132 kV* | *33 kV* |
| | b) Secondary | *33 kV* | *11 kV* |
| 10. | Insulation level of winding | | |
| | a) Basic impulse level as per IEC 76 | | |
| | - Primary | *650 kV (crest)* | *170kV (crest)* |
| | - Secondary | *170 kV (crest)* | *75kV (crest)* |
| | b) Power frequency induced over voltage (1 minute) | | |
| | - Primary | *275 kV(rms)* | *70kV(rms)* |
| | - Secondary | *70 kV(rms)* | *28kV(rms)* |
| 11. | Connections | | |
| | a) Primary | Star | Delta |
| | b) Secondary | Star | Star |
| | c) Tertiary | | |
| 12. | Vector group reference | Ynyn0 | Dyn11 |
| 13. | Type of tap changer/make | *On-load/MR Germany or ABB Sweden* | *On-load/MR Germany or ABB Sweden* |
| 14. | Range of taps | *± 10 %* | *± 10 %* |
| 15. | Number of taps | *17* | *17* |
| 16. | Method of tap changer control | | |
| | - Mechanical local | Yes | Yes |
| | - Electrical local | Yes | Yes |
| | - Electrical remote | Yes | Yes |
| | "MASTER-FOLLOWER-INDEPENDENT" and "AUTO -MANUAL" selection | Yes | Yes |
| 17. | Percent impedance voltage at rated MVA and 75 degree C On normal tap | *≈11 % (at normal tap)* | *≈ 8 % (at normal tap)* |
| 18. | System grounding | | |
| | a) Primary | Solidly grounded | Solidly grounded |
| | b) Secondary | Solidly grounded | Solidly grounded |
| 19. | Neutral terminals & BCT | | |
| | - Primary | Required | Required |
| | - Secondary | Required | Required |
| 20. | Tank Mounted Lightning Arrester | | |
| | HV | - | - |
| | LV | - | - |
| 21. | Bushing Current Transformers | | |
| | a) Number of core & current ratio | | |
| | HV Phase | *1 * 150/1A* | *1 * 300/1A* |
| | Neutral | *1 * 100/1A* | *1 * 100/1A* |
| | b) Number of core & current ratio | | |
| | LV Phase | *1 * 600/1A* | *1 * 900/1A* |
| | Neutral | *1 * 200/1A* | *1 * 200/1A* |
| | | *(ratio to be decided during design/ drawing approval)* | |
| | c) Accuracy class | PS | PS |

The transformer shall be equipped with on-line monitoring device and shall be compatible with SCADA system.

Fire protection shall also be provided for the power transformers.

The above parameters are applicable for installations up to an altitude of 1000m above mean sea level. For altitude exceeding 1000 MASL, necessary altitude correction factor shall be applicable as per IEC or part thereof.

# CHAPTER – 5
# CIRCUIT BREAKERS

## 1.1 SCOPE

1.1.1 These specifications are intended to cover the design, engineering, manufacturing, inspection and testing at manufacturer's works, packing, supply & delivery, storage, transportation up to site, testing & commissioning of the outdoor type 145/36 kV $SF_6$ Gas filled CBs, complete with motor operated spring charged/pneumatic operating mechanism, unitized air compressed system, air receiver, gas monitoring instruments, operating mechanism, terminal connectors, hot dip galvanized supporting structures with foundation bolts/ copper piping/ connectors/ valves, cable glands inter connecting cables complete with all materials, accessories and fittings, erection & maintenance tools & tackles, mandatory spares as detailed in this specification.

1.1.2 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life.

1.1.3 Any material and equipments 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.

## 1.2 PARTICULARS OF THE SYSTEM

1.2.1 The Circuit Breakers to be provided under the specification are intended to be used on 3 phase, AC, 50 Hz, earthed system. The nominal system voltage and the corresponding highest system voltage, short time current rating, basic impulse level etc. corresponding to standard values, are given in the technical parameters.

## 1.3 STANDARDS

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

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

## 1.4 Design Requirements

The circuit breakers shall be suitable for 3 phase, 50 Hz. and shall be installed in outdoor. The circuit breaker shall be located at an attitude as mentioned in chapter 1 PSR, above Mean Sea Level.

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

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

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

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

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

Technical particulars of the circuit breaker shall be as specified in the Table.

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

## 1.5 Construction Features

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

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

The circuit breaker shall also be capable of:

a) Interrupting line/cable charging current as per IEC without use of opening resistors.
b) Clearing short line fault (Kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.

The Breaker shall satisfactorily withstand the high stresses imposed on them during fault clearing, load rejection and re-energisation of lines with trapped charges. The breaker shall also withstand the voltages specified in the technical specification of this Section.

### 1.6 Reclosing operation

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

### 1.7 Contacts

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

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

#### 1.7.1 Gas Density Detector for SF6 circuit breaker

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

#### 1.7.2 Vacuum Interrupter for vacuum circuit breaker

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

#### 1.7.3 Local Test Switch

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

### 1.7.4 Emergency Trip

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

### 1.7.5 Position Indicator

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

### 1.7.6 Tripping Circuit

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

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

### 1.7.7 Motor-operated Spring-Charged Mechanism

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

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

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

As long as power is available to the motor, a continuous sequence of the closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty.

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

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

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

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

The bidder shall furnish detailed operation and maintenance manual of the mechanism along with the operation manual for the circuit breaker. The instruction manuals shall contain exploded diagrams with complete storage, handling, erection, commissioning, troubleshooting, servicing and overhauling instructions.

### 1.7.8 Operating Cubicle

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

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

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

A local control switch connected with a remote-local selector switch shall be furnished and wired in the control circuits of the breaker. The local control switch shall be

operative from within the operating cubicle only when the selector switch is in local position.

### 1.7.9 Terminal Connector Pad

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

### 1.7.10 Bushings

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

## 1.8 Accessories

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

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

## 1.9 Spare Parts

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

## 1.10 Tests

### 1.10.1 Routine Tests

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

a) Construction Inspection

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

### 1.10.2 Design Tests

Following design tests shall be performed on the offered model.

The circuit breaker design tests shall include following:

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

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

### 1.10.3 Field Tests

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

a) Insulation resistance of each pole.
b) Check adjustments, if any suggested by manufacturer.
c) Breaker closing and opening time.
d) Slow and Power closing operation and opening.
e) Trip free and anti-pumping operation.
f) Minimum pick-up voltage of coils.
g) Dynamic Contact resistance measurement.
h) Functional checking of compressed air plant and all accessories.
i) Functional checking of control circuits interlocks, tripping through protective relays and auto reclose operation.
j) Insulation resistance of control circuits, motor etc.
k) Resistance of closing and tripping coils.
l) SF6 gas leakage check.
m) Dew Point Measurement
n) Operation check of pressure switches and gas density monitor during gas filling.
o) Checking of mechanical 'CLOSE' interlock, wherever applicable.
p) Testing of grading capacitor.
q) Resistance measurement of main circuit.
r) Checking of operating mechanisms

s) Check for annunciations in control room.
t) Point of wave switching test (wherever applicable)

The contractor shall ensure that erection, testing and commissioning of circuit breaker shall be carried out under the supervision of the circuit breaker manufacturer's representative. The commissioning report shall be signed by the manufacturer's representative.

## 1.11 Performance Guarantee

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

## 1.12 Drawings, Data and Manual

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

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

## 1.13 Nameplate

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

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

- Manufacturer's name
- Manufacturer's serial number and type designation
- Year of manufacture
- Rated voltage, kV

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

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

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

## 1.14 Special Tools

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

**Technical particulars of 132 kV SF6 Circuit Breaker**

| | | |
|---|---|---|
| 1. | Type | SF6, outdoor type |
| 2. | Voltage rating: | |
| | a) Nominal system voltage | 132 kV |
| | b) Rated maximum voltage | 145 kV |
| 3. | Insulation level | |
| | a) Impulse withstand voltage | 650 kV (crest) |
| | b) Power-frequency withstand voltage (1 min.) | 275 kV (rms) |
| 4. | Frequency | 50 Hz |
| 5. | Current rating | |
| | a) Rated continuous current at 40 degree C ambient | 1250 A |
| | b) Short circuit breaking current | 31.5 kA |
| | c) Short circuit making current | 80 kA |
| 6. | Creepage distance | 3,625 mm |
| 7. | Auxiliary supply | |

| | | |
|---|---|---|
| | a) Control circuit | 110 V DC |
| | b) Space heater and auxiliary equipment. | AC, 230/400V, 50 Hz |
| 8. | Operation | three pole operation type |
| 9. | Reclosing duty cycle | O-0.3 sec-CO-3 min-CO |
| 10. | Total maximum break time | 60 ms |
| 11. | First pole to clear factor | 1.3 |
| 12 | Additional Auxiliary Contacts | 8 NO, 8 NC |
| 13. | Maximum make time | 120 ms |
| 14. | Spring charging motor | 110 V DC |

**Technical particulars of 33 kV Vacuum Circuit Breaker**

| | | |
|---|---|---|
| 1. | Type | 33kV VCB, outdoor type |
| 2. | Voltage rating: | |
| | a) Nominal system voltage | 33 kV |
| | b) Rated maximum voltage | 36 kV |
| 3. | Insulation level | |
| | a) Impulse withstand voltage | 170 kV (crest) |
| | b) Power-frequency withstand voltage (1 min.) | 70 kV (rms) |
| 4. | Frequency | 50 Hz |
| 5. | Current rating | |
| | a) Rated continuous current at 40 degree C ambient | 1250 A |
| | b) Short circuit breaking current | 25 kA |
| | c) Short circuit making current | 62.5 kA |
| 6. | Creepage distance | 900 mm |
| 7. | Auxiliary supply | |
| | a) Control circuit | 110 V DC |
| | b) Space heater and auxiliary equipment. | AC, 230/400V, 50 Hz |
| 8. | Rated Capacitor Breaking current | ≥400A |
| 9. | Rated Back to Back Capacitor Bank Breaking current | ≥400A |
| 8. | Operation | Three pole operation type |
| 9. | Reclosing duty cycle | O-0.3 sec-CO-3 min-CO |
| 10. | Total maximum break time | 60 ms |
| 11. | First pole to clear factor | 1.3 |
| 12 | Additional Auxiliary Contacts | 8 NO, 8 NC |
| 13. | Maximum make time | 120 ms |
| 14. | Spring charging motor | 110 V DC |

The above parameters are applicable for installations up to an altitude of 1000m above mean sea level. For altitude exceeding 1000 MASL necessary altitude correction factor shall be applicable as per IEC or part thereof.

# CHAPTER – 6
# SURGE ARRESTORS

## 1.1 General

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

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

## 1.2 Design Requirements

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

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

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

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

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

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

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

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

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

The technical features of the lightning arresters are given in Table below.

## 1.3 Constructional Features

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

a) The non-linear blocks shall be of sintered metal oxide material. These shall be provided in such a way as to obtain robust construction, with excellent mechanical and electrical properties even after repeated operations.

b) The surge arresters shall be fitted with pressure relief devices suitable for preventing shattering of porcelain housing and providing path for flow of rated fault currents in the event of arrester failure. Details shall be furnished in the bids along with quality checks.

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

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

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

f) The manufacturer will submit Data for rejection rate of ZnO blocks during manufacturing/operation for the past three years.

## 1.4 Fittings and Accessories

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

Self-contained discharge counters, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole unit along with necessary connection. Suitable leakage current meters should also be provided. The reading of mili ammeter and counters shall be visible through an inspection glass panel. The terminals shall be robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends.

Surge monitor consisting of discharge counters and mili ammeters should be suitable to be mounted on support structure of the arrester and should be tested for IP66 degree of protection. The standard supporting structure for Lightning arrester should be provided with a mounting pad, for fixing the surge monitor. The surge monitor should be suitable for mounting on this standard mounting pad. Also all nuts, bolts, washers etc. required for fixing the surge monitor shall have to be supplied by the Contractor.

The arrangement for Surge Monitor enclosure fixing to the structure shall be at its rear/bottom. Connection between the Surge Arrester base and Surge Monitor shall be through a 2.0 m (minimum) long insulated copper rod/strip of at least 75 sq.mm cross sectional area. The cable shall be terminated at rear/bottom side of the Surge Monitor. The gaskets of the surge monitors shall be of Neoprene, Butyl or equivalent material.

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

## 1.5 Tests

### 1.5.1 Routine Test

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

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

### 1.5.2 Design Test

The lightning arrester design tests shall include following:

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

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

### 1.5.3 Pre-Commissioning Tests

An indicative list of tests is given below.

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

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

## 1.6 Drawings and Data

The following documents shall be furnished along with the bid:

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

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

a) Outline drawings including dimensions

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

## 1.7 NAME PLATE

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

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

## 1.8 TECHNICAL PARTICULARS

**TABLE-1.1**

| | | | | |
|---|---|---|---|---|
| i. | Type | Heavy duty, station class, Gapless Metal oxide, outdoor | | |
| ii. | Arrestor rating (kV rms) | 120 | 30 | 9 |
| iii. | Maximum Continuous Operating voltage (kV rms) | 102 | 25 | 7.65 |
| iv. | Lightning Impulse withstand voltage (kVp) | 650 | 170 | 75 |
| v. | Power Frequency Withstand Voltage ($kV_{rms}$) | 275 | 70 | 28 |
| vi. | Standard Nominal Discharge Current | 10 kA (8/20 micro impulse shape) | | |
| vii. | Line discharge class | Class-3 | Class-2 | Class-1 |
| viii. | Degree of protection | IP 55 | | |
| ix. | Max.Steep current impulse residual voltage at 10 kA ($kV_p$) | 380 | 110 | 28 |
| x. | Max. Lightening Impulse residual voltage at 10 kA ($kV_p$) | 330 | 90 | 25 |
| xi. | Max. switching surge residual voltage at 1 kA ($kV_p$) | 280 | NA | 21 |
| xii. | Partial discharge at 1.05 COV not greater than | 50pC | | |
| xiii. | Max. discharge capability corresponding to rated voltage | 5Kj/kV | | |
| xiv. | Low current long duration test value | 2400 µs | | |

| | | | | |
|---|---|---|---|---|
| xv. | High current short duration test value (4/10 μ second wave) | 100kA | | |
| xvi. | Minimum Corona Extinction Voltage (kVrms) | 105 | NA | NA |
| xvii. | Maximum partial discharge at 1.05*Continuous Over Voltage(COV) | 50 pC | | |
| xviii. | Prospective symmetrical fault current for pressure relief test for (0.2 sec) kA | 31.5 | 25 | 18.4 |
| xix. | Creepage distance (mm) | 3625 | 900 | 300 |

The above parameters are applicable for installations up to an altitude of 1000m above mean sea level. For altitude exceeding 1000 MASL, necessary altitude correction factor shall be applicable as per IEC or part thereof.

# CHAPTER – 7

# INSTRUMENT TRANSFORMER

## 1. Instrument transformer

### 1.1 General

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

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

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

### 1.2 Design Requirements

Instrument transformers shall be suitable for 50Hz, 3 phases with solidly grounded neutral system. All equipment shall be installed at an attitude altitude as mentioned in chapter 1 PSR above Mean Sea Level.

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

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

Technical particulars of instrument transformers shall be as per Table 1 and Table 2 below.

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

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

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

## 1.3 Construction Features

### 1.3.1 General

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

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

Instruments transformers shall be hermetically sealed units. Bidder/ Manufacturer shall furnish details of the arrangements made for the sealing of instrument transformers during detailed engineering.
The capacitor voltage transformers shall be of high Capacitance with two nominal voltage outputs of $110/\sqrt{3}$ volts each. They must be suitable for revenue metering and protection system.

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

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

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

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

### 1.3.2 Junction Boxes

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

### 1.3.3 Insulating Oil:

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

### 1.3.4 Terminations

a) Current Transformers

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

b) Capacitive Voltage Transformer/ Voltage Transformer

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

### 1.3.5 Accessories

The following items shall be provided for each instrument transformer:

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

## 1.4 Tests

Test shall be performed as specified hereunder.

### 1.4.1 Current transformer

**Routine tests**

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

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

**Design tests**

The current transformer design tests shall include following:

- Short time current tests
- Temperature rise test

- Power frequency withstand voltage (wet) tests
- Lightning impulse withstand tests
- Switching impulse withstand tests
- Radio interference voltage measurement test

### 1.4.2 Capacitor Voltage Transformer

**Routine Tests**

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

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

**Design Tests**

The capacitive voltage transformer design tests shall include following:

- Lightning Impulse tests
- Switching Impulse test
- Ferro-resonance tests
- Temperature rise tests
- Measurement of radio interference voltage

### 1.4.3 Inductive Voltage Transformer

**Routine Tests**

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

- Construction Inspection
- Verification of terminal marking
- Power frequency withstand test on primary winding
- Partial discharge measurement
- Power frequency withstand test on secondary winding
- Power frequency withstand test on between sections
- Ratio Test
- Determination of error

**Design Tests**

The inductive voltage transformer design tests shall include following:

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

### 1.4.4 Field Tests

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

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

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

## 1.5 Drawings, Data and Manuals

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

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

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

**Table-1: Technical particulars of Capacitor Voltage Transformers for 132 kV and VOLTAGE TRANSFORMER for 33 kV**

| | | | |
|---|---|---|---|
| 1. | Type | Outdoor, oil immersed for protection and metering. | Outdoor, oil immersed/ epoxy resin for protection and metering. |
| 2. | Rated primary voltage | 132kV | 33 kV |
| 3. | Max. system voltage | 145 kV | 36 kV |
| 4. | Impulse withstand voltage | 650 kV (crest) | 170 kV (crest) |
| 5. | Power frequency withstand voltage (1min,rms) | 275kV(rms) | 70 kV (rms) |
| 6. | Rated frequency | 50Hz | 50Hz |
| 7. | Connection | Line to ground | Line to ground |
| 8. | Number of secondary winding | 2 | 2 |
| 9. | Voltage ratio | 132/√3/0.11/√3/0.11/√3 kV | 33/√3 / 0.11/√3/0.11/√3 kV |
| 10. | Rated burden | 100 VA | 50 VA |
| 11. | Accuracy class | 3P and 0.2 for metering | 3P and 0.2 for metering |
| 12. | Rated voltage factor | 1.1 Continuous | 1.1 Continuous |
| 13. | Creepage distance | 3,625 mm | 900 mm |
| 14. | Applicable standard | IEC 60186 | IEC 60044-2 |

The above parameters are applicable for installations up to an altitude of 1000m above mean sea level. For altitude exceeding 1000 MASL, necessary altitude correction factor shall be applicable as per IEC or part thereof.

**Table-2: Technical particulars of 132 kV and 33 kV Current Transformer**

| | | | |
|---|---|---|---|
| 1. | Type | Outdoor, oil immersed for protection and metering. | oil immersed /Epoxy resin outdoor for protection and metering. |
| 2. | Rated primary voltage | 132 kV | 33 kV |
| 3. | Maximum system voltage | 145 kV | 36 kV |
| 4. | Impulse withstand voltage | 650 kV (crest) | 170 kV (crest) |
| 5. | Power frequency withstand voltage (1min,rms) | 275kV(rms) | 70 kV (rms) |
| 6. | Rated frequency | 50 Hz | 50Hz |
| 7. | | | |
| 8. | Number of core | 4 | *2* |
| 9. | Short time thermal ratings | 31.5 kA | 31.5 kA |
| 10. | Current ratio | *900-600-300/1A*<br>*600-300-150/1A* | *800-400/1A*<br>*400-200/1A* |
| 11. | Rated burden for each core | 30 VA | 15 VA |
| 12. | Accuracy class | 5P20 for protection and 0.2 for metering | 5P20 for protection and 0.2 for metering |
| 13. | Creepage distance | 3625 mm | 900 mm |
| 14. | Applicable standard | IEC 60044-1 | IEC 60044-1 |

The above parameters are applicable for installations up to an altitude of 1000m above mean sea level. For altitude exceeding 1000 MASL, necessary altitude correction factor shall be applicable as per IEC or part thereof.

# CHAPTER - 8

# D.C. BATTERY, BATTERY CHARGER

## 1.0 General

This specification covers design, manufacture, assembly factory test, supply, delivery, installation, field test and commissioning of a stationary battery or batteries each complete with battery charger, distribution board and control gear.

One set of batteries and one sets of battery chargers shall be provided for each of the following voltage levels. The operation shall be such that each set of battery shall be connected with two sets of chargers, out of which one set shall be for main supply and the other as a backup.

- 110 V DC shall be used for protection and control
- 48 V DC shall be used for communication/SCADA system.

It shall be ensured that the 110 V power supply system operates with both battery terminals free of earth, whilst that for communications, 48 V DC system with positive earthed, to detect faults on both the positive and negative poles.

48V Battery Charger shall consist of required numbers of MCB's of adequate capacity for supply of 48V DC supply required different panel's loads.

## 1.1 Batteries

The Contractor shall offer maintenance free valve regulated lead-acid 110 V and 48 V batteries. The batteries shall be assembled in heavy-duty-steel structure designed for easy stack ability.

The battery cells shall be hermetically sealed, sturdy, weather proof and long lasting. The safety valves, if provided shall be explosion free. All the cells shall be mounted on racks of plastic-covered steel. More than 2 levels shall not be permitted. If the batteries are located together in two rows, provide enough space for maintenance access along the two long sides.

The arrangement of the rack shall be such as to allow easy access and adequate space for normal maintenance in battery room.

All battery stands shall be suitably protected against corrosion and attack by the battery electrolyte. Inter-cell connections shall be made of low resistance in a clean condition when bolted and protected against corrosion.

Battery banks shall be protected by appropriate fuses.

The lowest rack for accommodating battery cells shall be at a minimum of 30 cm above ground level.

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

| System Voltage | Maximum Voltage during Float operation | Minimum voltage available when no charger working and battery fully discharged up to 1.85V per cell. |
|---|---|---|
| 110 Volt | 121 Volt | 99 Volt |
| 48 Volt | 52.8 Volt | 43.2 Volt |

## 1.2 Battery Capacity Sizing

### 1.2.1 110V DC Battery

Battery nominal capacity shall be not less than 400 AH. The nominal voltage of the battery at its terminal shall be 110 V. At the end of the rated discharge period of 10 hours, the voltage available at the battery terminals shall be not less than the minimum 94 V. Batteries shall be suitable for operation on a floating charge system and capable of providing the guaranteed output throughout the range of ambient conditions specified. The battery rated output shall be available at the outgoing terminals, after making due allowance for the resistance of inter cell connections.

### 1.2.2 48V DC Battery

The battery capacity shall not be less than 200 Ah.

The equipment shall be designed to operate within voltage limits specified below i.e. no spurious operations or false controls shall be initiated. 48 V DC power supplied shall have the following general characteristics:

- Provision for grounding positive terminal to station earth
- Voltage variation between 42 V to 48 V
- Battery autonomy: 10 hours

## 1.3 Battery Charging Equipment

The chargers shall be of the automatic constant voltage output type designed for float charge operation. They shall be suitable for operation from the 400 V ± 10% ac supply, 50 Hz.

The chargers for communications batteries shall be such that the phosphometric noise level does not exceed the equivalent of 2 milli-volts at a frequency of 800 Hz after weighing in accordance with CCIF, the charger output being at any point within its rating with the battery connected.

The DC output of each main charger unit shall remain within the limits of +3% and -2% under any of the following conditions:

a) System frequency between ±5% of the nominal value;
b) System rated voltage input ± 10%
c) Output of charger between 5% and 100% of rated output.

The constant voltage charge level on a cell shall be 2.25 V or any other value recommended by the offered battery manufacturer. The Battery charger output rating shall be 80 A for 110 V charger and 40 A for 48 V charger.

The equalizing and float voltage levels shall be adjustable and suitable for the range of operating conditions recommended by the battery manufacturer.

The static direct voltage variation shall be maintained as specified over an ambient temperature range of 0-40$^{o}$C.

The end switching / dropper diodes, if required, to limit equipment over voltage during equalizing charge shall be provided.

A voltmeter and charge and load ammeters on the front of the charger panels shall be provided. Provisions of AC and DC, under voltage and DC earth fault alarms with local indication (LED type indicator lamp) and separate electrically isolated contacts shall be made in the control panel.

The charger shall be equipped with automatic switch to transfer from the floating voltage to the equalizing voltage under the following conditions:

- When the voltage of the connected battery reaches the minimum prescribed value for a time longer than one minute.
- Every 30 days.

A manual override switch for selection of float charge and equalizing charge for test purposes shall also be provided.

An adjustable timer (6-24 hours) to determine the length of time the equalizing voltage shall be provided.

The AC component through the battery of the delivered DC shall not exceed 1 A rms per

50 Ah of battery capacity. The superimposed alternating voltage component shall not exceed 2% of the peak values during continuous charge operation. This applies for the entire frequency range.

The connection blocks for the connection of cables shall be of a minimum of 16 sq. mm. or as required as per voltage drop calculation.

The float charging voltage shall be between 2.1 to 2.25 volts per cell or at any other voltage recommended by the battery manufacturer. The battery charger shall have boost facility.

The boost-charging voltage shall be about 2.3 to 2.4 volts/cell or at any other voltage recommended by the battery manufacturer.

The equipment shall be designed to facilitate cable entry from bottom. Removable plates shall be furnished with compression type cable glands to make entry dust tight and no weight is transferred on the terminal. The glands shall be suitable for terminating cable armor. Compression type cable lugs as required shall be furnished for termination of power and control cables.

Sufficient space shall be provided to avoid sharp bending and for easy connection. A minimum space of 200 mm from the gland plate to the nearest terminal block shall be provided.

Terminal blocks shall be as specified in General Technical Requirements. A copper ground bus of 25mm x 6mm cross section shall be furnished near the bottom of panels and shall be connected to the station earthing mat with appropriate copper conductor. All devices shall be grounded to this ground bus.

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

Each Charger shall be furnished completely wired 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.

The insulation of all circuits, except the low voltage electronic circuits shall withstand test voltage of 2 KV AC for one minute.

The following accessories shall be furnished for the batteries:

a) one (1) connector bolt wrench
b) one (1) cell testing voltmeter with leads
c) Battery racks.

The charger shall be complete with the standard accessories including but not limited to the following.

a) Solid state surge protectors on the AC and DC sides.
b) AC failure alarm relay.
c) DC time delay low voltage relay.
d) Ground detection alarm for positive and negative leads.
e) Manual voltage adjust switch.
f) DC ammeter and voltmeter.

## 1.4 Annunciation System

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

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

Any other annunciation if required. Potential free NO Contacts of above abnormal conditions shall also be provided for common remote indication "CHARGER TROUBLE" in for future use. Indication for charger in float mode and boost mode through indication lamps shall be provided for chargers. A potential free contact for float/boost mode shall be provided for external interlocks.

## 1.5 Tests

Type and routine tests at manufacturers' works and acceptance test at site shall be carried out on the battery/battery chargers as per stipulations of latest standard of IEC.

The tests shall include the following:

a) General inspection.
b) Leakage test and internal short test for each cell.

After initial charging, the following tests shall be performed at site:

a) Capacity test.
b) Efficiency test, etc.

The battery charger shall be subjected to the following tests at manufacturer's works:

a) Construction Inspection
b) Measurement on insulation resistance.
c) High voltage test.
d) Performance test.
e) Temperature rise test.

Test certificates shall be submitted to the Employer for approval.

## 1.6 Drawing, Data and Manuals

Technical leaflets on battery and battery charger shall be furnished with the Bid:

The following drawings and manuals shall be submitted by the successful Bidder for approval:

a) Dimensional layout arrangement of battery and battery charger.
b) Dimensional outline drawing of battery charger panel clearly showing the location of meters, switches etc.
c) Schematic and wiring diagram of battery charger panel.
d) Instruction manuals of battery and battery charger.

e) Battery and battery charger sizing calculation.

## 1.7 D.C. DISTRIBUTION PANEL

1.7.1 The board shall be metal clad, totally enclosed indoor floor mounted, and free-standing cubicle type. Entry for incoming and outgoing cables shall be from bottom. Bus-bars shall be made of tinned copper and insulated. The construction feature, pre-treatment, painting and other aspects shall comply with specification covered for LT AC/DC board. The frame shall be fabricated using suitable mild steel structural section or pressed and shaped cold rolled sheet steel of thickness not less than 2.0 mm. The panel shall be provided with circuits and components such as meters, relays, etc. as per the 110 V DC single line diagram enclosed. Main bus bar shall be of high conductivity tinned copper of uniform rectangular cross section provided with positive and negative bus bars of adequate size. Components such as MCBs etc. shall be of reputed make with proven performance record and suitable for DC application. The bus bars shall be insulated.

1.7.2 The DC distribution panel shall be complete with bus bars, input/output terminals, inter panel connections, internal wiring, name and rating plates, mimic diagram (at the front of the switchboard), earthing bus and space heaters etc. The terminals shall be of reputed make and will be subject to approval of Employer.

1.7.3 **Emergency Lighting**

In case of AC failure, DC board shall supply emergency light in the Control Room building. Necessary devices for automatic change over for emergency lighting from AC to DC supply complete with necessary relays, interlocking and indications etc. shall be provided. Details shall be approved during engineering stage.

1.7.4 An earth bus bar of 25 mm Cu. Flat (to be got approved from Employer during detailed engineering) shall be provided along the entire length of the switchboard at the bottom. Two nos. earthing terminals connected to the earth bus bar shall be provided on the external face of the board for connection to the earthing grid at the sub-station.

1.7.5 All outgoing & incoming feeders shall be through MCCB/MCB's the isolating links shall be provided before MCCB/MCB.

# CHAPTER - 09

# ILLUMINATION/LIGHTING SYSTEM

## 1.1 General

This chapter covers the scope and general description of the design, supply, installation, testing and commissioning of illumination system, which shall be incorporated and coordinated during the substation construction works. Illumination system design shall be submitted for approval of the Employer.

The explanations and listings hereinafter are intended to give a general requirement of the illumination design and installation and shall not be construed to be an itemized listing of each element of works required. The Bidder shall be responsible for design and installation of complete facilities, conforming in all respects to the relevant standards and to the details and requirements of the specifications.

Any materials even if not mentioned under the given specifications required to complete the scope of works shall be supplied by the Contractor without any additional cost to the employer.

## 1.2 System Description

The lighting system shall comprise of the following:

### A. AC Normal Lighting

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

### B. DC Emergency Lighting

A few DC emergency lighting fixtures operated on the 110 V DC system will be provided in the strategic locations including, outdoor substation, Battery charger room, control room, 11 kV switchgear room, communication room so that the operating personnel can safely find their way even during emergency of a total AC failure. These lights will be normally 'OFF' and will be switched 'ON' automatically when under voltage occurs in the AC lighting panel. Down light fixtures in false ceiling area and Bulkhead fixtures in non-false ceiling area shall be used. Control board shall be equipped with necessary contactors and timers to control number of lighting fixtures in gang. Details shall be worked out to the satisfactory to the employer.

### C. Portable Emergency Lighting

Three (3) numbers of self-contained battery operated, portable emergency lights will be provided in the Control Building. These fixtures will be provided at important locations after approval by the Employer.

### 1.2.1 Illumination Level

Following illumination (lux) levels shall be maintained at different areas:

| Sr. No. | Area | Average Lux Level (lx) |
|---|---|---|
| 1. | 11 kV Switchgear Room | 200 |
| 2. | Control Room / Communication Room / Office Room | 300 |
| 3. | Battery Room | 100 |
| 4. | Street Lighting | 20 |
| 5. | Outdoor Substation & Transformer Area | 50 |
| 6. | Store | 100 |

The minimum lux level to average lux level ratio should not be less than 0.6 times of average lux level specified (i.e $E_{min}/E_{av}$> 0.6). The maintenance factor for indoor illumination design shall be considered as 0.8. The surface reflectance for ceiling/wall/floor shall be 50/30/10.

Lighting in all indoor areas shall be done by LED, CFL & fluorescent energy efficient based low power consumption luminaries and HPSV type for outdoor areas to achieve desired lux level specified.

### 1.2.2 Receptacles

All receptacles shall be suitable for fixing on wall or column and complete with individual switch
Appropriate socket-outlet shall be installed near each Power and Distribution transformers for connecting mobile oil treatment equipment.

General purpose and welding sockets outlets for maintenance shall be distributed in the whole Substation area. The distance between two sockets shall not be greater than 30meters.

| Type Of Receptacle | Description | Detail Of Outgoing Feeders |
|---|---|---|
| RO | Outdoor | 15A, 240V, Receptacle 2 pole, 3- pin type |
| RP | Outdoor for oil filtration transformer | 63A, 415V, Interlocked switch of, socket, receptacle |
| RI | Indoor | 5/15A, 240V, Receptacle 3-pin type |

All switches and receptacles shall be flush type and shall be capable to carry a continuous current to the rated capacity. Corresponding plug shall be furnished for every installed receptacle plus 10 pieces for spares.

## 1.3 Description of Works

The illumination works shall consist of outdoor substation lighting, control building lighting and roads lighting, lighting for gate post etc. All lighting fixtures shall energy efficient type.

### 1.3.1 Outdoor Substation Lighting

The outdoor substation lighting shall consist of lighting of the area covered by substation equipment, access road, and substation compound lighting.

**Substation outdoor equipment and area lighting**

Lighting fixture shall be of outdoor, flood light type, symmetrical beam spread of not less than 2x30° with built-in ballast. The housing shall be die cast aluminum and the reflector shall be high-grade aluminum. A cast aluminum doorframe shall be designed for easy replacement of lamp. The front glass shall be heat & shock resistance with the gasket for jet proof and dust proof sealing.

The lamps shall be of sodium vapor, 400/250 watts, 230 volts and shall have minimum luminous flux of 20,000 lumens with 16,000 hour service life.

The ballast shall be high efficiency electronic type and shall be used with 400/250 watts lamp, 230 volts, 50 hertz. The ballast shall be electrically designed to ensure very low operating temperature and low wattage losses.

The wiring cable shall be of armored single core, directly burial and shall be installed underground or laid in the cable trench except those rising along the steel structures shall be run in conduits.

**Access Road/Street Lighting**

The luminaries' is based on CFL or HPSV. The street light poles of 8m height shall be steel tubular poles complete with fixing brackets and junction boxes mounted 1 m above ground. The galvanized sheet steel junction box for the street lighting pole shall be completely weather proof conforming to IP: 55 poles with lockable door and with MCB. The terminal shall be stud type and suitable for 2 nos. , 16 $mm^2$ cable and double compression gland. Wiring from junction box at the bottom of the pole to the fixture at the top of the pole shall be done by using 2.5 $mm^2$ copper cables.

**Substation Compound Lighting**

Lighting Fixtures shall be outdoor, post top, bottom support with built in ballast. The electrical unit shall be made of high-pressure die cast aluminum with non-corrosive finish and shall contain a ballast, capacitor and lamp holder. The diffusing bowl shall be conical and shall consist of spun aluminum canopy and white opal diffuser. The diffuser shall be vandal-proof and shall be ultra violet radiation and heat resistance. The fixture shall be rainproof and insect tight. All metal parts shall be made of non-corrosive material.

The lamp shall be of sodium vapor, 250 watts, and 230 volts and shall have minimum luminous flux of 11,000 lumens with 16,000 hour service life.

The ballast shall be of high efficiency electronic type and shall be used with 250 watts lamp, 230 volts, and 50 hertz. The ballast shall be electrically designed to ensure very low operating temperature and low wattage losses.

The wiring cable shall be of armored single core, directly buried and shall be installed underground or laid in the cable trench except those rising along the steel structures shall be run in conduits.

**Building (Indoor) Lighting**

Unless described herein, the control building lighting design shall conform to Illuminating Engineering Society, National Electrical Code and National Electrical Manufactures Association Standard.

All normal lighting fixtures of control building shall be of CFL type with granulated acrylic diffuser complete with all accessories. All lighting fixtures installed on the ceiling covered by false ceiling shall be recessed. Lighting fixtures shall conform to the Standard for Electric Lighting Fixtures or other internationally accepted standards.

## 1.4 Lighting Panels

The lighting panel shall conform to NEMA Standard requirements. All over-current protective devices shall be Moulded Case Circuit Breaker (MCCB) or Miniature Circuit Breakers (MCB).
The outdoor control panel shall be galvanized or enamel painted steel cabinet, outdoor type. The over current protective devices shall be of MCCB or MCB. The ON-OFF operation of outdoor lighting shall be both manual and automatic control (with photo-switch). The arrangement of lighting branch circuits shall be reliable and easy maintenance.

## 1.5 Cable and Raceway

All wiring cable shall be of single core and shall run in conduits.

## 1.6 Grounding

All lighting panels, junction boxes, fixtures conduits etc. shall be grounded in compliance with the provision of relevant standard or local statutory requirements.
All electrical equipment shall be effectively grounded. The ground wire shall not be less than 1.5 $mm^2$ copper for fixtures and 4 $mm^2$ copper for Panel.

## 1.7 Information to be furnished

After award of the Contract the Contractor shall submit detail design of the illumination system. The fixtures shall be satisfactory to the Employer and shall be energy efficient.

The Contractor shall submit detailed indoor and outdoor lighting calculation for reaching the above Lux level including surface illumination diagram at varying equipment surface levels, detailed drawing showing the lighting layout and lighting distribution wiring diagram, receptacles, switches and lighting panels for Employer's approval during detailed engineering.

Bidder shall confirm the Lux levels at different locations by measurement.

**Contractors shall provide all necessary foundations and / or supporting structures for all outdoor and indoor areas.**

All rectification, repairs or adjustment work found necessary during inspection, testing and commissioning shall be carried out by the bidder, without any extra cost to the Employer.

The Contractor along with the Employer shall measure the actual lux level in all the areas of the substations to prove compliance to the specification.

## 1.8 Tests

The entire illumination system operation shall be tested on completion of the works in presence of the Employer. The tests shall include but not limited to measurement of intensity of light. During Test, if it is observed that illumination level in any area is lower than the specified value, the contractor will rectify the same at his own cost.

# CHAPTER - 10

# POWER AND CONTROL CABLES

## 1.1 General

This specification covers the design, manufacture, factory test, supply, delivery, installation, field-testing and commissioning of all Power, Control, Communication and Instrumentation cables required for the entire project.

## 1.2 Codes and Standards

HV Cables shall comply as a minimum with the below mentioned standards.

| | | |
|---|---|---|
| IEC 60059 | : | Recommended current ratings for Cables |
| IEC 60332 | : | Tests on Electric Cables under fire conditions. |
| IEC-754 (Part_I) | : | Test on gases evolved during combustion of Electric Cables. |
| IEEE-383 | : | Standard for type test of Class IE Electric Cables. |
| ASTM-D-2843 | : | Standard test method for density of smoke from the burning or decomposition of plastics. |
| ASTM-D-2863 | : | Standard method for measuring the minimum oxygen concentration to support candle like combustion of plastics. |

## 1.3 Low Voltage Power Cables

### 1.3.1 General

Low voltage AC power systems will be solidly grounded neutral with phase to phase voltage level of 400 V and phase to neutral voltage of 230V AC and the DC system with 110V, ungrounded and 48 V DC.

The main characteristics of the low-voltage cables shall be as follows:

- Rated voltage : 0.6/1.1 kV
- Conductors : Multi stranded annealed copper
- Insulation : Cross-linked polyethylene (XLPE)
- Inner sheath : PVC
- Armor : Galvanized steel
- Outer sheath : PVC, black color, FRLS, rodent protected
- Fire behavior : flame retardant category according to IEC 60332.

Power cables will have a minimum cross section of 2.5 mm² for lighting and 4 mm² for power. The main (incomer) cable to AC distribution panel shall be three & half (3.5) core and not less than 150 $mm^2$.

### 1.3.2 Design Requirement

The cables shall be suitable for laying on racks, in ducts, trenches, conduits.

Conductor shall consist of stranded annealed copper wires. They shall comply with relevant IEC publication.
Cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses develop under steady state and transient operating conditions.

Outer sheath shall be of PVC black in colour. Outer sheath of all the cables shall have the following FRLS properties.

- Oxygen index of min. 29 (to ASTMD 2863)
- Acid gas emission of max. 20% (to IEC-754-I).
- Smoke density rating shall not be more than 60% during Smoke Density Test as per ASTMD-2843.

All cables shall meet the fire resistance requirement with cable installations made in accordance with 'Flammability Test' and as per Category-B of IEC 332 Part -3.

Selection & sizing of power cables shall be based on the following considerations.

- Rated current of the connected equipment
- The voltage drop in the cable, during motor starting condition, shall be limited to 10% and during full load running condition, shall be limited to 3% of the rated voltage
- Short circuit withstand capability
- De-rating Factors : De-rating factors for various conditions of installations including the following shall be considered while selecting the cable sizes:

a) Variation in ambient temperature for cables laid in air
b) Grouping of cables
c) Variation in ground temperature and soil resistivity for buried cables.

Cable lengths shall be considered to ensure that straight through cable joints are avoided.

### 1.3.3 General Technical Requirements

#### a) Conductor

Conductor shall consist of stranded annealed copper wires. They shall comply with IEC publication. The cable is intended for use at normal conductor operating temperatures not exceeding 75 degree C.

#### b) Insulation

The electrically and thermally stable insulation shall be extruded onto the conductor so as to prevent contamination and voids in the insulation.

### c) Current Rating

The Contractor shall state the maximum continuous current rating and conditions of installation for low voltage power cables.

### d) Jacket

The cable core assembly shall be covered with a flame-retardative and moisture resistant PVC jacket, which is free stripping from the insulation. The overall jacket shall be clean, dry, and free of grease and shall be suitable for ink or paint application.

Anti-termite protection shall be applied to the cable and shall consist of either a non-magnetic metallic barrier or layer of nylon sheathing.

### e) Identification

Each cable shall have a printed legend on the overall jacket with the manufacturer's name, voltage class, the number and size of conductors, type of insulation etc.

The colors for core identification and color sequence shall be in accordance with follows.

- Single core : Black
- Twin core : Red and black
- Three core : Red, yellow and blue
- Three & half / Four core : Red, yellow, blue and black

## 1.4 Control and Instrumentation Cable

### a) General

All control and instrumentation cable shall be 600 V grade as per IEC standard, multi conductor, color-coded, PVC insulated armored cable. Each multi-core cable shall have not less than 20 percent or 2 spare cores, whichever is the greater.

### b) Conductor

Copper conductor shall be stranded circular non compacted cross section of minimum 2.5 sq.mm. The Contractor shall calculate the load of CT core considering all connected loads and submit to the employer for approval. In case of CT burden constrain, CT circuit cable cross sectional area shall be increased. In this case the Contractor shall supply and install the cable required cross section area without any additional cost to the Employer.

### c) Insulation

The electrically and thermally stable PVC insulation shall be extruded onto the conductor so as to prevent contamination and voids in the insulation.

### d) Assembly

Multi core conductor cables shall be assembled in accordance with applicable IEC standards.

A flame-retardant binder tape may be used underneath the overall jacket of multi conductor cables, if required, to achieve the desired flame retardant characteristics. Tapes, if used, shall be non-hygroscopic.

**e) Jacket**

The cable core assembly shall be covered with a flame retardant and resistant jacket, which is free stripping from the insulation.

The overall jacket shall be clean, dry, and free of grease and shall be suitable for ink or paint application.
Cable jacketing and the interstices within the jacket shall be free of water. Evidence of water shall be the ground for rejection of the cable.

Anti-Termite Covering: Anti termite protection shall be applied to the cable and shall consist of either a nonmagnetic metallic barrier or layer of nylon sheathing.

**f) Identification**

Each cable shall have a printed legend on the overall jacket, with the manufacturer's name, voltage class, the number and size of conductors, and a unique number or code indicating the production run or batch. The identification shall remain legible for the life of the cable.

## 1.5 Communication Cable

All cables and wiring shall have copper conductors and PVC insulation and shall comply with IEC standards.
Each communication cable shall have not less than 20 percent or 4 spare twisted pairs whichever is the greater. Cabling and wiring installations shall be arranged to minimize the risk of fire and damages, which might be caused in the event of fire.

For telephone type cables, 2 conductor wires of not less than 0.6 mm diameter shall be used. Where twin or quad make up is required in any cable, the cores shall be uniformly twisted and the lays arranged such that cross talk is reduced to a minimum.

No conductor smaller than 32/0.2 mm (1 mm2), or having less than three strands, shall be used for interconnecting the cables except in the case of telephone extensions. All cables shall have insulation, which will withstand the highest temperature to be experienced in service.

Each conductor of a multicore cable shall be readily identified by a numbered marker tape or, in the case of telephone type cables, color coded insulation.

## 1.6 Cable Tags & Marker

Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.
The tag shall be of aluminum with the number punched on it and securely attached to the cable conduit by not less than two turns of 20 SWG Gl wire.

Conforming to IS: 280. Cable tags shall be of rectangular shape for power cables and of circular shape for control cables.

Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanized iron plate. Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable joints". The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road and drain crossings.
Cable tags shall be provided on all cables at each end Gust before entering the equipment enclosure), on both sides of a wall or floor crossing, ·on each duct/conduit entry and at each end & turning point in cable tray/trench runs.

## 1.7 Cable Termination and Connections

The termination and connection of cables shall be done strictly in accordance with cable and termination kit manufacturer's instructions, drawing and or as per instruction of the Employer.

Control cable cores entering control panel/switchgear/MCCB/MCC/Miscellaneous panels shall be neatly bunched, clamped and tied with nylon strap or PVC perforated strap to keep them in position.

The Contractor shall tag/ferrule control cable cores at all terminations, as instructed by the Employer. In panels where a large number of cables are to be terminated and cable identification may be difficult, each core ferrule may include the complete cable number as well.

Spare cores shall be similarly tagged with cable numbers and coiled up.

Double compression type nickel plated (coating thickness not less than 10 microns) brass cable glands shall be provided by the Bidder for all power and control cables to provide dust and weather proof terminations.

The cable glands shall conform to BIS: 6121. They shall comprise of heavy duty brass casting, machine finished and nickel plated, to avoid corrosion and oxidation.

Cable lugs shall be tined copper solder less crimping type conforming to IS-8309 & 8394. Bimetallic lugs shall be used depending upon type of cables used.

## 1.8 Installation of Cables

In general all power and control cables shall be in the cable trenches. In addition to the above, for lighting purpose also, cable trench can be used in outdoor area as far as possible.

Cabling in the Switchgear/control room shall also be done on ladder type cable trays.
For cables laid in conduits in outdoor area, conduits of 50 mm nominal outside diameter of class 4 as per IS 4985 shall be used, which shall be buried in the ground at a depth of 250mm below finish formation level. Separate PVC pipes shall be laid for control and power cables. Cable pull boxes of adequate size shall be provided if required.

Power and control cables in the cable trench shall be laid in separate tiers. The order of laying of various cables shall be as follows, for cables other than directly buried.

- Power cables on top tiers.
- Control instrumentation and other service cables in bottom tiers.

Single core cables in trefoil formation shall be laid with a distance of three times the diameter of cable between trefoil center lines. Power cables from station transformer to main ACDB shall be laid with a minimum center to center distance equal to twice the diameter of the cable.

Power and control cables shall be securely fixed to the trays/supports with self-locking type nylon ties with the interlocking facility at every 5 meter interval for horizontal run. Vertical and inclined cable runs shall be secured with 25 mm wide and 2 mm thick aluminum strip clamp at every 2m.

Cables shall not be bent below the minimum permissible limit.

Where cables cross roads, drains, these shall be laid in reinforced spun concrete or steel pipes buried at not less than one meter depth.

## 1.9 Cable Trays

Cable trays shall be used in control building and other areas within substation and within cable trenches outside substation area. The cable trays shall be of GS sheet and minimum thickness of sheet shall be 2 mm. cable trays shall have 2.5 meter straight section and 150, 300 mm and 600 mm wide

## 1.10 Conduits, Pipes and Duct Installation

Bidder shall supply and install all rigid conduits, mild steel pipes, flexible conduits, Hume pipes etc. including all necessary sundry materials such as tees, elbows, check nuts, bushing, reducers, enlargers, coupling cap, nipples, gland sealing fittings, pull boxes etc. The size of the conduit/pipe shall be selected on the basis of 40% fill criterion. Embedded conduits shall have a minimum concrete cover of 50 mm.

Size of conduit for lighting shall be selected by the Bidder during detailed engineering.

For directly embedding in soil, the conduits shall be coated with an asphalt-base compound. Concrete pier or anchor shall be provided wherever necessary to support the conduit rigidly and to hold it in place.

Conduit shall be installed in such a way as to ensure against trouble from trapped condensation.

FO cables shall be laid in galvanised steel (GS) conduits within cable trenches keeping proper clearance with HV cables

## 1.11 Special Requirements

The Contractor shall be responsible for estimating and supplying the quantity of various types and sizes of the cables. In course of actual execution, if it is found that additional cross sections, types or quantities of cables are required for the completion of the specified works the same shall be supplied without any additional charge to the employer.

Small cut piece lengths of cables will not be accepted. Cables up to 500 meters in length or as approved by Employer shall be of one length shipped in a drum of adequate size. For higher quantities, multiple lengths/drums may be shipped subject to the approval of Employer.

## 1.12 Drawings, Data & Manuals

The following information shall be furnished along with the bid.

a) Manufacturer's leaflets giving constructional details, dimensions and characteristics of different cables.
b) Current rating of cables including de-rating factor due to grouping, ambient temperature and type of various installation.

## 1.13 Tests

### Routine and Design Tests

Power cable shall be subjected to following routine tests. As far as practical, the procedure of IEC shall be followed:

a) Measurement of the electrical resistance of conductor
b) Partial discharge test
c) Voltage test

### Design Test

The power cable design tests shall include following:

a) Partial discharge test
b) Bending test, followed by a partial discharge test
c) Tan delta measurement
d) Heating cycle test, followed by a partial discharge test
e) Impulse test, followed by voltage test
f) Voltage test for 4 hours.

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

**Field Tests**

After installation at Site, cables shall be subjected but not limited to the following tests:

a) Continuity test
b) Measurement of insulation resistance
c) DC dielectric test

### 1.14 Performance Guarantee

The performance figures quoted on schedule of Technical Data shall be guaranteed within the tolerance permitted by relevant standards and shall become part of the Contract. In case of failure of the cables to meet the guarantees, the Employer reserves the right to reject the item. The Contractor shall have to rectify/replace the defect/defective part at no extra cost to the Employer and without delaying the commissioning schedule.

## 2.0. TECHNICAL SPECIFICATION FOR XLPE CABLE

2.0.1 The XLPE insulated, EHV cable shall confirm 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/IEC62067 (as applicable). The offered cables and its terminating accessories shall be compatible with each other.

2.0.2 As per the respective item mentioned in the bill of quantity, the cable shall be of 33 and 11 kV EHV grade, single and three core, unarmored, stranded compacted Copper conductor and Aluminum 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 Lead/aluminum alloy 'E' )**, metallic screening by concentric layer of plain copper wire followed by an open helix of copper & overall HDPE sheathed & graphite coated and conforming to the technical particulars of specification.

2.0.3 The construction of cable shall generally conform to the description mentioned at sl no.1.0.3 of the 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. The bidder shall enclose with the bid, drawing showing cross section of the cable.

2.0.4 The cable shall be suitable for laying underground buried installation with uncontrolled back fill and chances of flooding by water and suitably designed by the addition of chemicals in the outer sheath to be protected against rodent and termite attack

2.0.5 The conductors screen (non-metallic semi-conductive) shall be extruded in a single one-time process to ensure homogeneity and absence of voids.

2.0.6 They shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions.

2.0.7 Progressive sequential marking of the length of cable in meters at every one meter shall be provided on the outer sheath of the cable.

2.0.8 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.

2.0.9 The cables shall have outer sheath of HDPE material. Repaired cables shall not be accepted.

2.0.10 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

2.0.11 The conductor and metallic sheath shall be designed to meet the requirement of the system short circuit rating of 25KA **for 1 sec for 11 and 33 kV.**

## 2.2 TYPE TESTS

### 2.2.1 XLPE INSULATED EHV POWER CABLES

Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Section: Chapter 2: GTR for XLPE insulated EHV cables.

### 2.2.2 TESTS ON ACCESSORIES

The bidder shall submit type test reports for all type tests as per IEC 60840:1999/ IEC 62067 for owner's acceptance.

## 2.3 TESTS AFTER INSTALLATION

All tests as prescribed in IEC-60840:1999 shall be performed after installation of cable.

## 2.1 CABLE LAYING AND TERMINATION

XLPE insulated cable shall be laid in 132/33/11 kV Motipur and Sandhikharka Substation as per the requirement and approved layout of the substation for connection from transformer to the associated Bays in Buried cable trench . The

cable shall be laid in flat formation with 100mm (minimum) spacing. The depth of laying shall be 1.0 m. Single point bonding system shall be employed along with sheath voltage limiters (SVL) if required, to limit the standing voltage to 65V. Laying route along with cable length shall be planned to keep the provision of a future cable joint in all cables by providing S bend. Contractor shall propose his own design of cable trench and submit to owners for approval

# CHAPTER – 11

# A.C. 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 for 132/33/11 kV substation at Motipur and Sandhikharka in Nepal.

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 equipments 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 Distribution Board shall be fed from 200 KVA, 33/0.4 kV distribution transformer.

1.2.2 Tentatively the following minimum feeders shall be required but not limited 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.

1.2.4 400 V AC 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 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 color 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.

## 1.3 CONSTRUCTIONAL FEATURES

### 1.3.1 400 V 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 IS: 2147 or 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 form 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 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 bus bar 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, moulded 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 bus bars 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 bus bars 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 LTAC 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 them 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 | |

# CHAPTER 12 - AIR CONDITIONING SYSTEM

## 1 GENERAL

1.1 This specification covers supply, installation, testing and commissioning and handing over to NEA of Air conditioning system for the control room building.

1.2 Air conditioning units for control room building shall be set to maintain the inside DBT at 24 ° C ± 2°C and the air conditioning system for switch-yard panel rooms shall be set to maintain DBT inside switch-yard panel rooms below 24°C.

1.3 Controllers shall be provided in Control room and Battery room for controlling and monitoring the AC units in these rooms as detailed in clause no.2.3.4.

1.4 Each switch-yard panel room shall be provided with temperature transducer to monitor the temperature of the panel room. The Temperature transducer shall have the following specification:

| | | |
|---|---|---|
| Sensor | : | Air temperature sensor (indoor use) |
| Output | : | 4 to 20mA |
| Temperature range | : | -5°C to 60°C |
| Resolution | : | 0.1°C |
| Accuracy | : | 0.5°C or better. |

## 2 AIR CONDITIONING SYSTEM FOR CONTROL ROOM BUILDING.

2.1 Air conditioning requirement of control room building shall be met using a combination of following types Air Conditioning units as required.

a) Cassette type split AC units of 3TR.
b) High wall type split AC units of 2TR.

2.2 **Scope**

The scope of the equipment to be furnished and services to be provided under the contract are outlined hereinafter and the same is to be read in conjunction with the provision contained in other sections/ clauses. The scope of the work under the contract shall be deemed to include all such items, which although are not specifically mentioned in the bid documents and/or in Bidder's proposal, but are required to make the equipment/system complete for its safe, efficient, reliable and trouble free operation.

2.2.1 Required number of Cassette type split AC units of 3TR capacity each complete with air cooled outdoor condensing unit having hermetically sealed compressor unit with cordless remote controller.

2.2.2 Required number of High wall type split AC units of 2TR capacity each complete with air cooled outdoor condensing unit having hermetically sealed compressor and high wall type indoor evaporator unit with cordless remote controller.

2.2.3 Copper refrigerant piping complete with insulation between the indoor and outdoor units as required.

2.2.4 First charge of refrigerant and oil shall be supplied with the unit.

2.2.5 GSS/Aluminium sheet air distribution ducting for distributing conditioned dehumidified air along with supply air diffusers and return air grilles with volume control dampers and necessary splitters etc., suitable fixtures for grilles/diffusers and supports for ducting complete with insulation.

2.2.6 Local start/stop facility for local starting/ stopping of all electrical equipment/ drives.

2.2.7 All instruments and local control panels alongwith controls and interlock arrangements and accessories as required for safe and trouble free operation of the units.

2.2.8 PVC drain piping from the indoor units' upto the nearest drain point.

2.2.9 Supply and erection of Power and control cable and earthing.

2.2.10 MS Brackets for outdoor condensing units, condensers as required.

## 2.3 Technical specifications.

### 2.3.1 Cassette type split AC units.

The Cassette type AC units shall be complete with indoor evaporator unit, outdoor condensing units and cordless remote control units.

2.3.1.1 Outdoor unit shall comprise of hermetically/ semi hermetically sealed compressors mounted on vibration isolators, fans and copper tube aluminium finned coils all assembled in a sheet metal casing. The casing and the total unit shall be properly treated and shall be weatherproof type. They shall be compact in size and shall have horizontal discharge of air.

2.3.1.2 Indoor units shall be of 4-way, ceiling mounted cassette type. The indoor unit shall be compact and shall have elegant appearance. They shall have low noise centrifugal blowers driven by suitable motors and copper tube aluminium finned cooling coils. Removable and washable polypropylene filters shall be provided. They shall be complete with multi-function cordless remote control unit with special features like programmable timer, sleep mode etc.

2.3.1.3 Cooling capacity of 3TR AC units shall not be less than 36000btu/hr. and their EER shall not be less than 2.7.

2.3.2 **High wall type split AC units**

2.3.2.1 The split AC units shall be complete with indoor evaporator unit, outdoor condensing units and cordless remote control units.

2.3.2.2 Outdoor unit shall comprise of hermetically/semi hermetically sealed compressors mounted on vibration isolators, propeller type axial flow fans and copper tube aluminium finned coils all assembled in a sheet metal casing. The casing and the total unit shall be properly treated and shall be weatherproof type. They shall be compact in size and shall have horizontal discharge of air.

2.3.2.3 The indoor units shall be high wall type. The indoor unit shall be compact and shall have elegant appearance. They shall have low noise centrifugal blowers driven by suitable motors and copper tube aluminium finned cooling coils. Removable and washable polypropylene filters shall be provided. They shall be complete with multi function cordless remote control unit with special features like programmable timer, sleep mode and soft dry mode etc.

2.3.2.4 Cooling capacity of 2TR AC units shall not be less than 22000btu/hr. and shall have energy efficiency rating of 3star or above.

2.3.3 Controllers shall be provided in Control room and Battery room, one controller for each room, to control and monitoring of AC units and shall have the following facilities;

- Standby units shall come in to operation automatically when the running main unit fails
- Main and standby units shall be changed over periodically which shall be finalised during detailed engineering.
- Following alarms shall be provided:

  a. Compressor On/OFF condition of each unit
  b. Compressor failure of each unit
  c. Power OFF to AC unit
  d. High temperature in room.

2.4 **Warranty**

All compressors shall have minimum 5 years Warranty from the date of commissioning.

2.5 **Technical specification for Packaged AC units with Free Cooling.**

2.5.1 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.

2.5.2 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.

2.5.3 Packaged AC units with free cooling shall be designed for high sensitive cooling with sensible heat factor of 90% or above.

2.5.4 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.

2.5.5 The AC units shall be mounted on the wall and the maintenance of unit shall be possible from outside the Switchyard panel room.

2.5.6 Required Features of Various Components

The compressor shall be very reliable, trouble free and long life i.e. hermetically sealed Scroll type of reputed make suitable for continuous operation. Compressor should be installed on vibration isolated mountings or manufacturers recommended approved mounting. Valve shall be provided for charging/topping up of refrigerant. The bidder shall furnish details of their compressor indicating the MTBF, life of compressor and continuous run time of compressor without failure. The contractor shall also furnish details of all accessories i.e. refrigeration system, evaporator coil, condenser coil, evaporator blower, filter, cabinet, indoor supply and return grill etc. during detailed engineering.

2.6 **Warranty**

All compressors shall have minimum 5 years Warranty from the date of commissioning

2.7 For owner's remote monitoring purposes, necessary digital inputs shall be provided for 'ON' and 'OFF' condition of each compressor.

# CHAPTER - 13
# SUB-STATION STRUCTURES

## 1.1. SCOPE

**1.1.1.** These specifications are intended to cover the design, fabrication, trial assembly, galvanizing, testing at manufacturer's works, inspection before dispatch, packing, transportation, storage and handling at site, erection etc. of substation galvanized steel structures like towers/columns, lightening/lighting masts, beams, equipment supporting structures etc. and any other structure which may be required for receiving the line with all necessary accessories as required for successful commissioning of all substations as per tentative layout drawings of these substations appended with these specifications conforming to relevant Indian Standards/ equivalent International Standards.

**1.1.2.** The scope shall also include supply and installation of all types of galvanized structures including bolts, nuts, plain/tapered/spring washers, step bolts, ladders, all necessary inserts in concrete, gusset plates, base plates, foundation bolts, equipment mounting bolts, structure earthing bolts, fixing plates, necessary angles & bolts for structure or ground mounted marshaling kiosks/boxes (AC/DC Marshalling box & equipment control cabinets) and any other item as required to complete the job.

**1.1.3.** It is the intent of the Employer to provide structures which allow interchangeability of equipment 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.

**1.1.4.** 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 Indian Standards / equivalent International Standards. The weight of the zinc coating shall be at least 610 gram/$m^2$ for structural members as well as for anchor bolts and foundation bolts. One additional nut shall be provided in each foundation bolt below the base plate which may be used for the purpose of leveling.

**1.1.5.** Contractor shall provide suitable arrangement on the equipment supporting structures wherever required to suit fixation of accessories such as marshalling boxes, MOM

boxes, Control Cabinets, Junction box, surge counter etc and incorporate the details in the fabrication drawings of equipment supporting structures.

**1.1.6.** The lightening/lighting mast shall be designed suitably so as to have illumination platforms for installing the luminaries to obtain prescribed/desired illumination intensity.

**1.1.7.** The contractor shall furnish all materials, labor, plant and erection equipment required for the completion of the job.

**1.1.8.** The line diagrams of all structures of 132kV and 33 kV substations shall be prepared by the contractor based on their design during detailed engineering stage. The fabrication drawings, proto corrected drawings along with Bill of Material (BOM) for all the structures including equipment supporting structures shall be prepared by the contractor during detailed engineering for submission to Employer for their approval. Support structure for circuit breaker shall also be designed and supplied by the Equipment Manufacturer or Contractor.

**1.1.9.** The Contractor shall be fully responsible for designing and detailing of the steel structures as per these specifications, testing as per relevant Indian Standards/ equivalent International Standards and for their satisfactory performance. All designs/ drawings and details shall be subject to approval of the Employer/PMC who shall have the right to instruct the contractor to make changes in designs/drawings and details necessary to make the designs conform to these specifications and relevant Indian Standards/ equivalent International Standards. The contractor shall be required:

(a) To submit the detailed design calculations for all steel structures including gantry towers/columns, beams, lightening/lighting masts, equipment supporting structures etc. required at each substation as per the layout drawings, to be developed by the Contractor and approved by the Employer, taking into consideration all the applicable and prescribed loads.

(b) To submit designs and fabrications drawings of all structures including equipment supporting structures required for each substation for the approval of Employer.

(c) Testing of structures as per relevant codes and standards.

(d) To furnish all materials, tools and plants required for successful completion of job whether specified or not.

(e) To suitably mark and transport all steel structures and accessories to the site and their proper and safe storage at site.

(f) To carry out erection/assembling of all structures and accessories at site for the purpose for which structures have been designed, fabricated and supplied.

**1.1.10.** The bidder shall quote lump sum price for all the substation structures including all necessary hardware for installation and successful testing & commissioning thereof. The rates to be quoted shall also include the fee for the preparation of designs, design/fabrication drawings, furnishing the required number of copies of all design & drawings including soft copies, manuals, supply of all materials, fittings & fixtures, hardware, transportation charges, octopi & tolls, labour, freight insurance including arranging all erection plant and equipment, etc and all temporary and permanent works necessary for satisfactory completion of job in all respects.

## 1.2. SUBSTATION LAYOUT AND SECTIONS DRAWINGS

**1.2.1.** The preliminary layout plan and/or sectional elevations drawings of both Motipur & Sandhikharka substation is appended to these specifications for the information and guidance of bidders.

The drawings are purely tentative and for tender purpose only and in no way final drawing. The contractor shall be required to prepare substation layout and sectional elevation drawings to meet the requirements of these specifications and get them approved from Employer. The design of substation steel structures shall be based on approved layout & section drawings and shall be suitable for specified loadings and loading combinations.

## 1.3. SUBLET ORDERS

**1.3.1.** No sublet orders shall be placed by the Contractor with any manufacturer or supplier without prior written approval of the Employer and when such approval is given, the copies of all drawings/specifications referred to in the sublet orders shall be furnished to the Employer for information.

## 1.4. CODES AND STANDARDS

**1.4.1.** All works shall be carried out strictly in accordance with these specifications and relevant Indian/Nepalese Standards or equivalent International Standard Codes of

Practices whether mentioned in the specification or not as existing one month prior to date of submission of price bid.

**1.4.2.** Except where otherwise specified or implied, the design, manufacturing, fabrication and galvanization of switchyard steel structures shall conform to the provisions of IS: 802(Part-I/Sec-1)-1992, IS: 802(Part-I/Sec-2)-1995 and IS: 802(Part-II)-1978.

**1.4.3.** Unless otherwise stated, the Indian/ Nepalese/ International standards and some handy codes as given in Table 17.1 below shall be applicable.

**Table - 13.1**

**Indian Standards & Codes**

| Sl. No. | Standard No. | Title |
|---|---|---|
| 1 | IS:800 | Code of practice for use of structural Steel in general building construction. |
| 2 | IS:802 (Part-I/Sec-2)-1992 | Use of structural steel in Overhead Transmission Line Towers – Code of Practice: Part-1 Material, Loads and Permissible Stresses |
| 3 | IS:802 (Part-II)-1992 | Code of Practice for Use of structural Steel in Overhead Transmission Line Towers: Part-II Fabrication, Galvanizing, Inspection and Packing |
| 4 | IS:808 | Specification for Rolled Steel Beams, Channels and Angle Sections. |
| 5 | IS:813 | Scheme of symbols for welding |
| 6 | IS:814 | Covered electrodes for metal arc welding of structural steel |
| 7 | IS:815 | Classification coding of covered electrodes for metal arc welding of structural steels |
| 8 | IS:816 | Code of Practice for use of material arc welding for general construction in mild steel |
| 9 | IS:817 | Code of practice for training and testing metal arc welders |
| 10 | IS:822 | Code of practice for inspection of welds |
| 11 | IS:823 | Code of practice for manual metal arc welding of mild steel |
| 12 | IS:875 | Code of practice for structural safety of buildings: loading standards |
| 13 | IS:919 | ISO System of Limits and Fits |
| 14 | IS:1364 | Specification for hexagonal bolts, screws, nuts and lock nuts |
| 15 | IS:1367 | Technical supply conditions for threaded steel fasteners |
| 16 | IS:1573 | Specification for electroplated coatings of zinc on iron and |

| Sl. No. | Standard No. | Title |
|---|---|---|
| | | steel |
| 17 | IS:1730 | Dimensions for steel plate, sheet and strip for structural and general engineering purposes. |
| 18 | IS:1731 | Dimensions for steel flats for structural and general engineering purposes |
| 19 | IS:1893 | Criterion for earthquake resistant design of structures |
| 20 | IS:2016 | Specification for plain washers |
| 21 | IS:2062 | Specification for structural steel fusion welding quality |
| 22 | IS:2633 | Method of testing uniformity of coating of zinc coated articles |
| 23 | IS:4759 | Specification for hot-dip zinc coatings on structural steel and other allied products |
| 24 | IS:6639 | Specification for hexagonal bolts for steel structures. |
| 25 | IS:7215 | Tolerance for fabrication of steel structures |
| 26 | IS:7318 | Approved tests for welders when welding procedure approval is not required |
| 27 | IS:2363 | Black hexagonal bolts, nuts and lock nuts and hexagonal screws |
| 28 | IS:2629 | Recommended practice for hot dip galvanizing of iron and steel |
| 29 | IS:1978 | Specification for line pipe |
| 30 | IS:3063 | Specification for spring washers |
| 31 | IS:806 | Code of practice for use of steel tubes in general building construction |
| 32 | IS:1161 | Specification for steel tubes for structural purposes |
| 33 | IS:209 | Specification for zinc |
| 35 | IS:6610 | Specification for heavy washer for steel structures |
| 36 | IS:5358 | Specification for hot dip galvanized coatings on fasteners |
| 37 | IS:6745 | Specification for methods of determination of weight of zinc coating on zinc coated iron and steel articles |
| 38 | IS:228 | Method of chemical analysis of pig iron, cast iron, plain carbon & low alloy steel |
| 39 | IS:406 | Specification for Method of CHEMICAL Analysis for slab zinc |
| 40 | IS:1083 | Precision hexagonal bots, screws and nuts (BSW & BHF threads). |
| 41 | IS:1181 | Qualifying tests for metal arc welders (engaged in welding structures other than pipes). |

| Sl. No. | Standard No. | Title |
|---|---|---|
| 42 | IS:1182 | Recommended practice for radiographic examination of fusion welded butt joints in steel plates |
| 43 | IS:1363 | Specification for block hexagonal bolts, nuts and locks nuts and block hexagonal screws |
| 44 | IS:1477 | Code of practice for finishing of ferrous metal in buildings – painting and allied finishers – Part-I (Operation and workmanship). |
| 45 | IS:1599 | Method of bend tests for steel products other than sheet, wire & tubes |
| 46 | IS:1608 | Method of tensile testing of steel products other than sheet strip wire & tube |
| 47 | IS:1852 | Specification for rolling and cutting tolerance for hot rolled steel products |
| 48 | IS:2074 | Ready mix paint, red oxide zinc chromate primer |
| 49 | IS:2551 | Danger notice plates |
| 50 | IS:2595 | Code of practice for radiographic testing |
| 51 | IS:3502 | Steel for checked plates |
| 52 | IS:3613 | Acceptance tests for wire flux combination for metal arc welding for mild steel |
| 53 | IS:3658 | Code for practice for liquid penetrant flow detection |
| 54 | IS:3664 | Code of practice for ultrasonic testing by pulse echo method |
| 55 | IS:4000 | Code of practice for assembly of structural joints using high tensile friction grip fasteners |
| 56 | IS:5334 | Code of practice for magnetic practice flow detection of welds |
| 57 | IS:5613 | Code of practice for design, installation and maintenance of overhead power lines |
| 58 | IS:5624 | Foundation bolts |
| 59 | SP:6(4) | Use of high strength frication grip bolts (IS Publication) |
| 60 | IS:10238 | Step bolts for steel structures |
| 61 | IS:12427 | Transmission tower bolts |

**1.4.4.** The above list of Standards is not exhaustive but indicative only. All other relevant International/Nepalese Standard not mentioned in the list shall also be applicable.

**1.4.5.** The equipment/materials meeting the requirement of any other Indian/Nepal standard or equivalent International standards which ensure a quality equal or better than the standard mentioned above shall also be acceptable.

**1.4.6.** Where any equipment/material conforms to any other standard other than mentioned above is offered by the bidder, then the 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 his bid. It shall, however, be subject to the acceptance and the approval of Employer.

## 1.5. MATERIALS & WORKMANSHIP

All materials used in the manufacture of the substation steel structures shall be of tested and best quality conforming to relevant Indian standards and workmanship shall be of the high order in accordance with best engineering practices.

The materials, for which no Indian/ Nepalese Standards exist, shall be in accordance with any other International Standard subject to the approval of the Employer.

### 1.5.1. Structural Steel Sections and Plates

1.5.1.1. Structural steel of tested quality conforming to IS: 2062-2011 shall be used for the fabrication of steel structures, base plates, foundation bolts etc. The structural steel sections and plates shall be hot rolled manufactured either using mild steel of Grade E250 (Designated Yield Strength 250 MPa) or high tensile strength steel of Grade E350 (Designated Yield Strength 350 MPa).

1.5.1.2. Structural Steel Sections used for the fabrication of structures shall conform to IS: 808-1989.

1.5.1.3. Structural Steel plates shall also be of Grade E250 (Designated Yield Strength 250 MPa) or Grade E350 (Designated Yield Strength 350 MPa) of tested quality conforming to IS: 2062-2011.

1.5.1.4. Other equivalent grade of structural steel angle sections and plates conforming to International Standards can also be used if approved by the Employer. The steel sections as per any other International standards, if used, shall be of equal or superior quality with corresponding Indian Standards. However, the use of steel grade having designated yield strength of more than 350 MPa shall not be permitted.

1.5.1.5. Steel plates of thickness of less than 6.0 mm exclusively used for packing plates or packing washers produced as per IS: 1079-1994 are acceptable. However, if plates of

thickness of less than 6.0 mm are used as load bearing plates viz. gusset plates, joint splices etc., the same shall conform to IS:2062 or equivalent International Standard meeting mechanical strength and metallurgical properties corresponding to steel of Grade E250 or Grade E350 depending upon the type of grade of steel incorporated into design. Flats of equivalent grade meeting mechanical strength and metallurgical properties may also be used in place of plates for packing plates and packing washers.

1.5.1.6. All steel sections and plates supplied shall be free from all imperfections, mill scales, slag intrusion, laminations, pitting, rusts etc that may impair their strength, durability and appearance. All materials shall be of tested quality and the test certificates from Manufacturer in respect of each consignment shall be submitted by the contractor to employer in triplicate.

1.5.1.7. Samples of all materials procured by the Contractor and workmanship proposed to be employed in the execution of the works may be inspected, at any time, by the employer. In case such samples are found to be of substandard/unacceptable quality, the Contractor shall immediately discontinue use of such materials and workmanship and get fresh samples approved by the employer. Nothing shall affect the liberty of the employer to reject portions of the structures where defective materials and/or workmanship has already been used before detection.

### 1.5.2. Bolts, Nuts and Washers

1.5.2.1. The bolt conforming to IS: 12427 and of property class 5.6 as per IS: 1367(Part-III) and matching nut of property class 5.0 as per IS: 1367(Part-VI) shall be provided.

1.5.2.2. Flat and tapered washers shall be mild steed conforming to relevant Indian Standard.

1.5.2.3. Spring washers conforming to IS: 3063 shall be provided.

1.5.2.4. Foundation bolts shall be of mild steel of Grade E250 (Designated Yield Strength 250 MPa) conforming to IS: 2062.

## 1.6. STORAGE OF MATERIAL

**1.6.1.** All materials shall be stored in such a manner so as to prevent deterioration and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged shall be removed from Contractor's yard or site stores immediately.

**1.6.2.** Steel sections for fabrication of structures shall be stored in separate stacks above ground, section wise and length wise so that they can be easily inspected at any time.

**1.6.3.** Bolts, nuts and washers and other fastening materials shall be stored on racks off the ground with a coating of suitable protective oil. These shall be stored in separate gunny bags or compartments in accordance to diameter, length and quality.

## 1.7. GENERAL DESIGN REQUIREMENTS

**1.7.1.** The Contractor shall furnish the most economical design for substation steel structures conforming to these specifications, relevant Indian Standards/ equivalent International Standards and as per best engineering practices.

**1.7.2.** No welding shall be allowed in case of lattice structures except for connecting the base plates & stiffeners to the legs of structures.

**1.7.3.** Except where otherwise specified or implied, the design, manufacturing, fabrication, galvanizing etc of steel structures shall conform to the provisions of IS: 802 (Part-I/Sec-1)-1992, IS: 802 (Part-I/Sec-2)-1995 and IS: 802(Part-II)-1978.

**1.7.4.** Fully galvanized lattice type self-supporting steel structures with bolted connections shall be provided for the main substation structures comprising gantry towers/ columns, beams, lightening/lighting masts etc. and shall be designed to carry the load of conductors with the necessary insulators, earth wire, hardware and all fittings & fixtures, wind load, earthquake loads, short circuit forces etc. as applicable under specified loading conditions. The gantry towers/columns and lightening/lighting masts shall be connected to the foundation through base plate and foundation bolts. The portion of anchor bolts above concrete level and 300 mm below concrete level shall be galvanized.

**1.7.5.** The equipment supporting structures shall be either pipe type or lattice type as per the support requirement of equipments and fully galvanized and shall be designed to carry the weight of equipments, conductors, all fittings & fixtures, wind loads, earthquake load, short circuit forces, operational loads etc. The equipment supporting structures shall also be connected to the foundation through base plates and foundation bolts. The portion of foundation/anchor bolts projecting above concrete level and 300 mm length below concrete level shall be galvanized.

**1.7.6.** Grounding of all steel structures shall be done as specified in these specifications.

**1.7.7.** Lightening masts, if provided, shall cater to the station lighting purposes also. It shall be provided with structural steel ladder within its base upto the highest platform. The ladder shall be provided with safety cage. The platforms shall be provided at heights

required for mounting of lighting fixtures. Size of platforms shall be adequate for mounting a minimum of four lighting fixtures on each side. Provision shall be made for tilting the lighting fixtures to suitable angle. The platforms shall also have protection railing.

**1.7.8.** While designing gantry towers/columns, beams, lightening/lighting masts, equipment supporting structures etc., the Contractor shall ensure adequate electrical clearances as specified in these specifications, relevant Indian Standards/ equivalent International Standards and statuary rules and regulations of the country, whichever is more stringent.

**1.7.9.** All the structures shall be so designed that only the rationalized ISI metric hot rolled sections of tested quality conforming to IS: 2062 are used in fabrication of substation steel structures.

**1.7.10.** The Contractor, while designing substation structures, shall use only such sizes of steel sections which are easily procurable. If for any reason, the sections approved are not easily procurable, it is the Contractor's responsibility to procure the alternative sizes which are satisfactory from the point of view of design, fabrication, and galvanization and supply the same at no additional cost to the Employer.

**1.7.11.** The analysis of structures shall be done with well-established modern computer software programme like STAAD PRO. The computer software programme to be employed should have been prepared or approved by a recognized institution. The contractor shall submit the particulars and name of the computer programme as well as names of the customers to whom the substation steel structures have been supplied based on the above computer programme and also the structures test results providing the efficacy of the programme to the Employer for approval before taking up the design.

**1.7.12.** All gantry towers and beams shall be designed as dead end structures i.e. all the balancing conductors on one side of gantry shall be assumed broken. The Contractor can rationalize the designs and reduce the varieties if it is economical. All gantry towers and beams of same designation shall be interchangeable.

**1.7.13.** The base width of gantry towers and size of beams shall be so chosen so that there is no hindrance to various electrical clearances.

**1.7.14.** Hard copy of all designs along with soft copy of input files of the computer software used for analysis of various structures (i.e. gantry towers & beams, lightening/ lighting masts, equipment supporting structures etc.) shall be submitted by the contractor to Employer for approval. The contractor shall also submit manual calculations, if required by the Employer, for verifying the analysis and design results of the structures obtained using software. The Employer shall check the design of structures submitted by the Contractor and if any modifications/changes are necessitated consequent to the checking, the same shall be incorporated by the Contractor without any additional cost to the Employer.

## 1.8. DESIGN LOADS

**1.8.1.** The substation steel structures shall be designed to withstand the following loads as applicable to respective structure:

(a) Dead loads, tension in conductors under various climatic conditions, service loads etc.;

(b) Live Loads;

(c) Wind loads;

(d) Seismic loads;

(e) Short Circuit Forces;

(f) Erection loads;

(g) Operational loads;

(h) All secondary effects due to temperature, shrinkage etc; and

(i) Any other special load during erection or the service period of structures.

**1.8.2.** All structures shall be designed for the worst combination of dead loads, live loads, wind loads, Seismic forces, short circuit forces etc. as per relevant Indian Standards / equivalent International Standards. The loads due to deviation of conductor, load due to unbalanced tension in conductor, torsional load due to unbalanced vertical and horizontal forces, erection loads, operational loads including 'snatch' in the case of bundled conductors etc. shall also be considered in the design.

**1.8.3.** Wind and Seismic Loads shall not be considered acting simultaneously on structures i.e. only one load out of two shall be considered at a time in the design of structures in combination of other loads.

**1.8.4.** The gantries and equipment supporting structures shall be designed for the two conditions i.e. normal condition and abnormal condition. In abnormal condition, short circuit forces or earthquake loads whichever is more critical shall be combined with loads under normal condition. The earthquake loads and wind loads shall not be considered together i.e. one load shall be considered at a time. 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 conductors broken on the other side.

**1.8.5.** **Short Circuit Forces:** Short circuit forces shall be estimated as specified in IEC 865 or relevant Indian Standard/ equivalent International Standard and shall be subject to the approval of Employer. Short circuit forces shall be calculated considering a fault level of 31.5KA for 132kV and 25KA for 33kV or as applicable and directed by the Employer.

**1.8.6.** **Wind Loads:** Wind pressure on steel structures, rigid bus bar tubes, conductors, ground/shield wires, insulator strings and other fittings/hardware shall be considered as per IS:802(Part-I/Sec-1)-1995 for specified wind zone.

**1.8.7.** **Earthquake Forces:** Earthquake/Seismic Forces shall be estimated as per IS: 1893 for specified seismic zone. The appropriate inertia loadings on various structures shall be assessed depending upon individual responses of the structures and as stipulated in IS: 1893. The vertical seismic co-efficient, where applicable, shall be taken as half of the horizontal seismic co-efficient. In important structures wherever there is a possibility of amplification of vertical seismic co-efficient, the stipulations of IS: 1893 shall be followed.

**1.8.8. Vertical Loads**

1.8.8.1. The vertical loads shall comprise the following loads:

(i) Weight of rigid bus bar, conductor, shield wire, jumpers etc;

(ii) Weight of insulators, hardware and other fittings & fixtures;

(iii) Self-weight of structure and respective equipment;

(iv) Weight of under hung connectors where applicable; and

(v) Weight of man with tools at each conductor point or any location of structure critical for a particular member.

1.8.8.2. The vertical loads due to the weight of bus bars, approach span conductors, shield wires, insulator strings, equipment if supported on the beam/gantry towers shall be considered in the design of beams & gantry towers/columns.

1.8.8.3. A provision of a load of 1500 N shall be made for a lineman with tools in the design of substation structures. The weight of man with tools may also be assumed to act anywhere on the horizontal members and members with inclination up to $15^0$.

1.8.8.4. The self-weight of the beam shall be considered in the design of beams. In case of the design of gantry towers, lightening/lighting mast, equipment supporting structures, the weight of superincumbent portion of the structure shall be considered in the design.

### 1.8.9. Conductor/ Wire Tension Loads

1.8.9.1. The maximum working tension for bus bars, conductors and shield wires shall be considered as specified.

1.8.9.2. The loads due to wire tensions shall be calculated along and transverse to the beam axis at the points of attachment of conductor/wires. In case of gantry towers and lightening masts, the wire tensions shall be resolved in the direction of its adjacent faces.

1.8.9.3. The worst condition of unbalanced conductors and shield wire loads, with all balancing conductor/wire on the opposite side of the structure shall be assumed to be broken for the design of structures.

### 1.8.10. Terminal Gantries

1.8.10.1. Terminal/line take off gantries shall be designed for a minimum conductor tension of 1.0 ton per phase for 132 kV and 0.50 ton for 33 kV or as per requirement whichever is higher.

1.8.10.2. The distance between terminal gantry and dead end tower shall be taken as 150m for 132kV and 80 m for 33 kV switch yard or as actual whichever is more. The design of these terminal gantries shall also be checked considering $\pm$ $30^0$ deviation of conductor in both vertical and horizontal planes. For other gantries, the structural layout requirements shall be adopted in the design.

1.8.10.3. The maximum stringing tensions in the approach spans shall be taken as per design of dead end towers and actual site conditions.

## 1.8.11. COMBINATION OF LOADS

1.8.11.1. The combination of loads shall be made under the normal and abnormal conditions for wind blowing either normal to beam (longitudinal direction) or parallel to beam (transverse direction). In case of equipment supporting structures and standalone structures like lighting masts, wind shall be assumed acting normal to two adjacent faces of structure, one at a time as well as in diagonal direction. Loads shall be resolved into transverse, longitudinal and vertical directions for the purpose of design. All balancing conductors/wires shall be considered broken on one side in Normal Condition as well as in Abnormal Condition.

### 1.8.11.2. Normal Condition

(i) Wind loads on bus bars, conductors, shield wires, insulator string, jumpers, other hardware, equipments, members of structure etc.

(ii) Winds on approach span conductors and ground wire.

(iii) Unbalanced loads due to conductor/wire tensions considering all the conductor/wires on one side being broken;

(iv) Deviation loads due to wire tensions;

(v) Dead loads of wires, insulators, hardware fittings, equipment, structural members, weight of lineman with tools etc.

The above loads shall be resolved in transverse, longitudinal and vertical directions as under:

(a) **Wind Loads**: Wind load on gantry towers, Lightening/Lighting Mast, beams, bus bar, conductors, shielding wire, jumpers, connectors, insulators, equipment, other hardware etc. with wind blowing either in Transverse or Longitudinal direction;

(b) **Transverse Loads**: Component of Mechanical Tension due to conductor and shielding wire deviation in Transverse direction;

(c) **Longitudinal Loads**: Component of Mechanical Tension due to conductor and shielding wire deviation in Longitudinal direction;

(d) **Vertical Loads**: Load due to weight of conductor, shielding wire, insulator strings, jumpers, connectors, accessories, self-weight of structure, component of Mechanical Tension of conductor and shielding wire in vertical direction.

1.8.11.3. **Abnormal Conditions**

Either of the two conditions viz. short circuit condition or earthquake condition, whichever is more stringent, shall be considered for the design of substation steel structures as described below:

(a) **Short Circuit Condition**: Where short circuit loads are specified, these shall be considered in addition to the combination of loads as stipulated in Normal Condition.

(b) **Earthquake Condition**: Earthquake/Seismic forces as specified shall be considered in addition to the combination of loads as stipulated in Normal Condition excluding the wind loads.

1.8.11.4. **Safety & Maintenance Condition:** All bracing and redundant members of the gantry towers, beams, lightening/lighting masts and equipment supporting structures which are horizontal or inclined up to $15^0$ from horizontal shall be designed to withstand an ultimate vertical load of 1500 N considered acting at the center of the member independent of all other loads but including self weight of member. All gantry towers, beams and masts shall also be designed to withstand an wire peak independent of all other loads but considering self weight of structure. ultimate vertical load of 1500 N as a weight of Lineman with tools and an additional load of 3500 N acting at each conductor attachment point of beam and earth

1.8.11.5. The Substation steel structures shall be designed for the most stringent combinations of loadings as specified above in Normal and Abnormal conditions and checked under safety & maintenance condition and shall be able to withstand these loads without exceeding the minimum guaranteed yield stress of material as per IS:802(Part-1/Sec-1)-1995 without any injury or permanent deflection.

**1.8.12. Sag Tension Calculations**

1.8.12.1. Sag tension calculations for conductor and shielding/ground wire shall be made for the following combinations:

(i) Full wind pressure on conductor/ground wire at every day temperature;

(ii) 36 % of full design wind pressure on conductor/ground wire at minimum temperature;

(iii) Every day temperature and nil wind (Initial condition);

(iv) $85^0$ C temperature for ACSR conductor ($95^0$ C temperature in case of AAAC 0r AA conductor) and nil wind; and

(v) Minimum temperature and nil wind.

1.8.12.2. The sag of ground wire shall be maintained within 90% of the conductor sag. The effect of insulator string on calculation of conductor sag shall also be considered.

1.8.12.3. Initial tension under every day temperature and 'nil' wind as applicable for conductor/ground wire shall be such that maximum sag at maximum temperature is within permissible limits keeping in view the electrical clearances required from ground/ equipments / structures. Final sag shall be maintained considering the effect of insulator string.

### 1.8.13. Computation of Wind Loads

1.8.13.1. The wind pressure shall be assumed as acting horizontally.

1.8.13.2. Wind Load shall be corresponding to Wind Zone 4 of IS: 802 (Part-1/Section-1)-1995. The relevant design parameters for Wind Zone 4 shall be as under:

(a) Basic wind speed '$V_b$' = 47 m/s [which is peak gust velocity averaged over a short time interval of about 3 seconds at mean height of 10 meter above ground level in an open terrain (Terrain Category 2) and has been worked out for a return period of 50 years]

(b) Reliability Level : 1

(c) Terrain Category: 2

(d) Reference Wind Speed '$V_R$' = $V_b/K_0$[$V_R$ is extreme value of wind speed over an averaging period of 10 minutes duration and $K_0$ is factor to convert 3 seconds peak gust speed into average speed of wind during 10 minutes period at a level of 10 meters above ground. The value of $K_0$ is 1.375.

'$V_R$' = 47/1.375 = 34.18 m/s

(e) Design Wind Speed '$V_d$' = $V_R$ x $K_1$ x $K_2$

Where K1 is Risk Coefficient & $K_2$ is Terrain Roughness Coefficient;

$K_1$ = 1.0 (For Reliability Level 1)

$K_2$ = 1.0 (For Terrain Category 2)

Thus Design Wind Speed $V_d$ = 1.0 x 1.0 x 34.18 = 34.18 m/s

(f) Design Wind Pressure $P_d = 0.6 \times V_d^2$

$= 0.6 \times 34.18 \times 34.18 = 701\ N/m^2$

1.8.13.3. Gantry towers, beams, Lightening/Lighting Masts and equipment supporting structures etc. shall be designed for Design Wind Pressure of 701 $N/m^2$.

1.8.13.4. The wind load on structures shall be determined assuming the specified wind pressure to be acting on the projected area of the members on the windward face in accordance with IS:802 (Part-I/Sec-1)-1995 considering applicable Drag Coefficient, Gust Response Factor etc.

1.8.13.5. The wind load on bus bars, approach span conductors and shield wires shall be determined in accordance with IS:802 (Part-I/Sec-1)-1995 assuming the specified wind pressure to be acting on full projected area. In case of bundle conductors (more than one conductor per phase), the wind pressure shall be assumed as acting on full projected area of each sub-conductor in the bundle.

1.8.13.6. The wind load on insulator string shall be calculated in accordance with IS:802 (Part-I/Sec-1)-1995 by taking the effective projected area of the cylinder with diameter equal to that of the insulator skirt and length based on the number of discs and hardware in the insulator string. The wind load shall be computed corresponding to wind pressure for bus bars.

1.8.13.7. The wind load on equipment shall be calculated based on the design wind pressure in accordance with IS: 802(Part-I/Sec-1)-1995 considering projected area of equipment perpendicular to wind direction.

1.8.13.8. The direction of the wind shall be assumed so as to produce the maximum stress in any member for the combination of wind loads and other loads. For this condition, wind shall be assumed acting in two directions at right angles to each other and critical wind load shall be considered for the design of structures. The diagonal wind shall also be considered for standalone structures like equipment supporting structures, lighting masts etc.

1.8.13.9. Substation Steel Structures shall be designed for the maximum tension in conductor and shielding/ground wire (Normal) corresponding to any of the following conditions whichever is more critical:

(i) Full design wind pressure and every day temperature;

(ii) 36% of full design wind pressure and minimum temperature.

Provided that the ultimate tension in wires under any of the above conditions does not exceed 70% of ultimate tensile strength of conductor/ ground wire.

1.8.13.10. **Wind Load on Structure:** In order to determine the wind load on Gantry Tower, Beam, Lightening/Lighting Masts, Equipment Supporting Structure, it shall be divided into different panels having a height/length 'h'. These panels are normally taken between the intersections of the legs and bracings. For a lattice structures of square cross section, the resultant wind load $F_{wt}$ in Newton, for wind normal to the panel, on a panel under consideration of height/length 'h' applied at the center of gravity of this panel shall be as under:

$F_{wt} = P_d \times C_{dt} \times A_e \times G_t$

Where

$P_d$= Design wind pressure in $N/m^2$;

$C_{dt}$ = Drag coefficient for panel under consideration against which the wind is blowing. Values of $C_{dt}$ for the different solidity ratio shall be as per Table-5 of IS: 802(Part-1/Sec-1)-1995.

$A_e$ = Total net surface area of members in the panel under consideration projected normal to the face in sq m.

$G_t$ = Gust response factor, peculiar to the ground roughness and depends on the height above ground. Values of $G_t$ shall be as per Table-6 of IS: 802(Part-1/Sec-1)-1995.

1.8.13.11. **Wind Load on Conductor, Ground/Shielding Wire and Jumpers etc: T**he load due to wind on each conductor and ground/shielding wire, $F_{wc}$ in Newton applied at supporting point normal to the conductor/earth wire shall be determined by the following expression:

$F_{wc} = P_d \times C_{dc} \times L \times d \times G_c$

Where:

$P_d$ = Design wind pressure in $N/m^2$;

$C_{dc}$ = Drag coefficient, taken as 1.0 for conductor and 1.2 for earth wire;

L = Wind span, being sum of half the spans on either side of supporting Structures, in meters;

d = Diameter of conductor/earth wire, in meters

$G_c$ = Gust response factor, takes into account the turbulence of the wind and the dynamic response of the conductor. Values of $G_c$shall as per Table-7 of IS:802 (Part-1/Sec-1)-1995 for the average height of conductor / ground wire above ground.

The average height of conductor shall be taken up to clamping point of conductor less two-third sag at minimum temperature and no wind. The average height of the ground wire shall be taken up to clamping point less two-third sag at minimum temperature and 'nil' wind.

1.8.13.12. **Wind Load on Insulator Strings:** Wind load on insulator strings '$F_{wi}$' shall be determined on insulator length from the attachment point to the center line of the conductor in case of suspension insulators string and up to the end of clamp in case of tension insulators string , in the direction of the wind as follows:

$$F_{wi} = C_{di} x P_d \times A_i \times G_i$$

Where,

$C_{di}$ = Drag coefficient of insulators taken as 1.2;

$P_d$ = Design wind pressure in $N/m^2$;

$A_i$ = Area of insulator string projected horizontally on a vertical plane parallel to the axis of the string. In the absence of actual value, it may be taken as 50% of the gross projected area of the cylinder with diameter equal to that of the insulator skirt; and

Gi = Gust response factor, peculiar to the ground roughness and depends on the height of insulator attachment point above ground. Values of Gi shall be as per Table-6 of IS: 802 (Part-1/Sec-1)-1995.

## 1.8.14. Computation of Wires Tension Loads

1.8.14.1. The maximum tension (Normal) for conductors and shield wires shall be based on Sag Tension Calculations as per following conditions whichever is more stringent:

(i) Full design wind pressure on conductor / ground wire at every day temperature; and

(ii) 36% of full design wind pressure on conductor / ground wire at minimum temperature.

1.8.14.2. The maximum tension to be considered for the design of structures shall be subject to the approval of the Employer.

1.8.14.3. The loads due to wire tensions shall be resolved along three perpendicular directions to the beams and gantry towers and considered accordingly in the design.

1.8.14.4. The worst condition of unbalanced conductors and shielding wire loads, with all balancing conductor/wire on the opposite side of the structure assumed broken shall be considered for the design of structures.

### 1.8.15. Strength Factors Related to Quality

1.8.15.1. The design of substation steel structures shall be carried out in accordance with the provisions covered in IS: 802(Part-1/Sec-2)-1992. However, to account for the reduction in strength due to dimensional tolerances of the structural sections, the following strength factors shall be considered depending upon the yield strength of steel:

(i) If steel with minimum guaranteed yield strength is used for fabrication of substation structures, the estimated loads shall be increased by a factor of 1.02 to account for dimensional tolerances.

(ii) If steel of minimum guaranteed yield strength is not used for fabrication of substation structures, the estimated loads shall be increased by a factor of 1.05, in addition to that mentioned in (i) above.

## 1.9. DESIGN OF STRUCTURES

**1.9.1.** The design of lattice type of steel structures for gantries, masts and equipment supporting structures shall be carried out in accordance with procedure and guidelines specified in IS:802(Part-1/Sec-1)-1995, IS:802(Part-1/Sec-2)-1992 and IS:802(Part-

II)-1978 and as given herein under or as per relevant international standard. Indian Standard IS :800 shall be referred to and used for any aspect of design not covered in IS :802. All structures shall be designed for normal condition and under short circuit condition as well as for earthquake loads considering all the three wires on one side being broken. The sequence of applying tension during stringing shall also be taken care of in the design of structures and specified by the contractor on the drawings.

**1.9.2.** The structural design of pipe type equipment supporting structures shall be carried out in accordance with IS: 806 'Code of Practice for Steel Tubes in General Building Construction'.

### 1.9.3. Minimum Thickness of Members

1.9.3.1. The minimum thickness of angle section used in the design of substation steel structures, unless otherwise specified elsewhere in this specification, shall be kept not less than the following values:

(a) Main leg members of gantry towers, Beams, lightening/lighting masts, and equipment supporting structures : 5 mm

(b) For all other members : 4 mm

(c) The thickness for gusset plate shall not be less than 6.0 mm. Where a gusset plate is required to transmit stress, it shall not be less than thickness of the thickest bracing member connected plus 2.0 mm.

### 1.9.4. Allowable Stress

#### 1.9.4.1. Axial Stress in Tension

The estimated tensile stress on the net effective sectional area in various members shall not exceed 250 N/mm$^2$ for mild steel sections or the specified yield stress of steel for high tensile steel sections (if proposed to be used in the fabrication of substation steel structures and agreed to by Employer) as per IS: 2062-2011 or any other equivalent to International Standards.

#### 1.9.4.2. Axial Stress in Compression

**(A)** The estimated compressive stress in various members shall not exceed the value given by the formulae in clause 5.2 of IS: 802 (Part-I/Sec-2). As per said formula, the allowable unit stress Fa, in Mpa on the gross cross sectional area of the axially loaded compression members shall be calculated as under:

(a) $F_a = \left[1 - 1/2\left(\frac{Kl/r}{Cc}\right)^2\right] \times F_y$

Where $Kl/r \leq C_c$

and,

(b) $F_a = \frac{\pi^2 \times E}{Kl/r^2}$

When $Kl/r > C_c$

Where,

$C_c$ = $\pi \times \sqrt{\frac{2E}{F_y}}$

$F_y$ = minimum guaranteed yield stress of the material, Mpa

E = modulus of elasticity of steel that is $2x10^5$Mpa,

$Kl/r$ = largest effective slenderness ratio of any unbraced segment of the member,

L = un-braced length of the compression member in cm, and

r = appropriate radius of gyration in cm.

**(B)** The formulae given in **(A)** above are applicable provided the largest width thickness ratio 'b/t' is not more than the limiting value given by:

$(\frac{b}{t})_{Lim} = (210/\sqrt{F_y})$

Where

b = distance from edge of fillet to the extreme fibre in mm, and

t = thickness of flange in mm.

**(C)** Where the width to thickness ratio exceeds the limit given in **(B),** the formulae given in **(A)** shall be used substituting for $F_y$ the value $F_{cr}$ given by:

a) $F_{cr} = 1.677 - \frac{6.77 \times b/t \times F_y}{b/t_{lim}}$

When $b/t_{lim} \leq b/t \leq 378/\sqrt{F_y}$

And,

b) $F_{cr}$ = $65550/(b/t)^2$

When $b/t > 378/\sqrt{F_y}$

**Note:-** The maximum permissible value of b/t for any type of steel section shall not exceed 25.

### 1.9.5. Redundant Members

1.9.5.1. The redundant members shall be checked individually for 2.5 percent of axial load carried by the member to whom it supports.

### 1.9.6. Stresses in Bolts

1.9.6.1. The estimated stresses in bolts shall not exceed the values given in IS :802 (Part-1/ Sec-2) which is reproduced in Table – 13.2 below.

**TABLE – 13.2**

**ULTIMATE STRESSES IN BOLTS in MPa**

| Nature of stress | Permissible Stress For Bolts of Property Class 5.6 | Remarks |
|---|---|---|
| Shear Stress on Gross Area of bolts | 310 | For bolts in double shear, the area to be assumed shall be twice the area defined. For gross area of bolts, refer item (a) below. |
| Bearing Stress on Gross Diameter of Bolts | 620 | For the bolt area in bearing, see item (b) below |
| Axial Tensile Stress | 250 | |

1.9.6.2. Gross area and Bearing area of bolts shall be considered as under:

(a) Gross area of Bolt: For the purpose of calculating the shear stress, the gross area of bolts shall be taken as the nominal area of the bolt.

(b) Bearing Area of Bolt:- It shall be taken as ‘d x t’ where ‘d’ is the nominal diameter of the bolt and ‘t’ is the thickness of the thinner of the parts jointed.

(c) Where the material of bolt and the structural members are of different grades, the bearing strength of the joint shall be governed by the lower of two.

### 1.9.7. Slenderness Ratio

1.9.7.1. Slenderness ratios of compression and redundant members shall be computed in accordance with clause 6 of IS: 802 (Part-1/sec-2) as reproduced in Table – 13.3 below:

**Table – 13.3**

**Permissible Slenderness Ratio**

| Sl. No. | Type of Members | Value of KL/r |
|---|---|---|
| **1.** | **Compression Members** | |
| (i) | Leg sections or joint members bolted in both faces at connections for ) $0 < L/r \leq 120$ | L/r |
| (ii) | Members with concentric loading at both ends of the unsupported panel for $0 < L/r \leq 120$ | L/r |
| (iii) | Member with concentric loading at one end and normal framing eccentricity at the other end of the unsupported panel for $0 < L/r \leq 120$ | 30+0.75 L/r |
| (iv) | Member with normal framing eccentricities at both ends of the un-supported panel for $0 < L/r \leq 120$ | 60+0.50 L/r |
| (v) | Member unrestrained against rotation at both ends of the unsupported panel for $120 \leq L/r \leq 200$ | L/r |
| (vi) | Member partially restrained against rotation at one end of the unsupported panel for $120 < L/r < 225$ | 28.6+0.762 L/r |
| (vii) | Member partially restrained against rotation at both ends of the unsupported panel for $120 < L/r < 250$ | 46.2+0.615 L/r |
| **2.** | **Redundant Members** | |
| (i) | For $0 < L/r < 250$ | L/r |

1.9.7.2. For the values of 'KL/r' corresponding to 1(vi) and 1(vii) in above table, the following procedure of evaluation shall be adopted:

(a) The restrained member must be connected to the restraining member with at least two bolts.

(b) The restraining member must have a stiffness factor 'I/L' in the stress plane (I=Moment of inertia and L=Length) that equals or exceeds the sum of the stiffness factors in the stress plane of the restrained members that are connected to it.

(c) Angle members connected by one leg should have the holes located as close to the outstanding leg as feasible. Normal framing eccentricities at load transfer

connection imply that connection holes are located between the heel of the angle and the center line of the framing leg.

1.9.7.3. In calculating the slenderness ratio of the members, the Length 'L' shall be the distance between the intersections of the center of gravity lines at each end of the member.

1.9.7.4. The following maximum limit of the effective slenderness ratio i.e. the ratio of unsupported length of the section in any plane to the appropriate radius of gyration shall not exceed value specified herein under:-

(a) For main leg members of gantry towers, beams, lightening/lighting masts, and equipment supporting structures in compression : 120

(b) For the members having computed stresses : 200

(c) For redundant members : 250

(d) For members having axial tensile stress only : 400

### 1.9.8. Erection Stresses

1.9.8.1. Where erection stresses combined with other possible co-existent stresses could produce a working stress in any member above the permissible stress, such additional strengthening of the member shall be affected or such other provision made as is necessary to bring the stress within the permissible limit.

## 1.10. FASTENERS: BOLTS, NUTS AND WASHERS

**1.10.1.** All substation steel structure members shall have bolted connections. All bolts and nuts shall conform to IS: 12427. Bolts shall have hexagonal head, the heads being forged out of the solid, truly concentric, and square with the shank, which must be perfectly straight. All bolts and nuts shall be galvanized as per IS: 367 (Part-13)/IS: 2629.

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

**1.10.3.** Bolts up to 16 mm diameter and having length up to 10 times the diameter of the bolt shall be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control.

**1.10.4.** The shear strength of bolts for property class 5.6 shall be not less than 310 MPa as specified in IS :12427. Bolts shall be provided with washer face in accordance with IS: 1363 (Part-I) to ensure proper bearing.

**1.10.5.** Nuts for hexagonal bolts shall be double chamfered as specified in IS: 1363 (Part-III). It shall be ensured by the manufacturer that nuts shall not be over tapped beyond 0.40 mm oversize on effective diameter for size up to 16 mm. Nuts for anti-theft bolts shall be round tapered with hexagonal shear nuts. The hexagonal portion of shear nuts shall break away at specified torque recommended by the supplier to ensure proper tightening of members so that fasteners are not opened subsequently with tools. The tightening torque and shearing of anti-theft nuts shall be verified during proto-assembly.

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

**1.10.7.** All bolts shall be threaded to take the full depth of the nuts and threaded for enough to permit firm gripping of the members, but not further. It shall be ensured that the threaded portion of each bolt protrudes not less than 3.0 mm and not more than 8.0 mm when fully tightened. All nuts shall fit tight to the point where the shank of the bolt connects to the head.

**1.10.8.** Flat and tapered washers shall be provided wherever necessary.

**1.10.9.** Spring washers shall be provided for insertion under all nuts. These washers shall be electro-galvanized, positive lock type and 3.5mm in thickness for 16mm diameter bolts.

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

**1.10.11.** The bolt positions in assembled structures shall be as per approved structural drawings. Bolts at the joints shall be so staggered that nuts shall be tightened with spanners without fouling.

**1.10.12.** To ensure effective quality control during manufacturing process, the manufacturer shall have in house testing facility for all tests like weight of zinc coating, shear strength and other tests etc. The manufacturer should also have proper Quality Assurance System which should be in line with the requirement of this specification and IS: 14000 series Quality System Standard.

**1.10.13.** The bolt positions in assembled structures shall be as per IS: 5613(Part-3/Section-2)-1989.

## 1.11. DESIGNS & DRAWINGS

**1.11.1.** After the award of contract, the contractor shall submit to the Employer, for his approval, the detailed design calculations, drawings for each type of gantry tower, beams, lightening/lighting masts and equipment supporting structures etc. The design of structures shall be accompanied with the following drawings:

(a) Loading diagrams of structures; and

(b) Single line diagram of structures.

**1.11.2.** The contractor shall submit the following designs and also all necessary drawings as may be required for approval of Employer:

(a) Design of gantry towers, beams, lighting/lightening masts, equipment supporting structures etc.

(b) Design drawings of structures with the size of the various members and location of joints etc.

(c) Detailed fabrication drawings indicating the erection mark assigned to various sections, size of the members, details of joints, details of stringing points etc. The details of joints, stringing points etc. shall be furnished separately in the drawing on a larger scale.

(d) Four set of hard copies and soft copies of all the approved design calculations, drawings and bill of materials.

(e) Results of any test as & when conducted and as required by the employer and report thereof.

(f) Any other design or drawing or document as desired by Employer.

## 1.12. FABRICATION

Except where here-in-after modified, the details of fabrication shall, in general, conform to IS: 802(Part-II), other relevant Indian Standards or equivalent International Standards.

### 1.12.1. General Requirements

1.12.1.1. Members of the structures shall be fabricated as per the approved fabrication drawings in accordance with the best engineering practice and shall conform to the provisions of relevant Indian Standard/ or equivalent International Standard.

1.12.1.2. Structures shall be of bolted construction unless otherwise stated. Welding at any point shall not be permitted except for connection of base plates & stiffeners with leg member of structure.

1.12.1.3. No individual members shall be longer than 6000 mm.

1.12.1.4. The fabrication wastages, if any, shall not be paid for separately and deemed to be included in quoting rates. Employer shall not accept any liability in connection with wastage of steel during fabrication or otherwise.

1.12.1.5. Substitution, if any, of steel sections of the structures by higher sizes, due to non-availability or on account of any other reasons, shall be to the Contractor's account without any liability to Employer.

1.12.1.6. All structural members, bolts, nuts and fittings shall be hot dip galvanized. Spring Washers shall be Electro galvanized.

1.12.1.7. Normally bolted butt joint shall be used to connect the parts of structures. The thickness of inside angle cleat shall not be less than that of the heavier member connected. The lap splices may be used for connecting members of unequal thickness and the inside angle of lap splices shall be rounded at the heel to fit the fillet of the outside angle. All splices shall develop full stress in the members connected through bolts.

1.12.1.8. Joints shall be so designed so as to avoid eccentricity, as far as possible. However where the connections are such that the elimination of the guest plates and spacer

plates are not possible, the gusset/spacer plates may be used in conformity with modern engineering practice.

1.12.1.9. Members of the structures shall be accurately fabricated, so that the same can be assembled at site without any strain on members of structure or in bolts.

1.12.1.10. The Contractor during fabrication of structure members shall ensure that mild steel and high tensile steel sections don't get mixed up and as such identification mark shall be embossed on each and every H.T. Steel section at the time of shearing of members. The bidder in his bid shall clearly bring out the means proposed to be adopted to identify the mild steel and high tensile steel sections during fabrication.

1.12.1.11. All members of the structures shall be cut to correct lengths and fabricated in accordance with the shop drawings approved by the Employer. Welding of two or more pieces to obtain the specified length of member shall not be allowed. Members shall be straight to the permissible tolerances or better when required to ensure proper fit before being laid off or worked and after galvanizing.

1.12.1.12. The use of fillers in the connections shall be avoided as far as possible. The diagonal web members in tension may be connected entirely to the gusset plate where necessary to avoid the use of fillers. Each diagonal shall be in one piece without splices or centre gusset and it shall be connected at the point of intersection by one or more bolts.

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

1.12.1.14. All parts of the structures shall be accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets or depressions are likely to hold water.

1.12.1.15. All similar parts of structures shall be made strictly interchangeable. No rough edges shall be permitted anywhere throughout the work.

1.12.1.16. Structural members shall be so fabricated as to be bolted together easily at site. Preference shall be given to the design with least number of parts and the one which offers best facilities for transport, erection and maintenance. In designing the structures for minimum number of parts, the Contractor shall not however employ parts of such dimensions as will prove difficult to handle. The length of the longest piece shall not exceed 6 meters.

1.12.1.17. Workmanship and finish shall correspond to the modern engineering practice. All steel sections before any work is done on them, shall be carefully leveled, straightened and made true by a method which shall not injure the material so that, when assembled, the adjacent surfaces are in close contact.

### 1.12.2. Straightening

1.12.2.1. All steel sections, before any cutting is done, shall be carefully straightened and made true by pressure. Hammering shall not be permitted for straightening or flattening of members. All sheared edges shall be free from burrs and no rough edges from shears shall be left. Straightening shall be so done that it does not injure the material. Sharp bends shall be a cause for rejection.

### 1.12.3. Cutting

1.12.3.1. Cutting may be affected by shearing, cropping, sawing or by gas cutting by mechanically controlled torch. Gas cutting by hand shall only be used when specifically authorized in writing by the Employer. Shearing, cropping and gas cutting shall be clean, square and free from distortions and burns, and should the Employer find it necessary, the edges shall be ground afterwards by the Contractor without any additional cost. The cut surfaces shall be clean, smooth, reasonably square and free from any distortion. The cut edges of all plates shall be perfectly straight and uniform throughout.

### 1.12.4. Bending

1.12.4.1. Mild steel angle sections of size upto 75x75 mm (thickness up to and including 6.0 mm) shall be bent cold up to and including bend angles of $10^0$. Mild steel angle sections of size above 75x75 mm (thickness upto and including 6.0 mm) and upto and including 100x100mm (thickness upto 8.0 mm) may also be bent cold upto bend angles of $5^0$. All other angle sections and bend angles not covered above shall be bent hot.

1.12.4.2. All plates upto 12.0 mm thickness shall be bent cold upto a maximum bend angle of $15^0$. Hot bending shall be employed for greater bend angles and thicker plates. Bends on all high tensile steel sections shall be done hot.

1.12.4.3. The bends shall be of even profile and free from any surface damages. All hot bent material shall be air-cooled.

### 1.12.5. Holing

1.12.5.1. Holes for bolts in the members shall either be punched or drilled to jig but drilled holes are preferred. Holes shall not be formed by flame cutting process. All burrs left by punching or drilling shall be completely removed.

1.12.5.2. Members shall be straightened again after being punched and drilled.

1.12.5.3. Punching may be adopted for mild steel sections with thickness upto 16.0 mm. For thicker sections, drilling shall be done.

1.12.5.4. The holes near the bend line of a bent member on both sides of bend line shall be punched/drilled after bending and relative positions of those holes shall be maintained with the use of proper templates/jigs and fixtures.

1.12.5.5. The limit of punching for high tensile Steel sections shall be indicated by the contractor and shall be in accordance with relevant Indian Standard/ equivalent International Standard.

1.12.5.6. Punched/drilled holes shall be at right angle to the surface and walls of holes shall be parallel. Holes shall be perfectly circular unless specified otherwise in the approved drawings.

### 1.12.6. Spacing of Bolts and Edge Distance

1.12.6.1. The minimum spacing of bolts and edge distances shall be as given Table – 13.4 below:

**Table – 13.4**

**Spacing of Bolts and Edge Distance**

| Bolt Diameter (mm) | Hole Diameter (mm) | Minimum Bolt Spacing (mm) | Minimum Edge Distance of Hole Centre to Rolled or Sawn cut edge (mm) | Distance of Hole centre to sheared or flame cut Edge (mm) |
|---|---|---|---|---|
| 16 | 17.5 | 40 | 20 | 23 |
| 20 | 21.5 | 48 | 25 | 28 |
| 24 | 25.5 | 60 | 33 | 38 |

### 1.12.7. Locking Devices

1.12.7.1. Electro-galvanized spring washers of type 'B' of thickness indicated in the Table – 13.5 below corresponding to respective bolt diameter shall be provided for insertion under all nuts.

**Table – 13.5**

**Diameter of Bolt and Thickness of Spring Washer**

| F Diameter (mm) | Thickness of spring washer (mm) |
|---|---|
| 16 | 3.5 |
| 20 | 4.0 |
| 24 | 4.5 |

### 1.12.8. Welding

1.12.8.1. The welding shall be done as per approved fabrication drawings which shall clearly indicate various details of joints to be welded, type of weld, length & size of weld, weather shop weld or site weld etc. Symbols for welding on erection and shop drawings shall be according to IS: 813. Welding shall be done before galvanizing. No welding after galvanizing shall be allowed.

1.12.8.2. Welding of structural steel shall be done by an electric arc process. The procedure to be followed, materials, plant and equipment to be used and testing and inspection procedures to be applied shall be to the satisfaction of the Employer/PMC and shall, in general, conform to relevant Indian standards viz. IS: 816, IS: 823, IS: 814 and Indian Standards Hand Book for metal arc welding.

1.12.8.3. All the welders to be employed for the job shall have to qualify the appropriate tests laid down in IS: 1811 and IS: 817.

1.12.8.4. 100 per cent 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 drawings. It may be slightly over sized but shall not be under sized. The profile of weld is affected by the position of the joint but it shall be uniform. In case of butt and corner welds, the profile shall be convex and in case of submerged arc fillet weld, it shall be slightly concave.

1.12.8.5. The welds shall have regular height and width of heads. The height and spacing of 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 creaters in the weld surface. Welds shall be free from unfilled creaters on the surface, under cuts, slag on the surface and visible cracks. After such inspection, further radiographic/ultrasonic examination shall be undertaken if found necessary and directed by the Employer. In case of any defect, the work shall be dismantled and redone duly replacing the defective materials including basic members. Weld gauges shall be used to measure the size of the welds.

### 1.12.9. Step Bolts & Ladders

1.12.9.1. Each gantry tower, lightening/lighting mast and equipment supporting structure shall be provided with step bolts of not less than 16.0 mm diameter and 175 mm long, spaced not more than 450 mm apart and extending from about 0.5 meter above the ground level to the top of the structure at two diagonally opposite legs. These shall be provided as per IS: 5613 (Part-2/Sec-1)-1985

1.12.9.2. Each step bolts shall be provided with two nuts on one end to fasten the bolt securely to the structure and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of withstanding a vertical load not less than 1500 N.

### 1.12.10. ERECTION MARK

1.12.10.1. Each member of the structure shall have a unique erection mark conforming to component number given to it in the fabrication drawings. This mark shall be punched with marking dies of 16 mm size before galvanizing and shall be legible after galvanizing.

1.12.10.2. Erection Mark shall be in format A-BB-CC-DDD where:

A = Employer's Code assigned by the Contractor – Alphabet;

BB = Contractor's Mark – Numerical;

CC = Structure Type – Alphabet; and

DDD = Member Number assigned by the Contractor – Numerical

1.12.10.3. The proposal of Erection Mark shall be prepared by the Contractor and got approved from Employer before starting any fabrication work.

### 1.12.11. Fabrication Tolerances

1.12.11.1. The fabrication tolerances in general shall conform to IS: 7215-1974 unless otherwise specified here-in-under.

1.12.11.2. Tolerance on the overall length of a member shall be within $\pm$ 1.6 mm.

1.12.11.3. No bolt hole shall be more than 1.5 mm larger than the corresponding bolt diameter. The threaded portion of each bolt shall project out through the nut at least one thread.

1.12.11.4. The maximum allowable difference in diameter of the holes on the two sides of the angle or plate shall be $\pm$0.8 mm i.e. the allowable taper in a punched hole shall not exceed 0.8 mm on diameter.

1.12.11.5. Tolerance cumulative and between consecutive holes shall be within $\pm$1.6 mm.

1.12.11.6. Tolerance on gauge distance shall be within $\pm$ 0.5 mm so that structure could be assembled at site without any undue strain on structure members or in bolts.

1.12.11.7. The gap between the ends of two connected members in a butt splice shall not be more than 6.0 mm and less than 4.0 mm.

### 1.12.12. Proto Types

1.12.12.1. The Contractor, after the approval of designs & fabrication drawings, offer the proto type of the each structure for Employer's inspection at his works or works of manufacturer.

1.12.12.2. Before proceeding with the bulk fabrication of any of structure i.e. gantry towers, beams, lightening/lighting masts and equipment supporting structures etc., the Contractor shall fabricate and assemble in his works for inspection by the Employer

or his authorized representative, one structure of each type as finally approved by the Employer for checking the fabrication accuracy and workmanship. The check assembly shall be in a horizontal position. Proto assembly made on ground in horizontal position shall be adequately supported to prevent distortion and overstressing of members to ensure proper fit and shall be accomplished without extraordinary effort to align bolt holes or to force pieces into position. For the check assembly, bolts and nuts shall be not more than finger tight.

1.12.12.3. Any changes pointed out by Employer's representative during inspection shall be incorporated by the contractor.

## 1.13. GALVANIZING

**1.13.1.** All members of structures shall be fully galvanized. Galvanizing of the member of the structures shall conform to IS: 2629-1966 and IS: 4759-1968. All galvanized members shall withstand tests as per IS: 2633-1972.

**1.13.2.** For fasteners, the galvanizing shall conform to IS: 5358-1969.

**1.13.3.** The Galvanizing shall be done after all fabrication work is completed except that the nuts may be tapped or re-run after galvanizing. Threads of bolts and nuts shall have a neat fit and shall be such that they can be turned with finger throughout the length of the threads of bolts and they shall be capable of developing full strength of the bolts.

**1.13.4.** Spring washers shall be electro-galvanized as per Grade 4 of IS: 1573-1970.

**1.13.5.** Pickling shall be carried out by immersing the steel members in an acid bath containing either sulfuric or hydrochloric acid at a suitable concentration and temperature. The concentration of the acid and temperature of the bath can be varied, provided, the pickling time is adjusted accordingly. The pickling process shall be completed by thoroughly rinsing with water, which should preferably be warm, so as to remove the residual acid.

**1.13.6.** Galvanizing shall be carried out by hot dip process in a proper and uniformly heated bath. It shall meet all the requirements, when tested in accordance with IS: 2633 – 'Methods of Testing Weight, Thickness and Uniformity of Coating on Hot Dipped Galvanized Articles'. The zinc coating shall be uniform, clean and of a standard thickness on the entire surface of the material galvanized.

**1.13.7.** Galvanizing of each member shall be carried out in one complete immersion. Double dipping shall not be permitted. When the steel member is removed from the galvanizing kettle, excess spelter shall be removed by 'bumping'. The process known as 'wiping' or 'scrapping' shall not be used for this purpose.

**1.13.8.** All bolts, nuts, locknuts, washers etc shall also be hot dip galvanized. Excess spelter from bolts, nuts etc. shall be removed by centrifugal spinning of bolts or nuts. Threading after galvanizing, shall not be permitted. Nuts, however, may be tapped, but not to cause appreciable racking of the nut on the bolts.

**1.13.9.** The surface preparation for galvanizing and the process of galvanizing itself, shall not adversely affect the mechanical properties of the materials to be galvanized.

**1.13.10.** Materials on which galvanizing has been damaged shall be acid stripped and re-galvanized unless otherwise directed, but if any member becomes damaged after having under gone re-galvanization once, the same shall be rejected.

**1.13.11.** Special care shall be taken not to injure the galvanized surfaces during transport, handling and erection. Damages, if any, shall be made good in accordance with the provisions of this specification or as directed by the Employer.

**1.13.12.** All steel structures and accessories after galvanizing shall be treated by dipping them in Sodium Dichromate solution or treated with approved inhibitor (the details of which shall be given by the contractor before starting the galvanizing) for protection against white rust formation during transportation.

**1.13.13.** Employer's approval shall be obtained if galvanizing is done outside the Contractor's fabrication plant.

**1.13.14.** **Adverse** Atmospheric **Conditions**: Low temperature coupled with high humidity (RH approaching 80%) causes fast rusting to steel parts. The Contractor, therefore, shall be required to give special attention to galvanizing for ensuring that it is of superior quality and not less than specified. Items not properly galvanized or getting rusted shall be rejected at the cost and risk of Contractor.

**1.13.15.** The acceptable values of the coating of zinc on the steel members, bolts, nuts and washers shall be not less than specified in Table – 13.6 below:

**TABLE - 13.6**

| Sl. No. | Item | Zinc Coating |
|---|---|---|

| | | |
|---|---|---|
| 1. | Structural steel members except bolts, nuts and washers | Over 610 gm/$m^2$ |
| 2. | Bolts, nuts and washers | Over 450 gm/$m^2$ |

**1.13.16.** Members embedded in concrete shall be galvanized from the top to a point at least 300 mm below the proposed elevation of the concrete foundation. Utmost care shall be taken in not galvanizing the portion to be embedded in concrete below this stipulated level.

**1.13.17.** The Contractor shall furnish sufficient quantity of zinc paint of approved quality, free of cost, for repairing damages of minor nature in galvanized surfaces in transit or during handling.

## 1.14QUALITY ASSURANCE PLAN AND QUALITY CONTROL

**17.14.1.** A Quality Assurance Plan including customer's hold points covering the design, fabrication and manufacturing of the material and galvanizing activities shall be submitted by the contractor to Employer immediately after award of work. The Quality Assurance Plan shall be examined by the Employer and if found to be acceptable, the same shall be approved by the Employer subject to compliance to observations, if any. The Contractor shall follow the approved Quality Assurance plan in true spirit. If desired by the Employer, the contractor shall give access to all the documents and materials to satisfy the Employer that the Quality Assurance Plan is being strictly followed.

**17.14.2.** The Contractor shall establish and maintain quality control procedures for different items of work and materials to the extent deems necessary to ensure that all works are performed in accordance with this specification. In addition to the Contractor's quality control procedure, the materials and workmanship shall be subject to inspection by the employer or his authorized representative.

**17.14.3.** The quality control procedure shall cover but not be limited to the following items of work:

(i) **Steel:** Manufacturer's Test Certificates and Test Reports of representative samples of materials.

(ii) **Bolts, Nuts & Washers:** Manufacturer's certificates, dimensional check for bolts, nuts & washers.

(iii) **Galvanizing:** Tests for weight, thickness and uniformity of zinc coating in accordance with IS: 2633.

(iv) **Paints:** Manufacturer's test certificates, test physical inspection reports.

## 17.15. QUANTITIES

**17.15.1.** The quantities of substation structures including all hardware and accessories have been specified as a LOT in Price Schedule. Bidders shall ensure that they quote for full scope of work.

## 17.16. BILL OF MATERIALS

**17.16.1.** Based on the approved designs & fabrication drawings and after successful assembly of proto type, the bill of materials shall be submitted separately for each type of structure to the Employer for approval.

**17.16.2.** The bill of materials shall contain the erection mark of each member, dimensions, weight and total weight. Weight of bolts, nuts & washers shall be indicated separately. Total weight of the structure shall be indicated in the last page of bill of materials.

**17.16.3.** At no stage, mass manufacture of structures shall be taken up without the clear approval of prototype structure and bill of materials.

## 17.17. INSPECTION, TESTING & ACCEPTANCE CRITERIA

**17.17.1.** Employer/PMC or his representative shall have free access to manufacturer's works to satisfy that the fabrication is being done in accordance with the provisions of this specification.

**17.17.2.** Unless otherwise specified, the inspection shall be conducted on the materials prior to dispatch.

**17.17.3.** The tests as specified in this specification and/or in the relevant Indian Standard shall be conducted on the material before dispatch.

**17.17.4.** The Contractor shall provide all materials, stores, labor, tools and plant, apparatus and instruments, electricity, fuel, water, transport, accommodation etc. as may be required

by the Employer to carry out inspection and/or tests in accordance with this specification.

**17.17.5.** The Contractor shall guarantee compliance with the provisions of this specification and he shall carry out sampling and necessary tests in accordance with the relevant Indian Standards and as supplemented herein at his own cost, unless otherwise specified in the contract. The Contractor shall get the specimens tested in a laboratory approved by the employer and submit to the employer three copies of the test results within five days after completion of the test.

**17.17.6.** Only tested quality steel conforming to IS: 2062 having mill test reports shall be used in fabrication of structures.

**17.17.7.** All bolts, nuts and washers shall be procured from reputed manufacturers and shall conform to the relevant Indian Standards.

**17.17.8.** The weight, thickness and uniformity of zinc coating on hot dipped galvanized members shall be tested in accordance with IS: 2633 for ensuring the compliance with the requirements specified in specification.

**17.17.9.** The finished surfaces of steel structures shall be visually examined for defects like discolored patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel, globules, spiky deposits, blistered surface, flaking or peeling off etc. There shall be no flaking or loosening when struck squarely with a chisel faced hammer. The presence of any of these defects noticed on visual microscopic inspection shall render the material liable to rejection.

**17.17.10.** Defects in galvanizing in certain members indicating presence of impurities in the galvanizing bath in quantities larger than that permitted by the specifications, or lack of quality control in any manner in the galvanizing plant shall render the entire production in the relevant shift liable to rejection.

**17.17.11.** The galvanized steel member shall withstand minimum four, one minute dips in copper sulfate solution as per IS: 2633.

**17.17.12.** Should any structure or part of a structure be found not to comply with any of the provisions of this specification, the same shall be liable for rejection. No structure or part of the structure, once rejected, shall be offered again, except in cases where the employer considers the defects rectifiable. The employer may, at his discretion, check the test results obtained at the Contractor's works by independent tests at an approved

laboratory and should the items, so tested, be found to be unsatisfactory, the same shall be rejected. The cost of tests shall be borne by the Contractor.

**17.17.13.** To ascertain the quality of the steel used, the Employer reserves the right to get the material tested at an approved laboratory.

**17.17.14.** When all tests to be performed in the Contractor's shop under the terms of this contract have been successfully carried out, the steel work shall be accepted forthwith and the employer shall issue an acceptance certificate, upon receipt of which, the items shall be dispatched. No item shall be delivered unless an acceptance certificate for the same has been issued. The satisfactory completion of prescribed tests or the issue of the dispatch certificates shall not bind the employer to accept the work, should it, on further tests before or after erection be found not in compliance with the specification.

## 17.18. PACKING

**17.18.1.** The material shall be boxed or bundled for transport in the following manner:-

17.18.1.1. Angles shall be packed in bundles securely wrapped four times around at each end and in the middle and at every meter with No.9 gauge galvanized steel wire with ends twisted tightly. Gross weight of any bundle shall not exceed approximately 450 kg.

17.18.1.2. Cleat angles, brackets, fillet plates and similar small loose pieces shall be nested and bolted together in multiples and securely wired together through holes, wrapped round at least four times with No.9 gauge galvanized steel wire and ends twisted tightly. Gross weight of each bundle shall not exceed approximately 70kg.

17.18.1.3. The correct quantity of bolts, nuts and washers plus 2.50 percent extra for each type of gantry tower, beam, lighting/lightening mast, equipment supporting structure etc. shall be packed in gunny bags, accurately & securely tagged in accordance with the contents and a number of bags packed in wooden box tightly wrapped with 25 mm wide x 18 gauge iron band stretched entirely around the box with end overlapping at least 150 mm. Gross weight of each box shall not exceed approximately 70 kg.

17.18.1.4. All packing shall be subject to the approval of the Employer, or his appointed representatives. The packing shall be carried out with caution to protect the material from moisture, salt or any impurities which may cause rusting or harmful effects. The packages shall be new and sufficiently sturdy in construction to withstand normal handling during transportation and at site.

### 17.18.2. MARKING OF PACKING

The packing shall be marked in the following manner:

17.18.2.1. The bundles and the packages shall be clearly marked with the consignee and destination by indelible ink.

17.18.2.2. Erection mark of the members of gantry towers, beams, lighting/lightening masts and equipment supporting structures etc shall be indicated on the bundles or packages of gusset plates, bolts & nuts, cleats etc.

## 17.19. SCHEDULE OF DEVIATIONS / VARIATIONS

**17.19.1.** If the bidder has any exceptions to any of the clauses laid down in this specification, these shall be clearly stated in the schedule of deviations/variations (Technical or Commercial). Otherwise, it shall be presumed that the bidder agrees to the provisions of this specification and same shall be included in the award letter.

# CHAPTER-14: CONTROL AND RELAY 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.

## 2. CONSTRUCTIONAL FEATURES

2.1. Control and Relay Board shall be of panels of simplex 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 center lines of switches, push buttons and indicating lamps shall not be less than 750mm from the bottom of the panel. The center lines of relays, meters and recorders shall not be less than 450mm from the bottom of the panel.

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

3.6. No equipment shall be mounted on the doors.

3.7. At existing station, panels shall be matched with other panels in the control room in respect of dimensions, color, appearance and arrangement of equipment (center 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 colored 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. Colored 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 color 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 color 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', "SYNCHRONIZING" 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 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.

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 relevant international standard 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 color 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:

11.1.1. 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 Synchronizing equipment.

**11.2. Indicating Instruments**

11.2.1. Unless otherwise specified, all electrical indicating instruments shall be of digital type suitable for flush mounting.

11.2.2. Instruments shall have 4-digit display; display height being not less than 25 mm.

11.2.3. 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.

11.2.4. 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 color and all Non-trip facia shall have white color.

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 |
| Synchronizing switches | : | Oval, Black, Keyed handle (one common removable handle for a group of switches or locking facility having common key) |
| Synchronizing 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. Synchronizing 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 Synchronizing switches. These switches shall be arranged to connect the Synchronizing equipment when turned to the 'ON' position. One contact of each switch shall be connected in the closing circuit of the respective breaker so that the breaker cannot be closed until the switch is turned to the 'ON' position.

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 minimize 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** | | |
|---|---|---|---|
| | **110V DC** | **50V DC** | **230V AC** |
| Make and carry Continuously | 10 | 10 | 10 |
| Make and carry for 0.5 sec. | 30 | 30 | 30 |
| Break for Resistive load | 3 | 20 | 7 |
| Break for Inductive load With L/R = 40m sec. | 0.2 | - | - |

## 14. INDICATING LAMPS

14.1. Indicating lamps shall be of cluster LED type suitable for panel mounting with rear terminal connections. Lamps shall be provided with series connected resistors preferably built in the lamp assembly. Lamps shall have translucent lamp covers to diffuse lights colored 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 color 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. SYNCHRONIZING EQUIPMENT

16.1. For sub-station equipped with sub-station Automation system, the requirement of synchronization 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.

16.2. The Synchronizing instruments shall be mounted either on a Synchronizing trolley or on a Synchronizing panel. The panel/ trolley shall be equipped with double analog voltmeters and double analog frequency meters, synchroscope and lamps fully wired. The size of voltmeters and frequency meters provided in the Synchronizing panel shall not be less than 144 X 144 sq.mm. Suitable auxiliary voltage transformers wherever necessary shall also be provided for synchronizing condition. In case the synchroscope is not continuously rated, a

synchroscope cut-off switch shall be provided and an indicating lamp to indicate that the synchroscope is energised, shall also be provided.

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

16.4. The Synchronizing panel shall be draw out and swing type which can be swivelled in left and right direction. The Synchronizing panel shall be placed along with control panels and the number of Synchronizing panel shall be as indicated in SCHEDULES OF RATES AND PRICES. 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 Synchronizing panel for Synchronization 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 synchronizing mode at a time.

16.5. 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.

16.6. At existing sub-stations, the Synchronizing scheme shall be engineered to be compatible with the existing Synchronizing scheme and Synchronizing socket/switch on the panel. In substations, where Synchronizing 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 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 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 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 Specific Requirement (PSR)**

18.4. The maximum fault current could be as high as 31.5kA 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 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- 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)

(f) 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).Maximum operating time 45ms for 3 ph. Faults & 60ms for all other faults. A relaxation of 5 ms in above timings is allowed for 132 KV lines.

(g) Line Protection for 132 kV& 33KV system for remote end tripping will be done through OPGW.

(h) The relay shall have an adjustable characteristics angle setting range of 30 - 85 degree or shall have independent resistance(R) and reactance (X) setting.

(i) shall have two independent continuously variable time setting range of 0-3 seconds for zone-2 and 0-5 seconds for zone-3

(j) shall have resetting time of less than 55 milli-seconds (including the resetting time of trip relays)

(k) shall have facilities for offset features with adjustable 10-20% of Zone-3 setting

(l) shall have variable residual compensation

(m) 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

(n) shall have weak end in-feed feature

(o) shall be suitable for single & three phase tripping

(p) 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.

(q) 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

(r) shall be suitable for use in permissive under reach/ over reach/ blocking communication mode

(s) Shall have suitable number of potential free contacts for inter Tripping, Auto reclosing, CB failure, Disturbance recorder & Data acquisition system.

(t) 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

(u) 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

(v) 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

(w) 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 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

(c) have an adjustable setting range of 100-170% of rated voltage with a time delay of 100-200 mill seconds for the second stage

(d) be tuned to power frequency

(e) provided with separate operation indicators (flag target) for each stage relays

(f) have a drop-off to pick-up ratio greater than 95%

(g) 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:

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. TRANSFORMER PROTECTION

20.1. **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.

20.2. **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

20.3. **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

20.4. **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

20.5. **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%.

20.6. **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

20.7. **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.**

## 21. 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

## 22. 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.

## 23. 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.

## 24. BUS BAR PROTECTION

24.1. Double bus Single breaker protection scheme shall be provided for each main for 132 kV Voltage levels, Busbar protection for each busbar shall incorporate a main protection and check feature.

24.2. 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 31.5 KA fault level 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.

24.3. Built-in Local Breaker Backup protection feature as a part of bus bar protection scheme shall also be acceptable.

24.4. 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.

## 25. 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 color 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.

## 26. FAULT RECORDER

26.1. 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.

26.2. 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.

26.3. 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.

26.4. 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.

26.5. 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 color 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

26.6. The evaluation unit hardware, for substations having SAS, shall be as described in clause no. 4.0 of chapter sub-station automation system.

26.7. Fault recorder shall have atleast 8 analogue and 16 digital channels for each feeder.

26.8. 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.

26.9. 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.

26.10. 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.

26.11. 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 OPGW/PLCC/VSAT/LEASED LINE shall be provided.

26.12. 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)

26.13. The Evaluation unit shall be connected to the printer to obtain the graphic form of disturbances whenever desired by the operator.

26.14. Fault recorder acquisition units shall be suitable to operate from 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.

26.15. 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 carrier received

5 Main protection operated

6 Main BC Auto reclosed operated

7 Over Voltage -Stage-1 /2 operated

8 Direct Trip received

9 Back Up protection operated

10 Bus bar protection operated

11 LBB operated of main /BC circuit breaker

12 BC CB R phase open

13 BC CB Y phase open

14 BC 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.

26.16. The **color 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.

26.17. 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 Synchronization. Further, Fault recorder shall have facility to synchronize its time generator from Time Synchronization 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 Synchronizing within a specified time.

26.18. Substations where Time Synchronization 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 synchronized to follow the master.

27. **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

## 28. TIME SYNCHRONIZATION EQUPMENT

28.1. The Time Synchronization equipment shall receive the co-ordinated Universal Time (UTC) **transmitted** through Geo Positioning Satellite System (GPS) and Synchronize equipments to the Nepal Standard Time in a substation.

28.2. Time Synchronization equipment shall include antenna, all special cables and processing equipment etc.

28.3. It shall be compatible for Synchronization of Event Loggers, Disturbance recorders and SCADA at a substation through individual port or through Ethernet realised through optic fibre bus.

28.4. Equipment shall operate up to the ambient temperature of 50 degree centigrade and 80% humidity.

28.5. The Synchronization 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).

28.6. Equipment shall meet the requirement of IEC 60255 for storage & operation.

28.7. The system shall be able to track the satellites to ensure no interruption of Synchronization signal.

28.8. The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse, as per requirement.

28.9. 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

28.10. The equipment shall have a periodic time correction facility of one second periodicity.

28.11. Time Synchronization equipment shall be suitable to operate from 110V DC as available at Substation.

28.12. 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.

## 29. RELAY TEST KIT

29.1. 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) |

## 30. TYPE TESTS

30.1. 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.

30.2. 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.

## 31. 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. Similarly, Group-I & Group-II protections for transformer can not 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, Bus section, Bus Transformer |
| b | Wattmeter with transducer | 1 set | for each line, transformer |
| c | Varmeter with transducer | 1 set | for each line,transformer,Bus reactor |
| d | CB Control switch | 1 no. | for each Circuit breaker |
| e | Isolator Control switch | 1 no. | for each isolator |

| | | | |
|---|---|---|---|
| f | Semaphore | 1 no. | for each earth switch |
| g | Red indicating lamp | 1 no. | for each Circuit breaker |
| h | Red indicating lamp | 1 no. | for each isolator |
| i | Green indicating lamp | 1 no. | for each Circuit breaker |
| j | Green indicating lamp | 1 no. | for each isolator |
| k | White indicating lamp (DC healthy lamp) | 2 nos | for each feeder |
| l | Annunciation windows with associated annunciation relays | 18 nos | for each feeder |
| m | Push button for alarm Accept/reset/lamp test | 3 nos | for each control panel |
| n | Synchronising Socket | 1 no. | for each Circuit Breaker if required |
| o | Synchronising selector Switch if required | 1 no. | for each Circuit Breaker switch |
| p | Mimic to represent SLD | Lot | in all control panels |
| q | Voltmeter with selector Switch | 1 no | for each line, transformer, bus reactor |
| r | 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. 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 Synchronizing switch is also acceptable in Synchronizing trolley for new Substations. In this case. individual Synchronizing selector switch is not required for each Circuit Breaker in control panel

5. Each line /HV side of transformer/MV/LV side of transformer / BC/ Bus Section shall be considered as one feeder for above purpose.

## LINE PROTECTION PANEL (132kV)

The Line Protection panel for transmission lines shall consist of following protection features/schemes

| S.No | Description | 132kV |
|---|---|---|
| 1. | Main-I Numerical Distance Protection scheme with Having inbuilt feature of Disturbance recorder, Distance to fault Locator | 1 set |
| 2. | 3 phase trip relays | 2 nos |
| 3. | Flag relays , carrier receive relays ,aux. Relays timers etc as per scheme requirements | Built in Main Relay |
| 4. | Under voltage relay for isolator /earth switch | Built in BCU Built in main-I |
| 5. | Directional back up Over current and E/F Protection scheme | Built in BCU Built in main-I |
| 6. | DC Supply supervision relay | 2Nos. |
| 7. | Breaker failure protection | Built in BCU/ bus-bar protection |
| 8. | **Energy Meter** 3 phase, 4 wire, ABT | 1 No. |

## 132 kV BUS COUPLER PROTECTION PANEL

The 132 Bus Coupler Panel shall consist of following

| S.No | Description | 132kV |
|---|---|---|
| 1. | Non-Directional back up Over current and E/F Relay with non-directional high set | 1 set |
| 2. | Local Breaker Backup protection | 1 set/As built in Numerical Overcurrent Relay |
| 3. | 3 phase trip relays | 3 nos |
| 4. | Bay Control Unit | 1 No. |
| 5. | Red indicating lamp | 1 No. for each CB & DS |
| 6. | Green indicating lamp | 1 No. for each CB & DS |
| 7. | White Indicating lamp (DC healthy lamp) | 2 nos for each feeder. |
| 8. | Annunciation windows with associated annunciation relays | 18 nos for each feeder. |

| | | |
|---|---|---|
| 9. | Push button for alarm Accept/reset/lamp test | 3 nos for each control panel |
| 10. | DC Change over relay | 1 no |
| 11. | Local/Remote selector switch | 1 no |
| 12. | Breaker Control switch | 1 no |
| 13. | Isolator Control Switch | 1 no for each Isolator |
| 14. | CB close multiplication relay | 1 no |
| 15. | CB trip multiplication relay | 1 no as per scheme requirement |
| 16. | DC supervision relay | 2 nos |
| 17. | Trip Circuit supervision relay | 2 nos |
| 18. | Any other item required for successful completion of scheme | 1 lot |
| 19. | Flag relays, aux. relays, timers, trip relays etc. As per scheme requirements (Acceptable as part of BCU) | 1 lot |
| 20. | Complete Bus bar protection scheme as per Chapter 14, clause 24 | 1 set |

**a) 33 KV LINE CONTROL & PROTECTION PANEL ( For Substation with Automation)**

| Sl No. | DESCRIPTION | QTY |
|---|---|---|
| 1 | Bay Control Unit/Bay Control & Protection Unit | 1NO. |
| 2 | Numerical Non Directional Over Current and Earth Fault Relay 1No.with High Set Feature and in built LBB protection( LBB function as part of BCU is acceptable) | 1NO. |
| 3 | Electronic Trivector Meter with 0.2 Class Accuracy With RS 485, RS 232 & Front Optical port) | 1NO. |
| 4 | Master Trip Relay with adequate no of contacts 1 No.and Electrical Resettable type | 1NO. |
| 5 | CB Troubles and Alarm (Part of BCU) | 1 SET |
| 6 | Metering (part of BCU) | 1 SET |

## b) 132/33kV TRANSFORMER CONTROL & PROTECTION RELAY PANEL

I. The protection panel for 132/33kV Transformer shall consist of the following equipments.

| | | 132kV Side | 33kV |
|---|---|---|---|
| 1 | Transformer Differential protection scheme | 1 no | NIL |
| 2 | Restricted Earth fault protection scheme | 1 no | 1 no |
| 3 | Directional back up over current and E/F Relay With non-directional high set feature | 1set | Nil |
| 4 | Non-Directional back up over current and E/F Relay with non-directional high set feature (Part of 33kV BCU is acceptable) | NIL | 1 Set |
| 5 | Over fluxing protection scheme | Nil | 1No. |
| 6 | Over load protection scheme | 1No. | Nil |
| 7 | Three phase trip relays | 2No. | 2No. |
| 8 | Trip supervision relay | 2No. | 2No. |
| 9 | Scheme requirements including transformer Alarms and trip function | Lot | Lot |
| 10 | Disturbance Recorder | 1No. | Nil |
| 11 | Revenue Energymeter (As per T.S. Chapter-1) | 1No. | 1No. |
| 12 | Transformer Neutral Current relay | 1 Set | |
| 13 | 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 | |

**$ BCU for 132 kV Bay has been included in the BOQ details of SAS.**

## c) 33/11kV TRANSFORMER CONTROL & PROTECTION RELAY PANEL

I. The protection panel for 33/11kV Transformer shall consist of the following equipments.

| | | 33kV Side | 11kV |
|---|---|---|---|
| 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 11kV 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. | Nil |

| | | | |
|---|---|---|---|
| 11 | Revenue Energy meter (As per T.S. Chapter-1) | 1No. | 1No. |
| 12 | 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 | |

**d) 33kV BREAKER RELAY PANEL**

**(Acceptable as Part of Line /transformer Relay panel)**

The breaker relay panel for 33kV shall comprise of the following:

| | Without A/R |
|---|---|
| 1. DC supply supervision relay | 2 no. |
| 2. Trip circuit supervision relays | 2 nos. |
| 3. Emergency CB TNC Switches | 1 No. |
| 4. Flag relays, aux. relays, timers, trip relays etc. As per scheme requirements. (Acceptable as part of BCU) | Lot |

**e) <u>BREAKER RELAY PANEL (132kV)</u>**

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 may be accommodated in the Protection Panels to be provided for Transmission Line/Transformer/Reactor as applicable.

## 32. 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

## 33. 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.

**APPENDIX-A**

## 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)

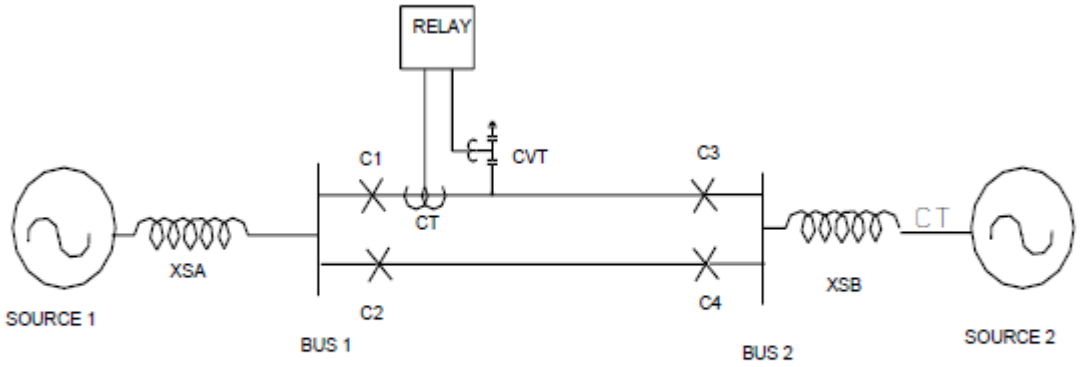



FIGURE 1

**Line parameters/km**

| | |
|---|---|
| Positive Sequence Resistance, (r1) | = 0.02897Ω |
| 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<br><br>(5500 | 109.09 Ω<br><br>(1467 MVA) | 290.9 Ω<br><br>(550 MVA) |

* Alternatively, the tests can be done with 10 Ω secondary impedance and source impedance may accordingly be modified

CVT Model

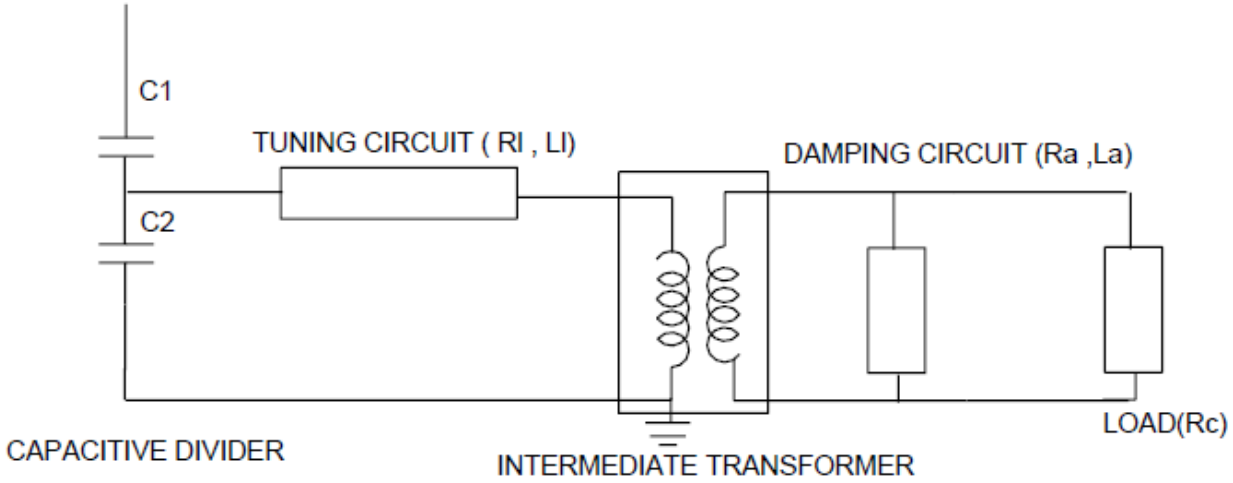



Figure-2

| | |
|---|---|
| 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<br>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 (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) | |

| 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) |
|---|---|---|---|---|---|---|
| 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 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 15: SUBSTATION AUTOMATION SYSTEM AND SCADA INTEGRATION

## 1.0 GENERAL

1.1. The substation automation system shall be offered from a manufacturer who must have designed, manufactured, tested, installed and commissioned substation automation system which must be in satisfactory operation on 220kV system or higher for at least 2 (Two) years as on the date of bid opening.

1.2. The Substation Automation System (SAS) shall be installed to control and monitor all the sub-station equipment from remote control centre (RCC) as well as from local control centre (LDC).

The SAS shall contain the following main functional parts:

- Bay control Intelligence Electronic Devices (IEDs) for control and monitoring.
- Station Human Machine Interface (HMI)
- Redundant managed switched Ethernet Local Area Network communication infrastructure with hot standby.
- Gateway for remote control via industrial grade hardware (to RCC) through IEC60870-5-101&104 protocols.
- Gateway for remote supervisory control (to RSCC), the gateway should be able to communicate with RSCC on IEC 60870-5-101&104 protocol. The specific protocol to be implemented is enclosed as Appendix-I. It shall be the bidder's responsibility to integrate his offered system with existing RSCC/LDC 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.

1.3. Peripheral equipment like printers, display units, key boards, Mouse etc. It shall enable local station control via a PC by means of human machine interface (HMI) and control software package, which shall contain an extensive range of supervisory control and data acquisition (SCADA) functions. It shall include communication gateway, intelligent electronic devices (IED) for bay control and inter IED communication infrastructure. An architecture drawing for SAS is enclosed.

1.4. The communication gateway shall facilitate the information flow with remote control centres. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions.

## 2. System design

### 2.1 General system design

The Substation Automation System (SAS) shall be suitable for operation and monitoring of the complete substation including future extensions as given in Chapter 1 - PSR.

The systems shall be of the state-of-the art suitable for operation under electrical environment present in extra high voltage substations, follow the latest engineering practice, and ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

The offered SAS shall support remote control and monitoring from Remote Control centres via gateways.

The system shall be designed such that personnel without any background knowledge in Microprocessor-based technology are able to operate the system. The operator interface shall be intuitive such that operating personnel shall be able to operate the system easily after having received some basic training.

The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signalling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records.

Maintenance, modification or extension of components may not cause a shutdown of the whole substation automation system. Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

**Bidder shall offer the Bay level unit (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer), bay mimic along with relay and protection panels and communication panels (described in other sections of technical specifications) and Station HMI in Control Room building for overall optimisation in respect of cabling**.

### 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 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 fibre shall not affect the normal operation of the SAS. However failure of fibre shall be alarmed in SAS. Each fibre optic cable shall have four (4) spare fibers

At station level, the entire station shall be controlled and supervised from the station HMI. It shall also be possible to control and monitor the bay from the bay level equipment at all times.

Clear control priorities shall prevent operation of a single switch at the same time from more than one of the various control levels, i.e. RCC, station HMI, bay level or apparatus level. The priority shall always be on the lowest enabled control level.

The station level contains the station-oriented functions, which cannot be realised at bay level, e.g. alarm list or event list related to the entire substation, gateway for the communication with remote control centres.

The GPS time synchronising signal (as specified in the section relay & protection) for the synchronization of the entire system shall be provided.

The SAS shall contain the functional parts as described in para 1.2 above.

## 2.3 FUNCTIONAL REQUIREMENTS

The high-voltage apparatus within the station shall be operated from different places:

- Remote control centres
- Station HMI.
- Local Bay controller IED (in the bays)

Operation shall be possible by only one operator at a time.

The operation shall depend on the conditions of other functions, such as interlocking, synchrocheck, 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 14 – 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 & Common Base time

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.

The internal clock of each SAS/RTUs shall be synchronized either from an internal, Contractor supplied and installed time synchronization source, such as a Global Positioning System (GPS) or an omega synchronizing signal receiver or through the telecommunication network from a master clock installed at the LDC.

The synchronization shall be done periodically such that the time-tags in each RTU shall be within five milliseconds (5 ms) accuracy between all RTUs.

Bidders shall clearly indicate the method used for time synchronization and describe in detail how the required accuracy is achieved.

In the SAS/RTU there shall be a digital output from which time synchronization messages can be forwarded to external devices. The frequency of the activation of the message shall be adjustable.

### 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 (with 1ms 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

### 3.3.1 Communication Interface

The Substation Automation System shall have the capability to support simultaneous communications with multiple independent remote master stations,

The Substation Automation System shall have communication ports as follows:
(a) Two ports for Remote Control Centre
(b) Two ports for Regional System Coordination Centre (RSCC)

The communication interface to the SAS shall allow scanning and control of defined points within the substation automation system independently for each control centre. The substation automation system shall simultaneously respond to independent scans and commands from employer's control centres (RCC & RSCC/LDC). The substation automation system shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to each remote control centre. Also, each control centre's data scan and control commands may be different for different data points within the substation automation system's database.

### 3.3.2 Remote Control Centre Communication Interface

Employer will supply communication channels between the Substation Automation System and the remote control centre. The communication channels provided by Employer will consist either of power line carrier, optical fibre 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 - PSR.

### 3.3.4 Communication Protocol

The communication protocol for gateway to control centre must be open protocol

and shall support IEC 60870-5-101/104 and IEC 61850 for all levels of communication for sub-station automation such as Bay to station HMI, gateway to remote station etc..

## 4.0 System hardware:

### 4.1 Redundant Station HMI, Remote HMI and Disturbance Recorder Work station:

The contractor shall provide redundant station HMI in hot standby mode. The servers used in these work stations shall be of industrial grade**.**

It shall be capable to perform all functions for entire substation including future requirements as indicated in the SLD. It shall use industrial grade components. Processor and RAM shall be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used. Supplier shall demonstrate these features.

The capacity of hard disk shall be selected such that the following requirement should occupy less than 50% of disk space:

1. Storage of all analogue data (at 15 Minutes interval)and digital data including alarm , event and trend data for thirty(30) days,
2. Storage of all necessary software,
3. 20GB space for OWNER'S use.

Supplier shall demonstrate that the capacity of hard disk is sufficient to meet the above requirement.

#### 4.1.1 HMI (Human Machine Interface)

The VDU shall show overview diagrams (Single Line Diagrams) and complete details of the switchgear with a colour display. All event and alarm annunciation shall be selectable in the form of lists. Operation shall be by a user friendly function keyboard and a cursor positioning device. The user interface shall be based on WINDOWS concepts with graphics & facility for panning, scrolling, zooming, decluttering 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 132

kV bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer). The Bay level unit shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All bay level interlocks are to be incorporated in the Bay level unit so as to permit control from the Bay level unit/ local bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out of service.

The bay control unit to be provided for the bays shall be preferably installed in the CB relay panel/feeder protection panel for respective bay.

The bay control unit for future bay (if required as per Chapter 1 – Project Specification Requirement) shall be installed in a separate panel.

The Bay level unit shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 61850. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.

### 4.2.1 Input/output (I/O) modules

The I/O modules shall form a part of the bay level unit and shall provide coupling to the substation equipment. The I/O modules shall acquire all switchgear information (i.e. data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear. The measured values of voltage and current shall be from the secondaries of instrument transformers. The digital inputs shall be acquired by exception with 1 ms resolution. Contact bouncing in digital inputs shall not be assumed as change of state

## 4.3 Extendibility in future

Offered substation automation system shall be suitable for extension in future for additional bays. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the employer. During such event, normal operation of the existing substation shall be unaffected and system shall not require a shutdown. The contractor shall provide all necessary software tools along with source codes to perform addition of bays in future and complete integration with SAS by the user. These software tools shall be able to configure IED, add additional analogue variable, alarm list, event list, modify interlocking logics etc. for additional bays/equipment which shall be added in future.

## 5.0 Software structure

The software package shall be structured according to the SAS architecture and

strictly divided in various levels. Necessary firewall shall be provided at suitable points in software to protect the system. An extension of the station shall be possible with lowest possible efforts. Maintenance, modification or an extension of components of any feeder may not force a shut-down of the parts of the system which are not affected by the system adaptation.

### 5.1.1 Station level software

#### 5.1.1.1 Human-machine interface (HMI)

The base HMI software package for the operator station shall include the main SAS functions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. Systems shall contain a library with standard functions and applications.

### 5.1.2 Bay level software

#### 5.1.1.1 System software

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. The lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance engineer for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage. In case of restoration of links after failure, the software along with hardware shall be capable of automatically synchronising with the remaining system without any manual interface. This shall be demonstrated by contractor during integrated system test.

#### 5.1.1.2 Application software

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They form part of a library.
The application software within the control/protection devices shall be programmed in a functional block language.

#### 5.1.1.3 Network Management System (NMS):

The contractor shall provide a network management system software for following management functions:

a. Configuration Management
b. Fault Management
c. Performance Monitoring

This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in DR work-station and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any fault in the monitored devices. The NMS shall

(a) Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports.
(b) Maintain a graphical display of SAS connectivity and device status.
(c) Issue alarms when error conditions occurs
(d) Provide facility to add and delete addresses and links

**5.1.1.4** The contractor shall provide each software in two copies in CD to load into the system in case of any problem related with Hardware/Communication etc.

## 6.0 TESTS

The substation automation system offered by the bidder shall be subjected to following tests to establish compliance with IEC 61850 for EHV sub-station equipment installed in sheltered area in the outdoor switchyard and specified ambient conditions:

### 6.1 Type Tests:

### 6.1.1 Control IEDs and Communication Equipment:

**a. Power Input:**
i. Auxiliary Voltage
ii. Current Circuits
iii. Voltage Circuits
iv. Indications

**b. Accuracy Tests:**
i. Operational Measured Values
ii. Currents
iii. Voltages
iv. Time resolution

**c. Insulation Tests:**
i. Dielectric Tests
ii. Impulse Voltage withstand Test

**d. Influencing Quantities**
i. Limits of operation
ii. Permissible ripples
iii. Interruption of input voltage

**e. Electromagnetic Compatibility Test:**
i. 1 MHZ. burst disturbance test
ii. Electrostatic Discharge Test
iii. Radiated Electromagnetic Field Disturbance Test
iv. Electrical Fast transient Disturbance Test

v. Conducted Disturbances Tests induced by Radio Frequency Field
vi. Magnetic Field Test
vii. Emission (Radio interference level) Test.
viii. Conducted Interference Test

**f. Function Tests:**

i. Indication
ii. Commands
iii. Measured value Acquisition
iv. Display Indications

**g. Environmental tests:**

i. Cold Temperature
ii. Dry Heat
iii. Wet heat
iv. Humidity (Damp heat Cycle)
v. Vibration
vi. Bump
vii. Shock

## 6.2 Factory Acceptance Tests:

The supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual bay level IED's applicable type test certificates shall be submitted**.**

The manufacturing and configuration phase of the SAS shall be concluded by the factory acceptance test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the user. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab. During FAT the entire Sub-station Automation System including complete control and protection system to be supplied under present scope shall be tested for complete functionality and configuration in factory itself. The extensive testing shall be carried out during FAT. The purpose of Factory Acceptance Testing is to ensure trouble free installation at site. No major configuration setting of system is envisaged at site.

If the complete system consists of parts from various suppliers or some parts are already installed on site, the FAT shall be limited to sub-system tests. In such a case, the complete system test shall be performed on site together with the site acceptance test (SAT).

### 6.2.1 Hardware Integration Tests:

The hardware integration test shall be performed on the specified systems to be used for Factory tests when the hardware has been installed in the factory. The operation of each item shall be verified as an integral part of system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software integration and factory testing of the system. The equipment expansion capability shall also be verified during the hardware integration tests. The vendor specifically demonstrates how to add a device in future in SAS during FAT. The device shall be from a different manufacturer than the SAS supplier.

### 6.2.2 Integrated System Tests:

Integrated system tests shall verify the stability of the hardware and the software. During the tests all functions shall run concurrently and all equipment shall operate a continuous 100 Hours period. The integrated system test shall ensure the SAS is free of improper interactions between software and hardware while the system is operating as a whole.

### 6.3 Site Acceptance Tests:

The site acceptance tests (SAT) shall completely verify all the features of SAS hardware and software. The bidder shall submit the detailed SAT procedure and SAT procedure shall be read in conjunction with the specification.

## 7.0 SYSTEM OPERATION

## 7.1 SUBSTATION OPERATION

### 7.1.1 NORMAL OPERATION

Operation of the system by the operator from the remote RCC or at the substation shall take place via industry standard HMI (Human Machine interface) subsystem consisting of graphic colour VDU, a standard keyboard and a cursor positioning device (mouse).

The coloured screen shall be divided into 3 fields:

i) Message field with display of present time and date
ii) Display field for single line diagrams
iii) Navigation bar with alarm/condition indication

For display of alarm annunciation, lists of events 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 110V DC system.

1No.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 110V 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 )
- 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 SCADA Integration

The Supervisory Control and Data Acquisition (SCADA) System at the LDC shall scan the new RTU/SASs utilizing the communication network.

The Contractor shall be responsible for the complete design, installation, wiring, testing, commissioning and documentation of the RTU/SASs, including any required new or parallel connections to NEA's field equipment as described in this Specification, including synchronization with the existing SCADA equipment.

Compatible interfacing shall be for all aspects, including software and hardware. In addition to other necessary compatibilities and interfacing, the Contractor shall be fully responsible for the integration of the SCADA data associated with the scope in this tender in the SINAUT Spectrum– the processing software of the Load Dispatch Centre. This integration requires modification, addition and parameterization in the Spectrum for the following main activities:

a) SCADA data entry: this includes data entry of different components of the substations, lines and other relevant components.
b) Creating Graphics: this includes creating graphics for substations, lines and other relevant components, network map creation and integration with existing system, etc.
c) Data entry for Telecontrols Interface (TCI);
d) Testing and commissioning of the newly integrated SCADA system for its full functioning; and
e) Network Application data entry required for network analysis.

For these purposes, the Contractor shall carry out necessary studies / investigations of the existing system carefully, in full coordination with the Load Dispatch Centre, and design / propose, install and integrate a suitable scheme/system to fulfill the specified scope of works for teleprotection, SCADA, voice communication etc., as required by NEA (Load Dispatch Centre).

## 10.1 Data acquisition principles

New RTU/SASs at each substation shall be installed and interfacing of the following supervisory controls shall be executed and data to be acquired shall be provided for:

Remote control

- remote control of all 132 kV circuit breakers
- remote control of all 33 kV, 11kv circuit breakers (off-control only for load curtailment)

Status indications

- status indication of all 132 kV circuit breakers
- status indication of all 132 kV bus bar and line isolators
- status indication of all 33 kV line feeders
- status indication of all 11 kV line feeders

In case of load shedding from the LDC, the substation operator shall be informed that the trip command for the respective 33 kV, 11kV CBs was initiated from the LDC. For this purpose, an Annunciator lamp and audio alarm shall be installed at all 33/11 kV feeders taking part in the load shedding scheme. The associated audio alarm shall be integrated in the central annunciation system of local 33/11 kV cubicles.

**Alarms**

- all 132 kV kV main protection trip indications (MPT)
- all 132 kV kV backup protection trip indications (BPT)
- one grouped alarm summarizing all causes that prevent operation of a circuit breaker (Circuit Breaker Fault Alarm, CBF)
- one grouped alarm summarizing all faults not affecting operation of a circuit breaker (Bay Fault Alarm, BFA)
- single indication for operation of auto re-closure relay for 132 kV transmission lines (ARO)
- transformer alarms:
  - "temperature alarm" (oil and winding temperature as grouped alarm)
  - "temperature trip" (oil and winding temperature as grouped alarm)
  - "Buchholz alarm" (tank and OLTC as grouped alarm)
  - "Buchholz trip" (tank and OLTC as grouped alarm)
  - "general alarm" (all other alarms except the above as one grouped alarm)
  - "general trip" (all other alarms except the above as one grouped alarm)

- for all 132 kV and 33 kV, 11kV bus bars a voltage status alarm (BVS)
- general station alarms and warnings
  - Station Urgent Fault (SUF)
  - Station None-urgent Fault (SNF)
  - RTU alarm (RTU)
  - Communication Equipment Alarm (COM)
  - Station Control Disabled (SCD), etc.

A table summarizing the alarms to be acquired by LDC from each type of bay in the 132/33/11 kV network is shown in Table 10.1.

Table 10.1 Alarms to be acquired from each type of bay

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

Measurements

- Bus bar voltages (separate for each bus bar and section) of all 132 kV bus bars.
- active / reactive power for
  - All 132 kV line feeders.
  - all 132 kV transformer feeders
  - all 132/33 kV transformers feeding into the distribution networks

(at secondary side)

- Single phase current measurements for all 33, 11 kV lines participating in the load shedding scheme.

In analog measurands, the information to the RTU/SAS is given in the form of an analog current supplied by the output of an analog measuring transducer.

The analog signals shall be converted to digital mode by an analog-to-digital converter, to which the inputs are connected. All inputs of a module shall be measured within one cycle, regardless of the number of inputs in use. Thus new points can be added to the RTU without reprogramming.

Analog measurements shall be transmitted to the master station with 16 bits or 16 bits + sign bit.

## *11.0* TRAINING FOR OPERATIONAL STAFFS

The Contractor shall design and arrange a training programme at least of 7 days at the manufacturer's premises for the SASs for three concerned NEA personnel so as to make them competent enough to operate and maintain the proposed equipment/system. The overview of such programme shall be proposed by the prospective Contractor along with its technical proposal. The cost of this training shall be included in the overall bid price.

## Annexure-I

### 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 and Bus-II

Voltage R-Y phase
Y-B phase
B-R phase

b) Frequency for Bus-I and Bus-II

c) Ambient temperature (switchyard)
**d) Control Room Temperature.**
**e) LT system**
i) Voltage R-Y, Y-B, B-R of Main Switch Board section
ii) Current from LT transformer
iii) Voltage of 110V DCDB

iv) Current from 110V Battery set
v) Current from 110V Battery charger
vi) Voltage of 48V DCDB
vii) Current from 48V Battery set
viii) Current from 48V Battery charger

**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) 110V DC-I source fail
xlvi) 110V DC-II source fail
xlvii) SPEECH CHANNEL FAIL
xlviii) PLCC Protection Channel-I FAIL
xlix) 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) 110v DC- 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) 110v DC-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) 110V DC- 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

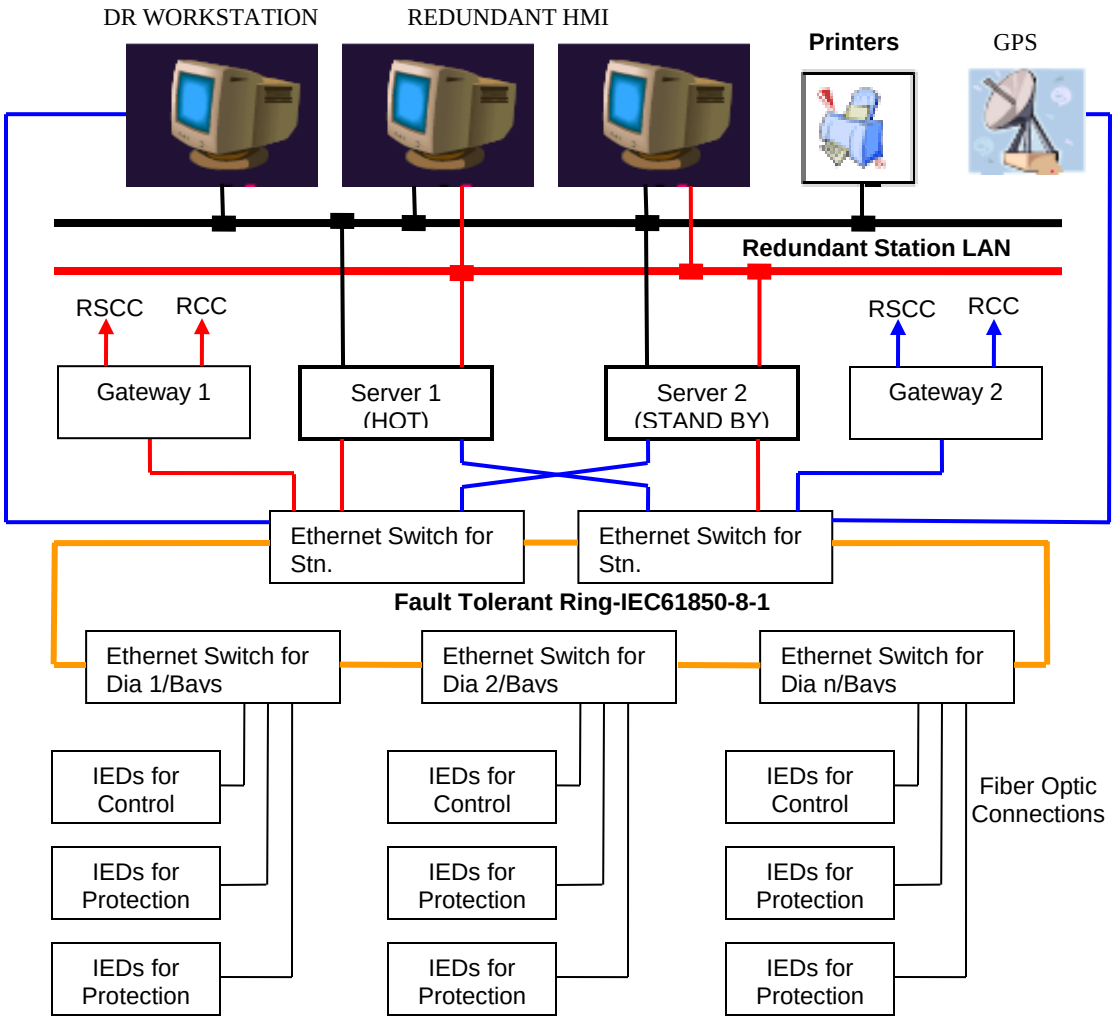
6. **Auxiliary system**

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) LT transformer-I Bunchholz Alarm & trip

vi) LT transformer-II Buchloz Alarm & trip
vii) LT transformer-I WTI Alarm & trip
viii) LT transformer-II WTI Alarm & trip
ix) LT transformer-I OTI Alarm & trip
x) LT transformer-II OTI Alarm & trip
xi) PLCC exchange fail
xii) Time sync. Signal absent
xiii) Alarm/trip signals as listed in Section: Battery and Battery charger
xiv) 110V DC-earth fault
xv) Alarm/trip signals as listed in Section: Fire protection system

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.

## Annexure-II

**List of IO Points to be transmitted to LDC**

a) MW and MVAR for all lines , transformers, reactors and Capacitors
b) Voltage of all buses
c) Frequency of 132kV 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

# CHAPTER 16: LT TRANSFORMER

## 1.0 INTENT

This specification is intended to cover outdoor type oil filled 33/0.4kV, 200kVA transformers (1 Nos.) at both Motipur & Sandhikharka Substation.

## 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 110 V DC Control supply. All alarm and trip Contacts shall also be suitable for connection in 110V 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.

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

| | |
|---|---|
| IEC60076 | Power transformers |
| IEC 60137 | Bushings for alternating voltages above 1 kV |
| IEC 60156 | Method of determination of electric strength of insulating oils |
| IEC 60296 | Specification for unused mineral insulating oils for transformers and switchgear. |
| IEC 60551 | Measurement of transformer and reactor sound levels |
| IEC 60616 | Terminal and tapping markings for power transformer |

IEC 60722 Guide to lightning and switching impulse testing of power transformers

## 4.0 TECHNICAL REQUIREMENTS

### 4.1 Tank

The station transformer shall be provided with a case of rigid construction, which shall be oil-tight and gas-tight complete with oil preservation system. The tank shall be capable of withstanding, without leakage or permanent distortion, a pressure 25% greater than the maximum operating pressure resulting from the system of oil preservation used. The tank cover shall be bolted and provided with suitable hand holes. Two grounding pads complete with clamp type terminal connector shall be provided on the tank wall near the base.

### 4.2 Core

Cores shall be constructed of high quality, non-aging, high permeability cold rolled grain oriented silicon steel. The steel shall be in thin laminations. Both sides of each sheet shall be insulated, with durable, rigidly clamped with positive locking devices to ensure adequate mechanical strength to support the windings and reduce vibrations to a minimum during operation. Cut type cores shall not be accepted.

### 4.3 Winding

The design, construction and treatment of winding shall give proper consideration to all service factors. The complete assembly of core and coils shall be dried in a vacuum sufficient to ensure elimination of air and moisture within the insulating structure. After the drying process, the assembly shall be immediately impregnated with dry oil. The windings of the transformer shall be fabricated of copper materials. Aluminum winding materials shall not be accepted.

### 4.4 Oil Preservation

Each transformer shall be provided with an oil conservator complete with oil filter flange or cap at the top.

### 4.5 Short Circuit Capacity

The transformer shall be designed and constructed to withstand, without injury, the mechanical and thermal stress produced by short-circuit current limited by the impedance of the transformer only.

### 4.6 Tap Changer

An externally - operated tap changer shall be furnished with the transformer, to be operated only when the transformer is de-energized. The tap changer shall include an operating handle, visible indication of tap position and means for locking the tap changer in any desired position. The locking device shall be arranged to prevent locking the tap changer in an off position. Mechanical means shall be provided for

limiting the maximum and minimum traveling of the extreme tap positions to be at the maximum and minimum position of the tap changer.

### 4.7 Insulating Oil

The insulating oil shall be refined mineral oil. Necessary quantity of oil for the transformer shall be furnished by the Contractor.

### 4.8 Bushings

The bushings shall be made of homogeneous and well vitrified porcelain. The color of the insulator shall be brown and the surface shall have polished glaze.

The cable terminal box on the low voltage side shall consist bolted terminal lugs suitable for terminating 95-150 sq. mm. stranded copper conductor cables.

The low voltage neutral bushings shall include a lug for terminating a *25* sq. mm. copper earth wire in addition to the *95-150* sq. mm. copper conductor neutral circuit.

### 4.9 Temperature rise

Average winding temperature rise above maximum ambient temperature (40 Deg C) when carrying maximum continuous rated kVA shall not exceed 55 Deg C. The temperature rise of the insulating oil shall not exceed 50 Deg C when measured near the top of the main tank.

### 4.10 Accessories

The following accessories shall be provided with each transformer.

- Upper oil filter valve
- Lower oil filter and drain valve
- Oil sampling device
- Liquid level gauge
- Lifting Lug
- Name plate
- Hand Hole
- Tank grounding terminal connector suitable for grounding cable of #6 SWG solid or stranded copper.
- Breather, oil conservator.

### 4.11 Tests

(a) Routine Test:

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

- Applied voltage test
- Induced voltage test
- No load loss and excitation current test
- Impedance voltage and load loss tests
- Winding resistance measurement

- Ratio tests
- Polarity and phase relation tests
- Leakage tests
- Insulation resistance tests
- Insulation power factor tests, etc.

(b) Design Test:

The Transformer design tests shall include following:

- Temperature rise tests
- Impulse voltage tests
- Pressure tests

The Bidder shall submit copy of design test report from recognized testing laboratory for the transformer of the offered model along with the bid.

### 4.12 Current limiting power fuse

For the protection of the station service transformer, high voltage (36 kV) current limiting power fuse with suitable cartridge holder, outdoor mounting shall be provided in a safe height. Cost of the power fuse its holder including installation shall be included in the price of the station service transformer.

### 4.13 Disconnecting Switch (If Needed and as per Approved Bill of Quantity)

Gang operated single throw disconnecting switch shall be provided for the transformer. This switch shall be easily operable from ground and capable of disconnecting the transformer.

**Technical Specification of 33/0.4 kV LT Transformer**

| | Description | 33/0.4 kV Transformer |
|---|---|---|
| 1. | Rated power | 200 kVA |
| 2. | Rated voltage<br>-Primary<br>-Secondary | <br>33 kV<br>400 / 230 V |
| 3. | Max. system voltage<br>-Primary<br>-Secondary | <br>36 kV<br>400 V |
| 4. | Rated frequency | 50 Hz |
| 5. | Connection<br>-Primary<br>-Secondary | <br>Delta<br>Gnd. Wye |
| 6. | Cooling system | ONAN |
| 7. | Voltage vector group | Dyn 11 |
| 8. | Rated impedance voltage | ~4.5 % |
| 9. | BIL of winding and bushing for primary side | 170 kV (crest) |
| 10. | Withstand voltage 50 Hz, 1 min.<br>-Primary | <br>75 kV |

| | | |
|---|---|---|
| | -Secondary | 3 kV |
| 11. | Off-circuit tap changer voltage taps on HV side | +/- 5 % |
| 12. | Mounting | *Platform on ground* |
| 13. | Bushing (suitable for)<br>-HV<br>-LV | exposed<br>enclosed for cable connection |
| 14. | Insulation temperature class (IEC 76) | A |
| 15. | Max. allowable noise level at 3 meter hemispherical radius | 44 dB |
| 16. | Applicable standard | IEC |

# CHAPTER 17
# Fibre Optic Based Communication Equipments

## 1. Introduction, General Information and General Requirement

This document describes the technical specifications for Communication Equipment which includes Fibre Optic Terminal Equipment and Multiplexer Equipments for Establishment of Fibre Optic Communication System under the contract. This specification describes the functional and performance requirements of the system.

### 1.1 Scope and General Requirements

The broad scope of the procurement of this part include the survey, planning, design, engineering, supply, transportation, insurance, delivery at site, unloading, handling, storage, installation, termination, testing, training, and demonstration for acceptance, commissioning and documentation for:

(i) SDH Equipment along with suitable optical line interfaces & tributary cards.
(ii) Associated Termination equipment (Drop-insert multiplexers, subscriber line interfacing card etc.)
(iii) Local Craft Terminal
(iv) All cabling, wiring, Digital Distribution Frame patch facilities, equipment MDF's and interconnections to the supplied equipment at the defined interfaces.
(v) MDF & DDF cross connects required to route and activate circuits.
(vi) System integration of the supplied subsystems and also integration with existing communication equipment such as SDH, MUX etc.
(vii) System integration of the supplied equipments (termination equipment system) with existing equipments for seamless transmission of communication channel
(viii) Integration of supplied system with the User equipments such as RTU/SASs, SCADA system, PLCC equipment etc.
(ix) Maintenance of the supplied system

All other associated works/items described in the technical specifications for a viable and fully functional communication network.

### 1.2 General Requirements

The Contractor is encouraged to offer standard products and designs. However, the Contractor must conform to the requirements and provide any special equipment necessary to meet the requirements stated herein.

It should be noted that preliminary design information and bill of quantity (BoQ) specified in this specifications are indicative only. The Contractor shall verify the design data during the site surveys & detail engineering and finalise the BoQ as required for ultimate design & system performance.

The Bidder's proposal shall address all functional and performance requirements within this specification and shall include sufficient information and supporting documentation in order to determine compliance with this specification without further necessity for inquiries.

An analysis of the functional and performance requirements of this specification and/or site surveys, design, and engineering may lead the Contractor to conclude that additional items are required that are not specifically mentioned in this specification. The Contractor shall be responsible for providing at no added cost to the Employer, all such additional items and services such that a viable and fully functional communication equipment system is implemented that meets or exceeds the capacity, and performance requirements specified. Such materials and services shall be considered to be within the scope of the contract. To the extent possible, the Bidders shall identify and include all such additional items and services in their proposal.

All equipment provided shall be designed to interface with existing equipment and shall be capable of supporting all present requirements and spare capacity requirement identified in this specification.

The communication equipment shall be designed and provisioned for expansions and reconfigurations without impairing normal operation, including adding and removing circuits. The offered items shall be designed to operate in varying environments. Adequate measures shall be taken to provide protection against rodents, contaminants, pollutants, water & moisture, lightning & short circuit, vibration and electro-magnetic interference etc.

The Bidders are advised to visit sites (at their own expense), prior to the submission of a proposal, and make surveys and assessments as deemed necessary for proposal submission. The successful bidder (Contractor) is required to visit all sites. The site visits after contract award shall include all necessary surveys to allow the contractor to perform the design and implementation functions. The Contractor shall inform their site survey schedule to the Employer well in advance. The site survey schedule shall be finalised in consultation with the Employer. The Employer may be associated with the Contractor during their site survey activities.

After the site survey, the Contractor shall submit to the Employer a survey report on each link and site. This report shall include at least the following items:

(a) Proposed layout of Equipment in the existing rooms and buildings.
(b) Proposed routing of power, earthing, signal cables and patch cords etc.
(c) Confirmation of adequacy of Space and AC/DC Power supply requirements
(d) Proposals for new rooms/buildings if required
(e) Identification of facility modifications if required
(f) Identify all additional items required for integration for each site/location.

### 1.2.1 Synchronization of the Communication Network

The Contractor shall be responsible for synchronization of new communication equipment with existing network utilizing the existing clock (if available). The Contractor shall make an assessment of additional clock requirement for synchronization of the communication equipment.

### 1.2.2 Contractor's Responsibilities and Obligations

The Contractor shall be responsible for all cables and wiring associated with the equipment provided, both inside and outside buildings in accordance with technical specifications. The Contractor shall also be responsible for determining the adequacy of the local power source for the equipment and for wiring to it, with adequate circuit protective breakers. In addition, the Contractor shall be responsible for shielding equipment and cabling to eliminate potential interference to or from the equipment, and for earthing all cabinets and shields.

Contractor's obligations include, but are not limited to, the following:

(1) Site visits, and surveys, necessary to identify and provide all equipment needed to implementation the network.

(2) Equipment Engineering and design specific to each location including review of, and conformance with local environmental and earthing considerations.

(3) Overall integration of communication equipments/subsystem procured in present and existing network.

(4) All cabling, wiring including supply, laying and termination etc of the cables, and distribution frame at wideband nodes required for full interconnectivity and proper operation of the telecommunications network including equipment supplied under this package and the connectivity and interfacing of user equipment.

(5) Installation and integration of network management software, hardware and firmware (as applicable).

(6) Project management, project scheduling, including periodic project reports documenting progress, review meeting during the contract period.

(7) Engineering and technical assistance during the contract and warranty period.

(8) Implement all minor civil works and identify any major civil works i.e. expansion or construction of rooms, trenches necessary for installation of proposed equipment and provide the details of such work to the Employer.

(9) Factory and site testing of all hardware, software, and firmware provided.

(10) Provide documented evidence of satisfactory Type Test performance to the Employer and if required by The Employer, conduct type test.

(11) Provide a Quality Assurance Plan, ensuring the Employer access to the manufacturing process.

(12) Training of the Employer personnel.

(13) Hardware, software, and firmware maintenance, debugging, and support of the equipment through final acceptance, and maintenance on all new equipment through out the warranty period and for a period of six (6) years after warranty period.

(14) Availability of service, spare and expansion parts for the supplied items for the designed life of the equipment or seven (7) years after the declaration of withdrawal of equipment from production, whichever is earlier. However, the termination of production shall not occur prior to Operational Acceptance of the system by the Employer.

Detailed descriptions of the Contractor's obligations, in relation to individual items and services offered, are delineated in other sections of this specification.

### 1.2.3 The Employer Responsibilities and Obligations

The Employer will provide the following items and services as part of this Project:

(1) Overall project management of the project
(2) Review and approval of the Contractor's designs, drawings, and recommendations.
(3) Communication network configuration data, including:
  (a) Channel assignments for voice and data
  (b) Interconnection drawings for existing equipment
(4) Review and approval of test procedures.
(5) Participation in and approval of "Type", factory and site acceptance tests where testing is required.
(6) Review and approval of training plans.
(7) Providing support and access to facilities at the sites.
(8) Implement the major civil works such as expansions or construction of rooms, trenches etc. as required for the equipment to be provided by the Contractor.
(9) Coordination of the Contractor's activities with the Employer's and constituents' concerned departments.
(10) Provide to the extent possible drawings for existing sites and facilities for which equipment installations are planned.
(11) Approval of the key personnel for the project

## 1.3 Applicable Standards

The following standards and codes shall be generally applicable to the equipment and works supplied under this Contract:

(i) IEEE 802.3
(ii) ITU-T/CCITT Recommendations, G.652, G.701, G.702, G.703, G.711/ 12/ 14/ 35/ 36, G.721, G.742, G.811 and G.823
(iii) ITU-T/CCITT Recommendations, G.801, G.821, G.822, G.823, G.826.
(iv) ITU-T/CCITT Recommendations of the V Series
(v) ITU-T/CCITT Recommendations R35, R37, and R38A (or R38B)
(vi) ITU-T/CCITT Recommendations M3010, G771
(vii) Internet Activities Board, RFC-1157 (SNMP)
(viii) International Electrotechnical Commission standards, IEC801-2/3/4/5, IEC-255-4, IEC-255-5, IEC-870-2-1, IEC-721-3-3, IEC-529.
(ix) International Electrotechnical Commission standards, IEC 1000-4-xx series.
(x) IEC publication 68, 68-2-2, 68-2-3, 68-2-14, 68-2-27, 68-2-32.
(xi) ITU-T/CCITT Recommendations K.11, K.17, K.20.
(xii) International CISPR standards

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.

## 2. Network Configuration and Equipment Characteristics

### 2.1 Introduction

This section describes the Fibre Optic Communication network configuration and the equipment characteristics for communication system to be installed under the project. The sub-systems addressed within this section are:

(1) Fibre Optic Transmission System (FOTS)
(2) Termination Equipment Subsystems
(3) MDF, DDF and Cabling

The requirements described herein are applicable to and in support of network requirements. The equipment supplied shall support existing network for Power system operational requirements.

The security related requirements of the equipment shall be as per relevant agency and shall be followed/complied by the vendor.

The manufacturer shall allow the Employer and/or its designated agencies to inspect the hardware, software, design, development, manufacturing, facility and supply chain and subject all software to a security/threat check any time during the supplies of equipment.

The contractor shall ensure that the supplied equipments have been got tested as per relevant contemporary International Security Standards e.g. IT and IT related elements against ISO/IEC 15408 standards, for Information Security Management System against ISO 27000 series Standards, Telecom and Telecom related elements against 3GPP security standards, 3GPP2 security standards etc. from any international agency/ labs of the standards e.g. Common Criteria Labs in case of ISO/IEC 15408 standards until 31st March 2013. From 1st April, 2013, the certification shall be got done from authorized and certified agency.

The Contractor shall also ensure that the equipment supplied has all the contemporary security related features and features related to communication security as prescribed under relevant security standards. A list of features, equipments, software etc. supplied and implemented in the project shall be given for use by the Employer

In case of any deliberate attempt for a security breach at the time of procurement or at a later stage after deployment/installation of the equipment or during maintenance, liability and criminal proceedings can be initiated against the Contractor as per guidelines of Government department.

### 2.2 General Network Characteristics

#### 2.2.1 Description

The fibre optic network shall be based on the Synchronous Digital Hierarchy (SDH) having bit rate of STM-1 as indentified in the BOQ. The network shall consist of overhead

fibre optic links with a minimum bit rate of Synchronous Transport Module-1 (STM-1). The Contractor can propose a system based on higher bit rate systems, if required, so as to meet the link budget requirements or any other specification requirement. The detailed BOQ is described in appendices.

### 2.2.2 Functional Requirement

The primary function of the communication network is to provide a highly reliable voice and data communication system for grid operation in support of the SCADA/EMS/RTU/SASs/PMUs. The communications support requirement for SCADA/EMS/RTU/SASs/PMUs system is for low & high speed data, express voice circuits and administrative voice circuits as defined in appendices. A brief summary of the communication system requirements is as follows:

(a) High speed E1 channel support

(b) 64kbps & nx64kbps data channel support

(c) Low speed (300 -9600 bps) data channel support

(d) Voice (2 wires, 4 wires) channel support.

(e) Data transport supporting Network Management channels

(f) The connectivity envisaged between RTU/SASs and Control Centre over TCP-IP using Ethernet interface or over serial interface.

### 2.2.3 General Systems Requirements

Required characteristics are defined and specified herein at the system level, subsystem level, and equipment level.

#### 2.2.3.1 System Synchronization

The Contractor shall synchronize the existing equipments and all the new equipments under the contract using existing Master clock, if available. The Contractor shall provide the additional clocks as required under the set of clock indicated in BoQ. In addition to GPS input reference, the synchronization clock must have provision to take INPUT reference coming from other clock. The contractor shall submit the synchronisation plan as per standard ITU-T G.811. All sync equipments proposed under this contract should meet ITU-T G.811 criterion. The holdover quality of slave clock, if any, shall meet ITU-T G.812 standard requirements.

The Contractor shall provide system wide synchronization fully distributed throughout the telecom network and connected to all equipments new & existing. The Contractor shall submit the synchronization plan for the entire network meeting the requirement of ITU-T G.803. The synchronization plan shall clearly indicate the requirement of additional clocks with full justification.

The system equipment requiring “clock” shall be connected to the master clock using external clocking. For this purpose, appropriate interfaces(s) in the transmission &

termination equipment being supplied and all other associated hardware shall be provided by the Contractor.

#### 2.2.3.2 System Maintainability

To facilitate performance trending, efficient diagnosis and corrective resolution, the system shall permit in-service diagnostic testing to be executed both locally and from remote locations, manually and/or initiated under TMN control (if provided). Such testing shall not affect the functional operation of the system.

#### 2.2.3.3 System Upgradeability and Expandability

Equipment supplied shall be sized (though not necessarily equipped) to support system/ subsystem expansion to full capacity as provided by specified aggregate transmission rates. Equipment units provisioned for equipped subunits shall be terminated at appropriate patching facilities or termination blocks. Power supplies shall be sized for maximum equipped system capacity.

#### 2.2.3.4 Equipment Availability

The calculated availability of each fibre optic link (E1 to E1) shall be at least 99.999%. The calculated availability is defined as the theoretical availability determined by a statistical calculation based on the mean-time-between-failure (MTBF) and the mean-time-to-repair (MTTR) of the components and subsystems comprising the FOTS. For this analysis, an MTTR of atleast 4 hours shall be assumed. The down time of the fibre optic cable shall not be considered in the aforesaid availability calculations. The calculated failure rates of the units and the calculated availabilities of the equipment being offered shall be provided by the Contractor during detailed engineering.

#### 2.2.3.5 Revision Levels and Modifications

All hardware, firmware and software delivered as part of the communications network shall be field proven and at the most of current revision level. All modifications and changes necessary to meet this requirement shall be completed prior to the start of the factory tests or under special circumstances, on written approval by Employer, prior to the completion of SAT.

#### 2.2.3.6 Equipment Capacities

Equipment supplied shall be sized and equipped with sufficient capacity to support BoQ and configuration requirements as identified in the appendices. Each subsystem supplied shall be sized (to be equipped as specified) to support full subsystem expansion.

#### 2.2.3.7 Software Upgrades

The Contractor shall provide antivirus software along with all the computer hardware/software which shall be upgraded periodically till the maintenance services contract in the bid. Further, to meet all the specifications requirements during implementation and maintenance, if upgrade in the hardware/software of supplied item is required, the same shall be done by the contractor without any additional cost to the Employer.

### 2.2.3.8 General Site Considerations

All fiber optic links up to 42.2 kms transmission line length shall be implemented by the Contractor without repeaters. In order to meet the link budget requirement, the Contractor shall provide all the necessary equipments only in the end stations. The contractor may provide the optical amplifier, wave length translator, optical cards or high capacity SDH equipment with suitable rack/subrack to meet the maximum distance limit. All the provided equipments shall be monitored/managed by Craft Terminal.

### 2.2.3.9 Proposed Optical Fibre Characteristics

The link budget calculations and equipment design shall be based on the specified fibre parameters. The optical cables shall have Dual Window Single Mode (DWSM) fibres conforming to ITU-T Recommendations G.652D and the major parameters of these optical fibre(s) are defined in Table below.

| **Optical Fibre Characteristics** | |
|---|---|
| **Fibre Description:** | Dual-Window Single-Mode (DWSM) |
| **Mode Field Diameter:** | 8.6 to 9.5 μm (±0.6 μm) |
| **Cladding Diameter:** | 125.0 μm ± 1μm |
| **Mode field Concentricity Error:** | ≤ 0.6μm |
| **Core-Clad concentricity error:** | ≤ 1.0μm |
| **Cladding non-circularity** | ≤ 1% |
| **Cable Cut off Wavelength:** | ≤ 1260 nm |
| **1550 loss performance** | As per G.652D |
| **Proof Test Level** | ≥ 0.69 Gpa |
| **Attenuation coefficient** | @1310nm ≤ 0.35 dB/Km<br>@1550nm ≤ 0.21 dB/Km |
| **Attenuation variation with wavelength**<br>**1285 nm - 1330 nm**<br>**1525 nm – 1575 nm** | <br><br>Attenuation coefficient @1310 ± 0.05 dB<br>Attenuation coefficient @1550 ± 0.05 dB |
| **Point discontinuities** | ≤ 0.1dB |
| **Chromatic Dispersion; Max.:**<br><br><br><br>**Zero Dispersion Wavelength:**<br>**Zero Dispersion Slope:** | 18.0 ps/(nm x km) @ 1550 nm<br>3.5 ps/(nm x km) @ 1288-1339nm<br>5.3 ps/(nm x km) @ 1271-1360nm<br><br>1300 to 1324nm<br>0.092 ps/($nm^2$xkm) maximum |

| Optical Fibre Characteristics | |
|---|---|
| **Polarization mode dispersion coefficient** | ≤ 0.2 ps/km^1/2 |
| **Temperature Dependence:** | Induced attenuation ≤ 0.05 dB (-60 deg C - +85 deg C) |
| **Bend performance:** | @1310nm (75±2 mm dia Mandrel), 100 turns;<br>Attenuation rise ≤ 0.05 dB<br>@1550nm (30±1 mm dia Mandrel), 100 turns;<br>Attenuation rise ≤ 0.10 dB<br>@1550nm (32±0.5 mm dia Mandrel), 1 turn;<br>Attenuation rise ≤ 0.50 dB |

### 2.2.5 **Fibre Optic Link Lengths**

The fiber optic route lengths are as specified in appendices. The lengths specified in Appendices are the transmission line route lengths; however the actual fiber cable length shall exceed the route lengths on account of extra cable requirement due to sag, jointing & splicing, approach cabling etc. For bidding purposes the Contractor may assume an additional cable length of 5% of given route length + 1Km towards approach cable for calculating the link length. The exact cable lengths shall be determined by the Contractor during the survey. The same shall be used by the Contractor for final link design during the detailed engineering of the project.

## 2.3 Fibre Optic Transmission System

The Fibre Optic Transmission System (FOTS) is defined herein to include ETSI digital optical line termination equipment. The FOTS shall be based on SDH technology. Minimum aggregate bit rate shall be STM-1 (upgradable to STM-4) and equipped with 2 nos. of minimum 16 port E1 interface(G.703) card, one no. of minimum 4 port Ethernet interface (IEEE 802.3/IEEE 802.3u) card supporting layer 2 switching as tributaries. The Ethernet interfaces shall support VLAN (IEEE 802.1P/Q), spanning tree (IEEE 802.1D) quality of service. Protection scheme for Ethernet traffic should be ERPS based (Ethernet ring protection scheme) as per ITU-T G.8032.

The Contractor shall provide (supply and install) connectorised jumpers (patch cords) for FODP-to-equipment and equipment-to-equipment connection. Two number spare jumpers shall be provided for each equipment connection. Fiber jumpers shall be of sufficient lengths as to provide at least 0.5m of service loop when connected for their intended purpose.

### 2.3.1 SDH Equipment

#### 2.3.1.1 Functional Requirement

There is a requirement for different types of equipment under this project which are described in this section. The Drawing is provided in the appendices. For the purpose of BOQ, the SDH Equipment is considered to be divided in three parts i.e. Optical interface/SFP, Tributary Cards (Electrical tributaries such as E1 & Ethernet 10/100 Mbps) and Base Equipment (Consisting of Common Cards, Control Cards, Optical base card, Power supply cards, sub-rack, cabinet, other hardware and accessories required for installation of equipment i.e. everything besides optical interface/SFP and tributary cards).

If bidder is offering equipment with multifunction cards such as cross-connect or control card with optical interface/SFP or tributary interface, such type of multifunction card shall be considered as Common control card and shall be the part of base equipment. In case optical interface/SFP is embedded with control card, the adequate number of optical interface/SFPs shall be offered to meet the redundancy requirements of the specifications. Further, control card shall not be equipped with more than one optical interface/SFP and optical base card shall not be equipped with more than two optical interface/SFPs.

The equipment shall be configurable either as Terminal Multiplexer (TM) as well as ADM with software settings only.

#### 2.3.1.2 Redundancy and Protection

Two fibre rings shall be implemented wherever the network permits. On linear sections of the network, protected links using 4 fibres shall be implemented.

#### 2.3.1.3 Service Channel

Service channels shall be provided as a function of the SDH equipment and shall be equipped with Service Channel Muldems that shall provide at a minimum: One voice channel (order wire) with analog interface (0.3 to 3.4 kHz) and one data channel. Both omnibus and selective calling facilities shall be provided. There shall be a facility to extend the line system order-wire to any other system or exchange lines on 2W/4W basis.

#### 2.3.1.4 Supervision and Alarms

ISM (In Service Monitoring) circuitry shall be provided as a function of the SDH equipment. Local visual alarm indicators shall be provided on the equipment, as a rack summary alarm panel. Alarms shall be as per ITU-T Standards G.774, G.783 and G.784. Additionally, F2/Q2 interfaces for a local craftsperson terminal interface and remote equipment monitoring is required.

The Equipment shall support collection of at least four (4) external alarms for monitoring and control of station associated devices by the TMN.

#### 2.3.1.5 Synchronisation

The equipment shall provide synchronisation as per Table given above. One 2MHz synchronisation output from each equipment shall be provided.

#### 2.3.1.6 Electrical and Optical I/O Characteristics and General Parameters

Table below provides the electrical and optical characteristics as well as other general parameters for SDH equipment.

| Electrical and Optical I/O Characteristics and General Parameters | |
|---|---|
| **Optical Wavelength** NOTE (1) | 1310/1550nm |
| **Optical Source** NOTE (2) | Laser |
| **Optical Source Lifespan** | Better than 5 $X10^5$ hours |
| **Optical Fibre Type** | G.652 D |
| **Optical Connectors** | Type FC-PC |
| **Transmission Quality** | Per ITU-T G.821, G.823, G.826 |
| **Source Primary Power** | -48 Vdc |
| **Equipment Specifications** | Per ITU-T G.783 |
| **Tributary, Electrical Interface** | Per ITU-T G.703, 75 Ω |
| **Ethernet Interface** | 10/100 Mbps |
| **SDH Bit Rates** | Per ITU-T G.703 |
| **Optical Interfaces** | Per ITU-T G.957, G.958 |
| **Frame and Multiplexing Structure for SDH** | Per ITU-T G.707 |
| **Synchronization** | Per ITU-T G.813 |
| **Management Functions** | Per ITU-T G.774, G.784 |
| **Protection Architectures** | Per ITU-T G.841 |
| **Built In Testing and Alarms** | Per ITU-T G.774, G.783, G.784 |

**NOTE (1)** Optical wavelength shall be selected considering the characteristics of the optical fibre and the link budget.

**NOTE (2)** **Eye Safety for Laser Equipment:** To avoid eye damage, when a receiver detects a line interruption, it is required that the optical power of the laser shall be reduced to safe limits on the transmitter in the opposite direction as per ITU-T G.958.

**NOTE (3)** In case other than FC-PC connector is provided in the equipment, suitable patch cord with matching connector are to be provided to connect with FODP.

### 2.3.2 Optical Link Performance Requirements

The optical fibre link performance requirements are specified as follows:

#### 2.3.2.1 Link Budget Calculations

The fibre optic link budget calculations shall be calculated based upon the following criteria:

(1) Fibre attenuation: The fibre attenuation shall be taken to be the guaranteed maximum fibre attenuation i.e. 0.21 dB/Km @1550nm and 0.35 dB/km @1310nm.

(2) Splice loss: Minimum 0.05 dB per splice. One splice shall be considered for every 3 kms.
(3) Connector losses: Losses due to connectors shall be considered to be minimum 1.0 dB per link.

(4) Equipment Parameters: The equipment parameters to be considered for link budget calculations shall be the guaranteed "End of Life (EOL)" parameters. In case, the End of Life parameters are not specified for the SDH equipment, an End of Life Margin of at least 2 dB shall be considered and a similar margin shall be considered for optical amplifiers.

(5) Optical path Penalty: An optical path penalty of at least 1 dB shall be considered to account for total degradations due to reflections, inter symbol interference, mode partition noise and laser chirp.

(6) Maintenance Margin: A maintenance margin of at least 2.5 dB/100Km shall be kept towards cabling, repair splicing, cable ageing and temperature variations etc.

(7) Other losses: Other losses, if any required specifically for system to be supplied shall also be suitably considered.

(8) Dispersion: The fibre dispersion shall be taken to be the guaranteed maximum dispersion i.e. 18 ps/nm.Km @1550 nm & 3.5 ps/nm.km @ 1310 nm for DWSM fibres.

(9) Bit Error Rate: The link budget calculations shall be done for a BER of $10^{-10}$.

The bidders shall determine the total link loss based on the above parameters and shall submit the system design (including link budget calculations) for each category of fibre optic link during detailed engineering.
For finalising the FOTS system design & BOQ, above methodology shall be adopted taking into account fibre attenuation, dispersion and splice loss determined during the detailed engineering. Accordingly, additions and deletions from the contract shall be carried out based on unit rates indicated in the contract.

#### 2.3.2.2 Link Performance

The Link performance for ES, SES and BER for the fibre optic links shall correspond to National Network as defined in ITU-T G.826.

#### 2.3.2.3 FODP to SDH Equipment

The Contractor shall be responsible for connectivity between the FODP and the SDH equipment. The Contractor shall provide FC PC coupled patch cords. The patch-cord length between the FODP & equipment rack shall be suitably protected from rodents, abrasion, crush or mechanical damage.

### 2.4 Termination Equipment Subsystem

The Termination Equipment Subsystem is defined to include the equipment that interfaces (adapts) the subscriber (user) to the Fibre Optic Transmission System (FOTS). A Functional description of these equipments are as follows:

### 2.4.1 Functional Description

The transmission network node provides subscriber interface to the transmission network and/or switching/routing. For clarity, the basic functions accomplished at the network nodal points, are described briefly as follows:

Primary Multiplexer shall be used to accomplish subscriber connectivity to the Digital Communication Network. Subscriber Line Units shall provide analog to digital and direct digital conversion to 64 Kbps digital channel. In the CEPT standard hierarchy, thirty (30) such 64 Kbps digital channels shall be Time Division Multiplexed (TDM) resulting in a single 2.048 Mbps (E-1) digital bit stream.

Digital Drop-Insert and Branching Equipment shall be used to digitally interface a small number of channels at spur locations without requiring successive D/A and A/D conversions of the throughput channels.

The equipment shall also have an interface for external 2048 kHz synchronisation signal according to ITU-T Recommendation G.703.

### 2.4.2 First Order (Primary) Multiplexing

The Contractor shall be required to provide E-1 Drop & Insert Multiplexer and E-1 Channel Bank primary multiplexing in compliance with the electrical input-output characteristics provided in Table below.

#### 2.4.2.1 Drop & Insert Primary Multiplexing

Drop & Insert primary multiplexing in conformance with CEPT E-1 characteristics shall be required at locations where the subscriber requirement is minimal. The drop and insertion of up to thirty 64 Kbps channels supporting subscriber line units (SLU) shall be required at intermediate locations. The Drop & Insert Muxes supplied shall be performance and card compatible with the Channel Bank Equipment provided so that all Subscriber Line Interface cards are interchangeable.

**CEPT E-1 Standard First Order Multiplexing**

**Electrical Input/Output Characteristics**

| | |
|---|---|
| **Applicable Standards:** | CEPT per CCITT Recommendation G.702, G.703, G.711 and G.712 |
| **Number of Tributaries:** | 30 X 64 Kbps |
| **Alternative Sub-rate Tributaries:** | n X 64 Kbps V.36<br>64Kb/s V.11/V.36 |
| **Output Aggregate Rate:**<br>**Interface Code:** | 2.048 Mb/s ± 50 ppm<br>HDB3 |

**CEPT E-1 Standard First Order Multiplexing**

**Electrical Input/Output Characteristics**

| | |
|---|---|
| **Impedance:**<br>**Peak Level @ 120 ohm:**<br>**Peak Level @ 75 ohm:**<br>**Maximum Insertion Loss:** | 75 ohm unbalanced<br>3.0 volts ± 10%<br>2.37 volts ± 10%<br>6 dB |
| **Signal Waveform:**<br>**Frame Structure:**<br>**Jitter Performance:** | Per CCITT G.703<br>Per CCITT G.742<br>Per CCITT G.823 |
| **Power Supply Voltage:** | -48 Vdc |

### 2.4.2.2 Channel Banks (Mux, Drop/Insert)

User voice and data equipment interfacing requirements are defined at the subscriber line level. Primary multiplexing in conformance with CEPT E-1 characteristics shall be used to provide first order multiplexing of up to thirty 64 Kbps channels supporting Subscriber Line Units (SLUs).

### 2.4.2.3 Subscriber Line Units\Subscriber Line Interface Cards

The terms Subscriber Line Interface Cards and Subscriber Line Units have been used interchangeably throughout the specification. Multiple configurations of SLUs shall be required to provide subscriber to primary multiplexer Bank interfacing for a variety of voice and data communications. In case there are changes in number or type of cards because of changes in channel requirements, the contract price shall be adjusted accordingly.

The SLU interface requirements are discussed in the following subparagraphs:

#### (A) Voice Channels

The voice channel requirement is for (I) 4-Wire E&M trunking in support of PLC VF and (II) 2-Wire telephonic interfaces. 2 wire SLUs shall be DTMF/TP optioned for 2-wire loop start or 2-wire GND start. The voice cards shall utilize ITU.T A - law companded PCM G.711, 64 kbits/s encoding. The voice card requirements are indicated in the BoQ in appendices.

#### (B) Sub-Channel Data Multiplexing

For this Project, the RTU data interface to the wideband telecommunications network node shall be defined at the DTE level at low-speed rates of 300, 600 and 1200 baud. The port shall be compatible with RS232C interface. The Contractor shall be required to furnish 64 Kbps SLU asynchronous dataplexing for at least 4 selectable low speed DTE interfaces whenever multiple asynchronous data circuits are required.

#### (C) Synchronous Data

The Contractor shall provide a direct DTE interface for synchronous communications at speed of 64Kbps and compatible with CCITT G.703 Kbit/s, V.35 and X.21 interfaces. Data rate selection shall be switch selectable or programmable.

**(D) Nx64 kbps Synchronous Data**

There is also a requirement for N x 64 kbps V.35, X.21 interfaces. The tentative quantities have been identified in the appendices. However the final BOQ shall be worked out during detailed design and contract price shall be adjusted accordingly.

## 2.5 MDF, DDF and Cabling

For the purposes of the specification, the contractor shall provide cabling, wiring, DDF patching facilities and MDFs interfacing to the wideband telecommunications system. Equipment and material components for MDF, DDF and cabling are also part of this procurement. It shall be the Contractor's responsibility to provide all cable support required for full supplied equipment interconnection with the MDF and shall be in accordance with communications industry standard practices and the requirements mentioned in the technical specifications.

### 2.5.1 Digital Distribution Frame Functional Requirements

The Contractor shall provide DDF for Digital Signal Cross connect (DSX) Broadband-quality (better than 20 MHz) patching facilities configured "normally-thru" with Equipment, Line and Monitor Patch Jacks. DDFs shall provide the following basic functions:

(i) "Normally thru" circuit routing
(ii) Circuit rerouting via patch cord assemblies
(iii) Circuit disconnect and termination

All DDFs shall be sized and equipped to support the offered configuration of the provided equipment. Independent Transmit and Receive patch jack assemblies (line and equipment) shall provide for separate transmit and receive single-plug patching. Transmit and receive patch jack assemblies shall be located side-by-side such that dual-plug patch cord assemblies may be used to route both transmit and receive for the same circuit.

### 2.5.2 Main Distribution Frames

The Contractor shall make provision for cross connection of subscriber services to the subscribers utilizing Krone type or equivalent and shall provide full connectivity up to and terminated on the equipment side of the appropriate DDFs and line side of MDFs. The Contractor shall terminate on the equipment side of patching facilities provided by other contracts and shall provide DSX type patching facilities supporting aggregate bit streams (i.e. dataplexers and E-1 Channel Banks). Separate Patch panels or MDFs shall be provided for Data and Voice. All cross connects shall be accomplished utilizing one, two or three pair patch cords. Patch plugs are permissible for direct one-to-one circuit "cut-thru".

## 2.6 Patch Cords

The Contractor has to supply FC PC coupled Patch cords as described in BOQ. The Patch cord return loss shall be equal to or better than 40 dB and insertion loss equal to or less than 0.5 dB.

## 2.6 Telecommunication Management Network / Network Management System (As Applicable)

The Contractor shall provide a Telecommunications Management Network System (TMN) for operational support to the FOTS and associated Termination equipment subsystems. This TMN shall provide the capability to monitor, reconfigure, and control elements of the telecommunications network from a centralized location and at each node of the network where equipment is located. This TMN system shall assist Employer/Owner in the operations and maintenance of the wideband communication resources of the including detection of degraded circuits, system performance, the diagnosis of problems, the implementation of remedial actions and the allocation or reallocation of telecommunications resources and addition/deletion of network elements.

The contractor shall supply preferably a single TMN for all the NEs (Network Elements) such as SDH equipment, Mux, Drop-Insert, DACS etc. In case a single TMN can not be provided for all the NEs, the contractor may supply separate TMNs. Each of the offered TMN shall meet the requirements indicated in this section. The bidder shall provide details of the offered TMN in the bid.

### 2.7.1 Applicable Standards

The TMN design concept, functional and informational architecture and physical architecture, shall be in compliance with ITU-T Recommendation M.3010. The offered TMN system shall be capable of integration to other supplier's Network Management System (NMS) upwardly through North bound interfaces. The north bound interface in the EMS shall be CORBA/TMF-814 compliant.

### 2.7.2 TMN Architecture

The TMN shall provide

a. Collection of Management data from all Network Elements (NEs) supplied under this package. The minimum monitoring and control requirements for the communication equipment shall be as defined in this section.

b. Processing of above management data by using processor(s) located at control Centre and additional intermediate station processor(s), wherever required.

c. Monitoring and control of the NEs as defined below:

   I) TMN system at LDC (including local operator console, if applicable) shall support management of all equipments supplied and monitoring of the entire regional network supplied under this package. At a minimum functions of Network management layer (NML) and Element management layer (EML) as defined in CCITT M3010. The detailed functions are listed in TS.

   II) Monitoring and control of NEs using Craft Terminals as defined in this Section .

d. Supervisory monitoring and control of the following station associated devices:

I) Intrusion Detection Alarms
II) Power Failure
III) Fire and Smoke Detection
IV) Environmental Control (Temperature, Humidity etc.)

e. Communication channel support for TMN System as specified in Technical Specifications (TS).

The supplied TMN system shall be capable of handling all management functions for at least 150% of the final network elements. Further, the centralised TMN system shall also have provision for addition of at least two remote operator consoles. The TMN hardware shall be so designed that failure of a single processor/component (router, switch, converter etc.) shall not inhibit any of the functionality of the TMN at control centre. The Contractor shall submit for Employer's approval the TMN architecture describing in detail the following subsystems/features:

a. Database used in TMN
b. Master Processor, server/workstation, LAN, Peripherals and hardware
c. Software and operating system
d. Local Consoles/remote consoles
e. Craft Terminals
f. Data communication between NEs, Remote/Local Consoles and TMN Processor(s)
g. Routers/Bridges
h. Expansion Capabilities

### 2.7.3 Management Functions

The TMN shall support following Management functions:

#### 2.7.3.1 Configuration Management

Configuration management is concerned with management, display, and control of the network configuration. Minimum specific requirements that shall be satisfied include the following:

a. Provide tools to establish and maintain the backbone topology and configuration information and provide graphical maps depicting the configurations.

b. Gather descriptive information about the current configuration of the equipment, provide operator displays, and prepare reports.

c. Provide tools for planning, establishing, and changing the static equipment configuration. Provide for changes to the equipment configuration in response to equipment failures, planned upgrades, and operator requests to take equipment offline for testing.

d. Provide verification testing to support new equipment installation.

#### 2.7.3.2 Fault Management

Fault management is concerned with detecting, diagnosing, bypassing, directing service restoration, and reporting on all the backbone network equipment, systems, and links. Minimum specific requirements that shall be satisfied include the following:

a. Display equipment status in a consistent fashion regardless of the source of the data on a graphical topological, map-type display. Status shall be displayed through the use of colours on links and nodes as well as through text.

b. Obtain status and detect faults through periodic polling, processing of unsolicited alarms and error events, and periodic testing for connectivity.

c. Maintain an alarm summary of unacknowledged alarm events on the management station display and maintain a log of all received alarms. The operator shall be able to acknowledge and clear alarms individually and as a group. The use of alarm correlation techniques is encouraged to minimize the proliferation of alarms caused by a single, common event. All alarms shall be configurable as critical alarms, major alarms and minor alarms with different colours.

d. Provide the capability to diagnose and isolate failures through analysis of error and event reports and through the use of both on-line and off-line diagnostic tests and display of monitored data.

e. The criteria for fail over shall be configurable as automatic fail over to redundant equipment wherever possible and through operator-initiated actions where automatic fail over is not possible. The status of fail over shall be reported to the NMS.

f. Track network equipment failure history.

### 2.7.3.3 Performance Management

Performance management is concerned with evaluation of the use of network equipments and their capability to meet performance objectives. Minimum specific requirements that shall be satisfied include the following:

a. Provide support for an operator to initiate, collect, and terminate performance metrics under both normal and degraded conditions. For example, BER of each link, together with other data measured at each node, shall be available on operator request (atleast for SDH).

b. Monitor point to point & end to end signal quality and history. Provide operator controls to monitor performance of specified events, measures, and resources (atleast for SDH). Specifically provide displays to permit the operator to:

1. Select/deselect network equipments, events, and threshold parameters to monitor

2. Set monitoring start time and duration or end time

3. Set monitoring sampling frequency

4. Set/change threshold values on selected performance parameters

5. Generate alarm events when thresholds are exceeded.

6. Set multiple thresholds on certain performance parameters. Alarm categories include as a minimum a warning and a failure.

7. Calculate selected statistical data to measure performance on selected equipment based on both current and historical performance data maintained in performance logs. Performance data provided is limited to what is available from the equipment Contractors.

8. Provide graphical displays of point to point and end to end current performance parameter values. Provide tabular displays of current, peak, and average values for performance parameters.

9. Generate reports on a daily, weekly, monthly, and yearly basis containing system statistics.

#### 2.7.3.4 Security Management

The TMN shall be provided with security features to limit access to monitoring and control capabilities to only authorized personnel. One access level of System Administrator and at least two levels of operator access shall be provided - read (view) only, and write (configure). The system administrator shall be able to create, define and modify operators with different access levels, network domains and perform all kind of maintenance and up gradation of the TMN system. With "read only" access level, network parameters should only be viewed. Access to database maintenance, command control and test functions shall be available with "write " access level. Means shall be provided to ensure only one authorized user has write capability for a selected domain of the network. It shall be possible to define multiple domains for purposes of monitoring and control.

Human error and conflict detection are also required. Such errors and access violations shall be reported to the offending user as error messages and warnings.

### 2.8 Communication Channel Requirement and Integration

Communication requirements for TMN system have not been considered in Appendices and the Contractor shall provide these as a part of TMN system. The Contractor shall provide all required interface cards / devices, LAN, routers/bridges, channel routing, cabling, wiring etc. and interfacing required for full TMN data transport.

The TMN data transport shall utilize the wideband communications transmission system service channel in the overhead whenever possible. This will provide inherent critical path protection

Should the configuration requirements dictate multiple TMN station processors, the TMN Master Station shall require bidirectional data transport with its station processor(s). This communications interfacing shall be via critically protected data channels. It shall be the Contractor's responsibility to provide for and equip all necessary critically protected TMN data channel support.

In case supervisory channels are not available, the Contractor shall provide suitable interfaces in their supplied equipment for transport of TMN data. The Contractor shall also be responsible for providing suitable channels with appropriate interfaces to transport the TMN data.

The NMS information of existing PDH & SDH system shall be transported through the new communication network, wherever required, up to the NMS location. The NMS information of the new SDH & PDH system being procured under the package shall be transported through the existing communication network using 64 kbps/2Mpbs (G.703) interfaces. Any hardware required for above interfacing shall be provided by the Contractor.

The bidders shall describe in the proposal the TMN data transport proposed to be used by the bidder in detail including capacity requirements and various components/equipment proposed to be used.

## 2.9 Craft Terminal

Each equipment (SDH equipment, Mux, Drop/Insert and DACS etc.) on the fibre optic communication network shall include provision for connecting a portable personal computer (PC) to be known as craft terminal to support local commissioning and maintenance activities. Through the use of this PC and local displays/controls, the operator shall be able to:

a. Change the configuration of the station & the connected NEs.
b. Perform tests
c. Get detailed fault information

The craft terminal shall be connected to the interface available in the communication equipment. Portable (laptop) computers (Craft terminals), each complete with necessary system and application software to support the functions listed above, shall be supplied to the employer as per BOQ given in the appendices.

## 2.10 Hardware Requirements

### 2.10.1 Master Processor, Server/Workstation and Craft Terminal

The server/workstation and craft terminal shall have suitable processor(s) which shall be sufficient to meet all the functional requirement and expansion capabilities stipulated in this specification. Only reputed make like Dell, IBM, HP, Compaq make shall be supplied.

The server shall have minimum configuration of 3GHz for CISC based or 1.6GHz for RISC based processor, 2GB RAM, DVD-ROM drive, redundant 80 GB internal Hard Disk Drive, 101-Enhanced style keyboards, mouse, parallel, serial, USB(2.0) ports and hot swap redundant power supply. VDUs shall be 17" TFT active matrix color LCD with a minimum resolution of 1024 X 768. Appropriate network drive card shall also be provided wherever required. However, the internal hard disk drive for the server shall be redundant and all the data shall be mirrored. Further, the TMN software shall support data mirroring on redundant disk drives.

The workstation shall have minimum configuration of 2.4GHz for CISC or 1.4GHz for RISC based processor, 1GB RAM, DVD-RW drive, 160 GB Hard Disk Drive, 101-Enhanced style keyboards, mouse, parallel, serial and USB (2.0) ports. VDUs shall be 19" TFT active matrix color LCD with a minimum resolution of 1024 X 768. Appropriate network drive card shall also be provided wherever required.

CPU enclosures shall be desktop type and shall include available expansion slots except for the Craft Terminal which shall be a laptop. The craft terminal shall have minimum configuration of 2.4 GHz, 2 GB RAM, 256 MB VRAM, DVD RW drive, 160 GB Hard Disk Drive, keyboard, mouse/trackball etc., parallel, serial/USB (2.0) ports to accommodate printers, and Internal/external Data/Fax modem and a battery back-up of at least 60 minutes. VDUs shall be 15" TFT active matrix color LCD with a minimum resolution of 1024 X 768.

### 2.10.2 Peripherals and hardware

TMN system shall be provided with laser printer. The laser printer shall have a minimum print speed of 17 pages per minute and a minimum resolution of 1200 x 1200 dpi. The laser printer shall have parallel and LAN ports for connecting to TMN system.

The laser printer under this specification shall be black & white and include print enhanced buffering to prevent loss of print data in the event of a print failure.

### 2.10.3 Local/Remote Operator Consoles (As Applicable)

The Contractor shall provide operator consoles sized and equipped to support the subsystem(s) furnished and in compliance with the specification. The console shall provide hardware interfacing for the TMN users to the software operating support systems. At a minimum, a console shall include the hardware similar to a workstation.

### 2.10.4 Power Supplies

The TMN system shall use 220 volts 50 Hz A.C or -48 volt D.C as available at site for its operation as available at site.

## 2.11 General Software/Firmware Requirements

Due to various alternative design approaches, it is neither intended nor possible to specify all software and firmware characteristics. It is the intent herein to provide design boundaries and guidelines that help to ensure a demonstrated, integrated program package that is maintainable and meets both hardware systems requirements and the customer's operational requirements.

### 2.11.1 Operating System Software

Operating system software shall be provided to control the execution of system programs, application programs, management devices, to allocate system resources, and manage communications among the system processors. The contractor shall make no modifications to the OEM's operating system, except as provided as USER installation parameters.

### 2.11.2 Applications Software

All applications software shall be written in a high-level programming language unless developed using industry proven application programs and development tools provided with the system. The contractor shall make no modifications to the applications program except as provided as USER development tools.

### 2.11.3 Software Utilities

A utility shall be provided to convert all reports into standard PC application formats such as excel.

### 2.11.4 Revisions, Upgrades, Maintainability

All firmware and software delivered under this specification shall be the latest field proven version available at the time of contract approval. Installed demonstration for acceptance shall be required. All firmware provided shall support its fully equipped intended functional requirements without additional rewrite or programming.

All software shall be easily user expandable to accommodate the anticipated system growth, as defined in this specification. Reassembly recompilation or revision upgrades of the software or components of the software, shall not be necessary to accommodate full system expansion.

Software provided shall be compliant with national and international industry standards.

### 2.11.5 Database(s)

The contractor shall develop all the databases for final wideband network following the global acronyms for all stations. Database(s) to be provided shall contain all structure definitions and data for the integrated functional requirements of TMN system.

TMN operator Groups shall share the same virtual database. This means that they shall share the same database and database manager, whether or not physically separate databases are maintained.

### 3.1 Inspection

Access to the Contractor's facilities during system manufacturing and testing and to any facility where systems/ equipment are being produced/ tested/ integrated for the fibre optic communication network, shall be available to the Employer. At all times the Employer shall have full facilities for unrestricted inspection of such materials or equipment. To facilitate this, the Contractor shall submit for the Employer approval, a comprehensive Quality Assurance Plan using ISO 9000 as a general guideline. In addition, the Quality Assurance Plan shall satisfy the following:

(a) Sufficient office facilities, equipment, and documentation necessary to complete all inspections and to verify that the equipment is being fabricated and maintained in accordance with the Specification shall be provided by the Contractor to the Employer.

(b) Inspections to be performed by the Employer will include visual examination of hardware, cable dressings and labeling. Contractor's documentation will also be examined to verify that it adequately identifies and describes all offered items and spare parts.

(c) Access to inspect the Contractor's standards, procedures, and records that are applicable to the supplied equipment shall be provided to the Employer. Documents will be inspected to verify that the Contractor has performed the required quality assurance activities.

(d) The inspection rights described above shall also apply to sub Contractors who are responsible for supplying major components described in this Specification. These items shall be inspected and tested at the sub Contractor's factory by the Employer's representatives prior to shipping this equipment to the Contractor's facility or directly to the Employer.

(e) The above inspection rights shall also apply to sub Contractors supplying assemblies, subassemblies and components. However, such items will normally be inspected and tested by the Employer's representatives at the Contractor's site before acceptance.

### 4.1 Test Plans and Procedures

Test plans and test procedures for both factory and site acceptance tests shall be provided by the Contractor. Test plans and test procedures shall ensure that each factory and site test is comprehensive and verify all the features of the equipment to be tested. Test plans and test procedures shall be modular to allow individual test segments to be repeated upon request.

The Contractor shall submit a Test Schedule for the Employer's approval within one (1) week after the award of contract for Type Tests and three (3) months after the award of contract for all other tests. The test schedule shall list the tests to be carried out, and the approximate test duration. The test periods shall also be indicated in the PERT chart or equivalent for the work.

The Contractor shall give the Employer twenty one (21) days written notice of any material being ready for testing. Fifteen days prior to the scheduled testing, the Employer shall provide written notice to the Contractor of any drawings, equipment, material, or workmanship which, in the Employer's opinion, are not compliant to the specification. The Contractor shall give due consideration to such objections, if valid, effecting the corrections as necessary or shall prove, in writing, that said modifications are unnecessary for contract compliance.

#### 4.1.1 Factory and Site Test Plans

A test plan for factory and site acceptance tests shall be submitted for approval, at least four (4) weeks before the start of testing. The test plan shall be a single overview document that defines the overall schedule and individual responsibilities associated with conducting the tests, documenting the test results, and successfully completing the test criteria. Test Plans shall include, at a minimum, the information contained in Table below.

| Item: | Description: |
|---|---|
| **1.** | Test schedule |
| **2.** | Record-keeping assignments, procedures and forms |
| **3.** | Procedures for monitoring, correcting and retesting variances |
| **4.** | Procedures for controlling and documenting all changes made to the communications equipment after the start of testing |

#### 4.1.2 Test Procedures

Test procedures for factory and site testing shall be submitted for the Employer approval at least four (4) weeks before each individual test. Fully approved test procedures shall be submitted to the Employer at least four weeks prior to the commencement of testing. Testing shall not

commence without approved test procedures. At a minimum, test procedures shall include the items listed in Table below.

All test equipment and/or instruments shall bear calibration stickers indicating valid calibration on and beyond the testing date. The time lapsed since last calibration shall not exceed the test equipment/ jig manufacturer recommended calibration interval or the interval recommended in the test lab's internal quality procedures.

The Contractor shall ensure that all testing will be performed by qualified testing personnel well experienced in performing such tests.

| Item: | Description: |
|---|---|
| **1.** | Test Title and Revision Level, if applicable |
| **2.** | List of Standard(s) complied with |
| **3.** | Function(s) / parameter(s) to be tested |
| **4.** | Purpose of each test segment |
| **5.** | List of required test equipment |
| **6.** | Description of any special test conditions or special actions required. This includes complete descriptions, listings and user interface procedures for all special hardware and software tools and/or display formats to be used during the test. |
| **7.** | Test setup including test configuration block diagrams and/or illustrations. |
| **8.** | Test procedures to be followed. |
| **9.** | Required inputs and expected outputs for each test segment |
| **10.** | Acceptance criteria for each test segment. |
| **11.** | List of test data to be supplied by the Contractor(s) and copies of any certified data to be used |
| **12**. | Format of test reports. |

### 4.1.3 Test Records

Complete and indexed records of all factory and site acceptance tests results shall be maintained and provided to the Employer by the Contractor in hardcopy. The records shall be keyed to the steps enumerated in the test procedures. The minimal items required in test records are described in Table below.

| Item: | Description: |
|---|---|
| **1.** | Test Title and Revision Level, if applicable; contract references |
| **2.** | Date and time for test start and test completed |
| **3.** | Test title and reference to the appropriate section of the test procedures |
| **4.** | Description of any special test conditions or special actions taken (Includes test-case data). |
| **5.** | Test results for each test segment including an indication of Passed, Conditional Pass, Incomplete or Failed. |
| **6.** | Test procedure modifications made during testing. |
| **7.** | Variance Report(s) tracking information and copies (if variance(s) was detected). |
| **8.** | Contractor's test engineer(s) identification, signature and remarks |

| Item: | Description: |
|---|---|
| **9.** | Employer's test witness identification, signature and remarks |
| **10.** | List of all attachments |
| **11.** | Attachments (including system logs, printouts, variances, hard copies of visual test result displays, etc.) |

All principle test records, test certificates and performance curves shall be supplied for all tests carried out as proof of compliance with the specifications and/or each and every specified test. These test certificates, records and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Employer within the specified duration after the completion of test. Information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificates refer, and shall also bear the Contractor's reference and heading.

### 4.1.4 Rejection of Elements

Any item or component which fails to comply with the requirements of this Specification in any respect, at any stage of manufacture, test, erection or on completion at site may be rejected by the Employer either in whole or part as considered necessary.

Material or components with defects of such a nature that do not meet the requirements of the Specification by adjustment or modification shall be replaced by the Contractor at his own expense. After adjustment or modification, the Contractor shall submit the items to the Employer for further inspection and/or tests.

### 4.1.5 Test Periods Defined

The terminology used in Volume I, General Conditions of Contract and their correlation with the tests requirements described within this section is as follows:

Pre-Commissioning & Commissioning Period - The Site Acceptance Test (SAT)
Operational Acceptance - Successful completion of SAT

## 4.2 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 conditions specified in Chapter 2- GTR.

### 4.2.1 List of Type Tests

The type testing shall be conducted on the following equipment

(a) SDH Equipment with all types of cards (optical card, Tributary card or any other equipment as part of repeater less links)
(b) Primary Multiplexer & Drop – Insert Multiplexer with subscriber interface card

#### 4.2.1.1 List of type test to be conducted on Telecom equipment

The type tests for SDH Equipment with all types of cards, Primary Multiplexer & Drop – Insert Mux with subscriber interface card are described below:

#### 4.2.1.1.1 Temperature and Humidity Tests

The tests listed below are defined in IEC Publication 60068.

**(a) Low Temperature Test: Operation to Specifications**

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for sixteen (16) hours. Its performance is checked during the test.

(2) Degree of Severity: Test shall be done at 0°C

(3) Acceptance Criteria: No degradation of performance during and after the test.

**(b) Low Temperature Test : Operation without Damage**

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 72 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*).

(2) Degree of Severity: Test shall be done at -10° C

(3) Acceptance Criteria: Degradation of performance is allowable during the test, however there shall be no degradation of performance in the *post-test*.

**(c) Dry Heat Test: Operation to Specifications**

Dry heat test shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test.

(2) Degree of Severity: As per operation to specification range.

(3) Acceptance Criteria: No degradation of performance during and after the test.

**(d) Dry Heat Test: Operation without Damage**

Dry heat tests shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*).

(2) Degree of Severity: Test shall be done at 55ºC.

(3) Acceptance Criteria: Degradation of performance is allowable during the test, however there shall be no degradation of performance in the *post-test*.

**(e) Damp Heat Test**

Damp heat testing reveals aging with respect to the humidity level and applies basically to electronic equipment. This test shall be done as defined in IEC Publication 60068-2-3 with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 10 days. Its performance is checked during the test.

(2) Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

**(f) Temperature Variation Test**

Temperature variation testing shall be as per IEC Publication 60068-2-14 (Gradual Variations, Method Nb). The equipment shall be powered on and various parameters shall be monitored continuously during the test period.

(1) Number of cycles required is five (5)
(2) The degree of severity: temperature TL:0°C, TH: As per operation to specification range
(3) Cycle duration for each temperature is three (3) hours.
(4) Ramp : 1 ºC/minute.
(5) Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

**4.2.1.1.2 Power Supply and EMI/EMC tests**

The test procedure and acceptance criteria shall be as defined in IEC 60870-2-1.

**(a) Immunity Tests**

The list of Immunity tests are specified below in Table below.

**Recommended Immunity Tests**

| S. No. | Immunity Test | AC Power Supply | DC Power Supply | Control & Signal | Telecom Line | Para-metres |
|---|---|---|---|---|---|---|

**Recommended Immunity Tests**

| S. No. | Immunity Test | AC Power Supply | DC Power Supply | Control & Signal | Telecom Line | Para-metres |
|---|---|---|---|---|---|---|
| **1** | Voltage Fluctuations | Yes | Yes | N/A | N/A | Table 11 of IEC 60870-2-1: 1995 - **Level : 1** |
| **2** | Voltage dips and Interruptions | Yes | Yes | N/A | N/A | |
| **3** | 1.2/50 - 8/20 µs surges | Yes | Yes | Yes | N/A | Table 12 of IEC 60870-2-1: 1995 - **Level : 4** |
| **4** | Fast transient bursts | Yes | Yes | Yes | Yes | |
| **5** | Damped oscillatory waves | Yes | Yes | Yes | Yes | |
| **6** | 10/700 µs surges | N/A | N/A | N/A | Yes | |
| **7** | Electrostatic discharge | Yes | | | | Table 13 of IEC 60870-2-1: 1995 - **Level : 4** |
| **8** | Power frequency magnetic field | Yes | | | | Table 14 of IEC 60870-2-1: 1995 - **Level : 4** |
| **9** | Damped oscillatory magnetic field | Yes | | | | |
| **10** | Radiated electromagnetic field | Yes | | | | Table 15 of IEC 60870-2-1: 1995 - **Level : 4** |
| **11** | Power Frequency voltage on control and signal lines | N/A | N/A | Yes | Yes | IEC 61000-4-16 : 2002-07 **Level : 4** |
| **12** | DC voltage on control and signal lines | N/A | N/A | Yes | N/A | IEC 61000-4-16 : 2002-07 **Level : 4** |
| | | | | | | |

**(b) Emission Tests**

The list of Emission tests are specified below in Table.

| S. NO. | Emission test | AC Power Supply | DC Power Supply | Control & Signal | Telecom Line | Para-metres |
|---|---|---|---|---|---|---|

| S. NO. | Emission test | AC Power Supply | DC Power Supply | Control & Signal | Telecom Line | Para-metres |
|---|---|---|---|---|---|---|
| **1** | LF disturbance voltages CCITT recommendation P.53 | N/A | Yes | N/A | N/A | Table 17 of IEC 60870-2-1: 1995 - Class **: B** |
| **2** | RF disturbance voltages CISPR 22 | Yes | Yes | N/A | N/A | |
| **3** | RF disturbance currents CISPR 22 | N/A | N/A | N/A | Yes | |
| **4** | RF radiated fields CISPR 22 | Yes | | | | |

**(c) Insulation Withstand Voltages**

As per section 6 of IEC 870-2-1. Recommended class: VW1 of Table 18.

#### 4.2.1.1.3 Mechanical Tests

**(a) Mechanical Vibration Test**

The procedure for this test is described in IEC Publication 60068-2-6. The testing procedure shall be carried out in the sequence 8.1 + 8.2.1 + 8.1 as described in document 60068-2-6.

For the vibration response investigation (clause 8.1 of 60068-2-6), the test shall be carried out over a sweep cycle under the same conditions as for the endurance test (described later), but the vibration amplitude and the sweep rate may be decreased below these conditions so that the determination of the response characteristics can be obtained.

The endurance test conditions are selected according to the vibration withstand requirements.

Transportation tests shall be performed with the equipment packed according to the Contractor's specifications.

**(b) Shock Test**

The procedure of this test is defined in IEC Publication 60068-2-27 (each test) with a semi-sinusoidal shape (clause 3.1.1.2).

The recommended severity shall be A = 294 $m/s^2$, D = 18 ms. Three shocks per axis per direction shall be applied to the equipment packed according to the Contractor's specifications.

**Or Free Fall Test**

This test could be performed as an alternative to the shock or Bump test. The procedure is defined in IEC publication 60068-2-32. The equipment shall be packed according to the Contractor's specifications. The drop height shall be defined in accordance with IEC 68-2-32. The surface of the packing case which comes into contact with the ground is the surface on which the packing case normally rests; if the packing does not have any features (inscription, special shape, etc.) identifying this surface, the test is carried out successively on all the surfaces of the packing.

**Or Bump Test**

This test could be performed as an alternative to Shock test or Free Fall test. The procedure is defined in IEC 60068-2-29.

### 4.3 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 SDH Equipments, associated line & tributary cards, Termination Equipments (Primary Mux, Drop/Insert, associated Subscriber Line Interface Cards etc) and all other items for which price has been identified separately in the Bid Price Schedules.

Equipment 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 test shall demonstrate the technical characteristics of the equipment in relation to this specifications and approved drawings and documents. List of factory acceptance tests for Fibre Optic Transmission system, Termination Equipment Sub-system and NMS are given in specified Tables in this section. This list of factory acceptance tests shall be supplemented by the Contractor's standard FAT testing program. The factory acceptance tests for the other 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, alarms and diagnostics etc.

For Test equipment & clock, FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer’s final inspection certificate/ report.

**Factory Acceptance Testing Requirements for Termination Equipment (MUX)**

| Item | Description: |
|---|---|
| 1. | Physical Inspection for conformance to DRS, BOQ, drawings and appearance of |

| Item | Description: |
|---|---|
| | equipment |
| **2.** | Performance of supervision, alarm, control and switching systems, diagnostics, loopbacks, Craftsperson interface etc. |
| **3.** | Electrical interface tests which include: output and input jitter, bit error rate, pulse shape, cable compensation, and line rate tolerance for the channel banks/low-level multiplexers |
| **4.** | Framing, signaling, and operational and maintenance tests consistent with applicable ITU-T requirements |
| **5.** | Simulation of failure conditions and failover of each redundant unit |
| **6.** | Test of spare card slots and test of spare parts/modules/cards as per applicable tests |
| **7.** | Checks of power supply/converter voltage margins and short circuit and overvoltage protection |
| **8.** | Random inspections to verify the accuracy of documentation |

| **FAT on Craft Terminal** | |
|---|---|
| 1 | Physical inspection of Craft Terminal hardware for conformance to approved BoQ, DRS & drawing |
| 2 | Testing of Craft Terminal to demonstrate proper operation of all functions |

### 4.4 Site Acceptance Tests

The Contractor shall be responsible for the submission of all equipment & 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 Telecom equipment. 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 Telecom equipment 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.

#### 4.4.1 Phases for Site Acceptance Testing

The SAT shall be completed in following phases:

##### 4.4.1.1 Installation Testing

The field installation test shall be performed for all equipment at each location. If any equipment has been damaged or for any reason does not comply with this Specification, the Contractor shall provide and install replacement parts at its own cost and expense.

In the installation test report, the Contractor shall include a list of all hardware or components replaced or changed between the completion of factory tests and the start of field tests and show that documentation and spare parts have been updated.

The minimal installation testing requirements for fiber optic transmission subsystem, Termination equipment sub-system are provided in respective Tables in this section.

#### 4.4.1.2 Link Commissioning Tests

The commissioning tests shall verify that communication can be performed over the fiber optic link under test. Delay measurement, Bit Error measurements & service channel performance monitoring shall be made on the fibre optic links to verify compliance with designed link performance.

For Ethernet interface: At a minimum the following test requirements shall be demonstrated as per RFC 2544:

a) Ping test
b) Throughput test
c) Latency test
d) Packet Loss

10% of the total links (Chosen by the Employer, generally to cover links from all configurations used) shall be tested for a duration of 12 Hours. Rest of the links shall be tested for 1 Hour. In case a link does not meet the performance requirements during 1 hour, then the duration of the test shall be increased to 12 hours.

In case any link does not meet the performance requirements during 12 hour, then the cause of failure shall be investigated and the test shall be repeated after rectifying the defects.

This phase of testing shall be conducted by the Contractor and witnessed by the Employer. Field adjustments shall be made to meet established standard, however if the field adjustments fail to correct the defects the equipments may be returned to the Contractor for replacement at his own expense. In case any adjustments are required to be made during the interval of the test then the test shall be repeated.

#### 4.4.1.3 Integrated Testing

Prior to commencement of integrated testing the overall system shall be configured as required to provide all the data and voice channel required to interconnect the various User's interfaces. The integrated testing for a batch shall include end-to-end testing of back-bone network included in that batch. Integrated testing for last batch shall include testing of the entire back-bone. The intent of integrated testing is to demonstrate that the equipment is operational end to end under actual conditions, that all variances identified during factory and field installation and communications testing have been corrected, and that the communication equipment is compatible with other equipment at all locations. The Integrated System Test shall include all fibre optic transmission equipment, termination equipment, the network management subsystem and other components.

At a minimum the following tests shall be included in the integrated testing:

(1) Equipment configuration shall be checked to establish that it supports the channel routing.
(2) End to end testing of all individual voice circuits
(3) End-to-end testing of all individual Data Circuits.

(4) Demonstration of Protection switching and synchronization of equipment as per synchronization plan.

**Fibre Optic Transmission system Installation Testing**

| Item: | Description: |
|---|---|
| **1.** | Physical Inspection for conformance to drawings, rack elevations and appearance of equipment and cabling |
| **2.** | Station power supply input and equipment power supply (DC-DC converter) output voltage measurements |
| **3.** | Terminal transceiver performance testing (Tx power, Tx spectrum, receive signal strength, connector losses etc.) |
| **4.** | Service channel performance |
| **5.** | Craftsperson interface, alarm and control functional performance |
| **6.** | Rack and local alarms: No alarms shall be present and all alarms shall be demonstrated to be functional |
| **7.** | Network management interface and supervision performance |
| **8.** | Correct configuration, level setting & adjustments and termination of Input/ output interfaces |
| **9.** | Proper establishment of Safety and signalling earthing system and resistance to ground to be checked. |
| **10.** | Simulation of failure conditions and failover of protected components. |

**Termination Equipment Sub-system Installation Testing**

| Item: | Description: |
|---|---|
| **1.** | Physical Inspection for conformance to drawings, rack elevations and appearance of equipment and cabling |
| **2.** | Power supply/converter voltage measurements |
| **3.** | Muldem performance testing |
| **4.** | Craftsperson interface, alarm and control functional performance |
| **5.** | Rack and Local alarms |
| **6.** | Network management interface and supervision performance |
| **7.** | Channel performance |
| **8.** | Safety and signalling earthing system |
| **9.** | Simulation of failure conditions and failover of protected components. |

**NMS Installation Testing (if Applicable)**

| Item: | Description: |
|---|---|
| 1. | Physical inspection for conformance to drawings, rack elevations and appearance of equipment and cabling |

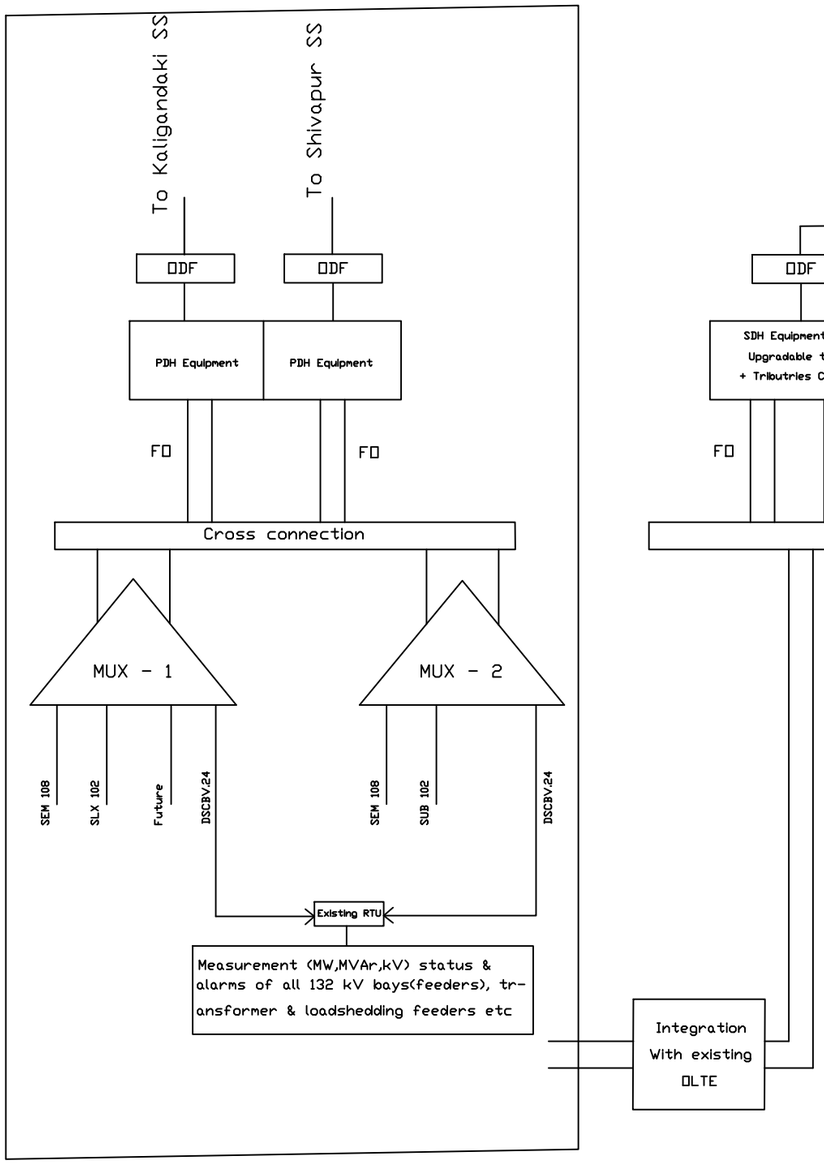
**NMS Installation Testing (if Applicable)**

| | |
|---|---|
| 2. | Workstation hardware inventory, configuration and characteristics |
| 3. | Demonstration of proper operation of all hardware, including workstations peripherals |

## 4.0 *TRAINING FOR OPERATIONAL STAFFS*

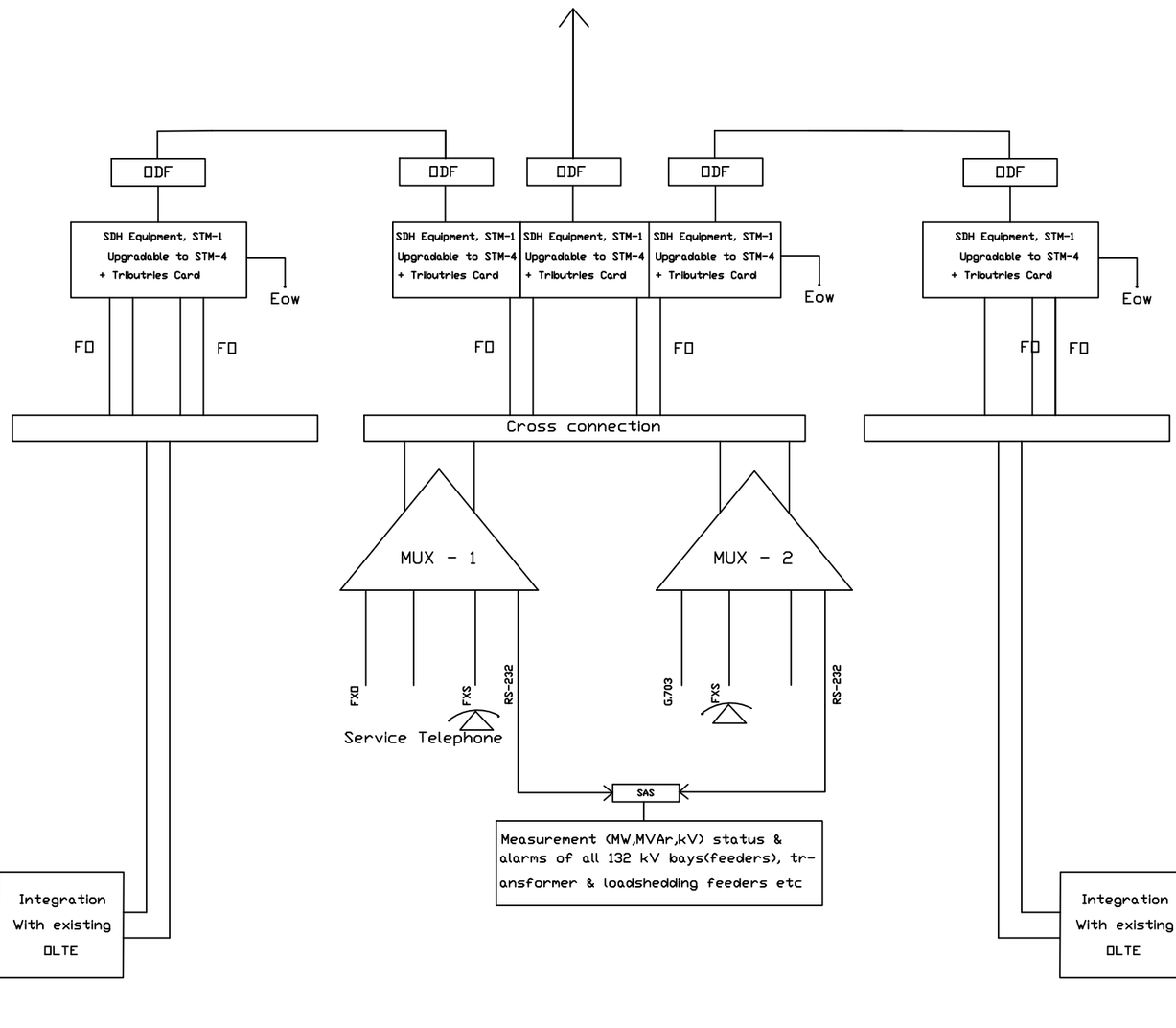
The Contractor shall design and arrange a training programme atleast of 7 days at the manufacturer's premises for the Fibre Optic Based Communication system for three concerned NEA personnel so as to make them competent enough to operate and maintain the proposed equipment/system. The overview of such programme shall be proposed by the prospective Contractor along with its technical proposal. The cost of this training shall be included in the overall bid price.

Existing System at Butwal Substation



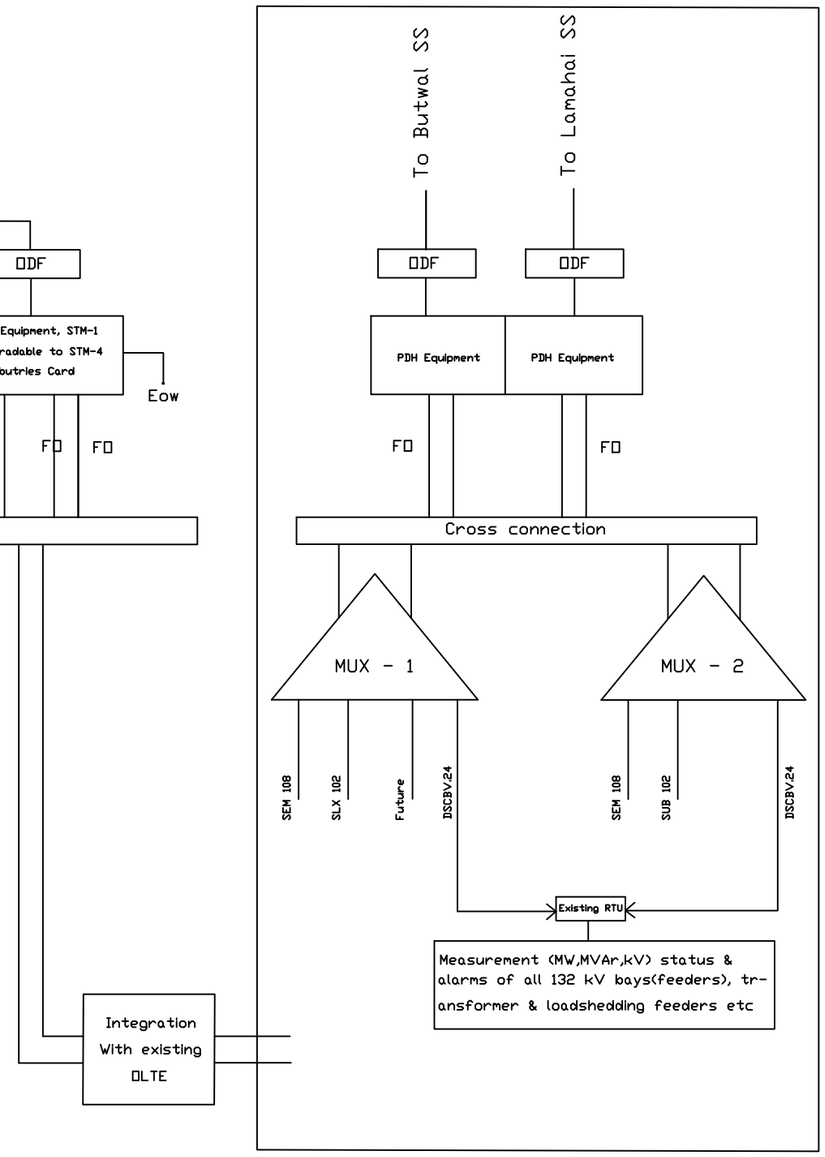

BUTWAL SUBSTATION

TO Sandhikharka Substation




MOTIPUR SUBSTATION

Existing System at Chanauta Substation

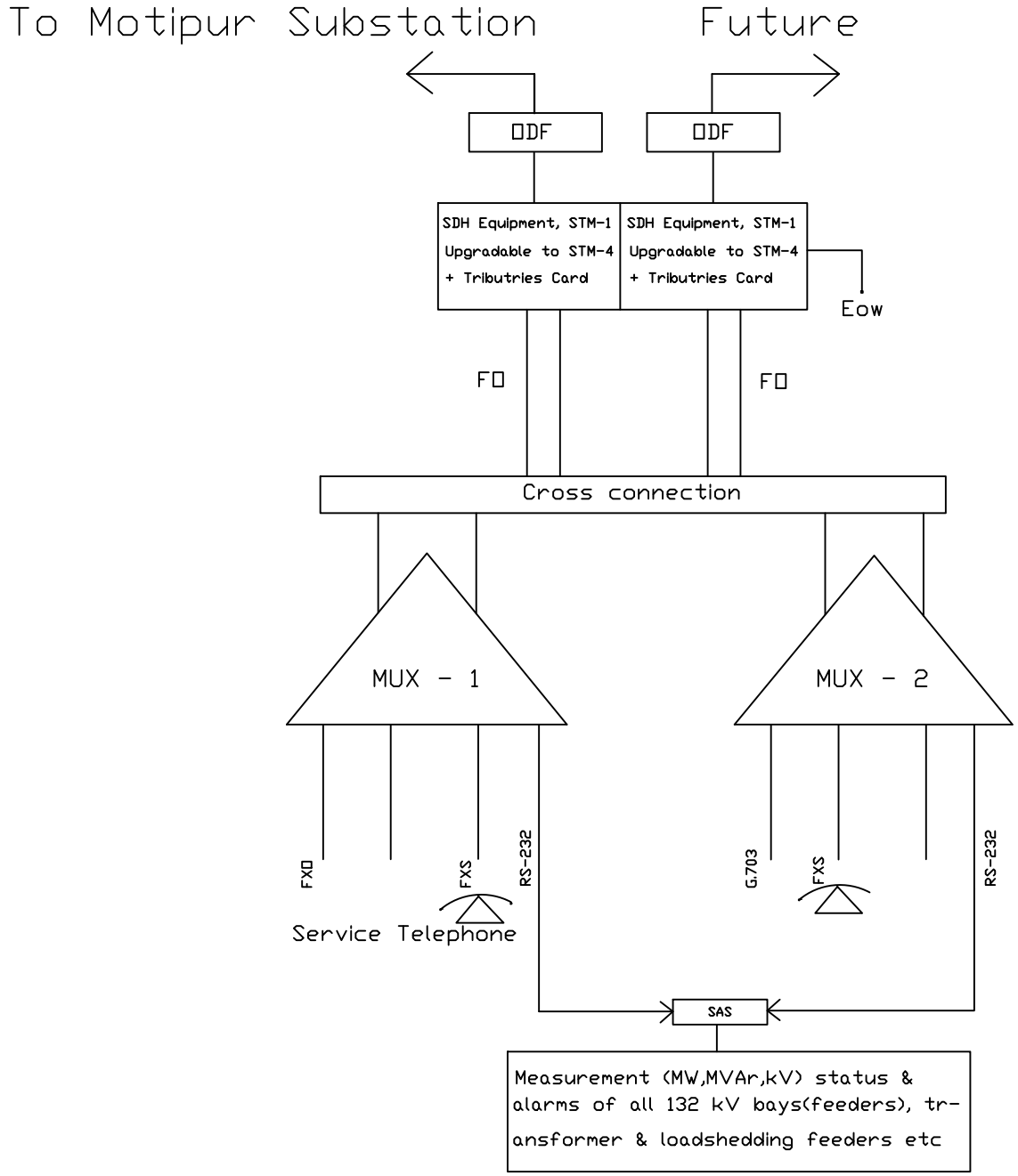



CHANAUTA (SHIVAPUR) SUBSTATION

Nepal Electricity Authority
Transmission Directorate
Grid Development Department
BURTIBANG PAUDI-AMARAI TAMGHAS SANDHIKHARKA GORUSHINGE 132 kV TRANSMISSION LINE PROJECT

ONLY FOR BIDDING PURPOSE

Communication drawing for Motipur substation




ONLY FOR BIDDING PURPOSE

# SANDHIKHARKA SUBSTATION

Communication drawing of
Sandhikharka substation

Nepal Electricity Authority
Transmission Directorate
Grid Development Department
BPTSG 132 kV TRANSMISSION LINE PROJECT

# CHAPTER 18: 11 kV Indoor Switchgear

## 1.0 11 kV INDOOR SWITCHGEAR

### 1.1 General requirements:

The manufacturer, whose 11 kV Indoor switch gear panels are offered should have designed, manufactured, type tested as per relevant IEC, supplied and commissioned the Panels of similar rating. These Panels should have been in satisfactory operation for at least two years as on the date of bid opening.

In addition to the requirements above, the VCB 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 for at least two years as on the date of bid opening.

**1.2** 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.

Specific reference in this specification and documents to any Material by trade name, make, or catalogue number shall be constructed as establishing quality and performance requirements.

Equipment shall be installed in 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 labors, tools, equipment rigging materials, bolts, wedges, anchors, concrete inserts etc. in proper time, required to completely install, test and commission the equipment.

Manufacturers and Employer's instructions and recommendations shall be correctly followed in handling, erection, testing and commissioning of all equipment.

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.

Switchgear shall be installed on finished surfaces, concrete or steel sills. Contractor shall be required to install and align any channels sills, which form part of foundations. Circuit breaker trolley wheels shall move on channels, which shall form part of floor. The channel length shall be minimum of 1 meter from the door of switchgear panel. 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 spilled 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.

Foundation work for all switchgear panels will be carried out by contractor.

### 1.3 Switchgear panel

1.3.1 The switchgear boards shall have a single front, single tier, fully compartmentalized, metal enclosed construction complying with IEC Standard, 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 expect in busbar compartments where insulated barriers shall be provided to segregate adjacent panels. However, manufacturer's standard switchgear designs without internal barriers in busbar compartment may also be considered.

1.3.2 The circuit breakers and Bus VTs shall be mounted on with draw able trucks which shall roll out horizontally from service position to isolated position.

1.3.3 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.

1.3.4 The number of trolleys to be provided shall be as specified in clause 1.3.17. Testing of the breaker shall be possible in isolated position by keeping the control plug connected.

1.3.5 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 compartment would be preferred, standard designs of reputed switchgear manufacturer's 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-42 degree of protection in the Isolated position. In case the later arrangement is offered, the Bidder shall explain how this sealing is achieved and shall include blanking covers one for each size of panel per switchboard in his total bid price.

1.3.6 The truck in any position SERVICE, ISOLATED or removed, and all doors and covers closed. All doors, removable covers and glass windows shall be gasketted all round with synthetic rubber or neoprene gaskets.

1.3.7 The bus VT/ relay compartments shall have degree of protection not less then IP:52 in accordance with IEC-60529. However, remaining compartments shall be dust, moisture, rodent and vermin proof, with degree of protection of IP:42. All louvers if provided, shall have very fine brass or GI mesh screen. IPH-2 degree of protection as per IEC standard to all live parts shall (whether isolated or removed from panel) even when the breaker compartment door is open. Tight fitting garments/gaskets are to be provided at all openings in relay compartment.

1.3.8 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 design 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 minimising 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. The bidder shall ensure

satisfactory operation of pressure relief device in accordance with relevant IEC. The test reports for internal arc fault test for all HT chambers shall be submitted.

1.3.9 Enclosure shall be constructed with rolled steel sections and cold rolled steel sheets of atleast 2.0 mm thickness, Gland plates shall be 2.5mm thick made out of hot rolled or cold rolled steel sheets and for non-magnetic material it shall be 3.0 mm.

1.3.10 The switchgear shall be cooled by natural air flow and cooling by any other method shall not be accepted.

1.3.11 Total height of the switchgear panels shall not exceed 2450 mm. The height of switches, pushbuttons and other hand operated devices shall not exceed 1800 mm and shall not be less than 700 mm.

1.3.12 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 level arrangement shall preferably be provided for smooth and positive movement of, truck between Service and Isolated positions.

1.3.13 Safety shutters complying with IEC-298 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. It shall also be possible to padlock shutters individually. In case, insulating shutters are provided, these shall meet the requirements of Clause 3.102.1 Note-2 of IEC-298 and necessary tests are per IEC-298 Clause 5.103.1 shall be carried out. A clearly visible warning label "Isolate elsewhere before earthing" shall be provided on the shutters of incoming and the connections which could be energised from other end.

1.3.14 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

1.3.15 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 bolted compartment covers with self retaining bolts. Breaker compartment doors shall have locking facility.

1.3.16 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.

1.3.17 Suitable base frames made out of steel channels shall be supplied alongwith 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 as per approved installation drawings. The bidder may offer panels with built in base frame ready for dispatch and suitable for installation on indoor cable trenches.

1.3.18 The switchboard shall have the facility of extension on both sides. Adopter panels and dummy panels required to meet the various bus bar arrangement, cable/bus duct termination and layouts shall be included in Bidder's scope of work.

**1.4 Circuit breakers**

1.4.1 The circuit breakers shall be of **VCB type** and shall comprise of three separate, identical

single pole interrupting units, operated through a common shaft by a sturdy operating mechanism.

1.4.2 Circuit breakers shall be suitable for switching lines at any load.

1.4.3 Circuit breaker shall be restrike free, stored energy operated and trip free type. Motor wound closing spring charging shall only be acceptable. An antipumping device shall be provided for each breaker; even 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.

1.4.4 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.

1.4.5 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.

1.4.6 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 or change in adjustment due to repeated operation of the breaker and the mechanism.

1.4.7 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.

1.4.8 Mechanical indicators shall be provided on the breaker trucks 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 may be visible without opening the breaker compartment door.

1.4.9 The rated control supply voltage shall be as mentioned in Section-GTR. The closing coil and spring charging motor shall operate satisfactorily at all values of control supply voltage with specified variation mentioned in Section-GTR. The shunt trip coil shall operate satisfactorily under all operating conditions of the circuit breaker up to its rated short circuit breaking current at all values of control supply voltage between 70 and 110 percent 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.

1.4.10 The time taken for charging of closing spring shall not exceed 30 second. 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. Operating 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.

1.4.11 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 any where between 85% and 110% of the 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 short circuit protection.

1.4.12 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.

1.4.13 Circuit breaker may be provided with inter pole barriers of insulating materials, if the same is standard design of the manufacturer. But use of inflammable materials like Hylam shall not be acceptable.

**1.5 Control and interlocks**

1.5.1 The control switch located on the switchgear would normally be used for operation of circuit breaker in service/isolated position, and for tripping it in an emergency .

1.5.2 The Bidder shall study the basic control scheme as proposed to be adopted and clearly state in his bid the extent to which it can be complied with.

1.5.3 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.

1.5.4 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

1.5.5 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.

1.5.6 For Employer's use six (6) normally open (NO) and six (6) normally closed (NC) auxiliary contacts shall be provided for all feeder and shall be wired out to the terminal blocks.

1.5.7 Contact multiplication, if necessary to meet the above contact requirement, shall be done through suitable latch relay.

1.5.8 The contacts of all limit switches and all breaker/auxiliary contacts located on truck portion and fixed portion shall be silver plated, rated to make, carry and break 1.0 Amp 110 V DC (Inductive) 10 Amps. 230V AC. Contacts of control plug and socket, shall be capable of carrying the above current continuously.

1.5.9 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.

1.5.10 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.

1.5.11 Mechanical (Castle key) or a full proof electrical interlock shall be provided between the isolator and associated circuit breaker such that the former cannot be operated unless the later is open.

1.5.12 It shall be possible to easily insert breaker contactor of one feeder into any one of the panel meant for same rating but at the same time shall be prevented from inserting it into panels meant for a different type of rating.

1.5.13 Indicating lamps shall be provided in the panel front as brought out in Clause 1.2.11. It shall be possible to easily make out whether the truck is in SERVICE or ISOLATED position even when the compartment door is closed.

**1.6 Bus bars and interlocks:**

1.6.1 All busbar and jumper connections shall be of high conductivity aluminium/copper of adequate size and the bus bar size calculation shall be submitted for approval. They shall be adequately supported on insulators to withstand electrical and mechanical stresses due to specified short circuit currents.

1.6.2 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.

1.6.3 Contact surfaces at all joints shall be silver plated or properly cleaned and no 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. Suitable bimetallic connectors shall be used for aluminium to copper connections.

1.6.4 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 100 picocoulomb at rated voltage x1.1/√3. Use of insulators and barriers of inflammable material such as Hylam shall not be accepted.

1.6.5 Successful Bidder shall furnish calculation-establishing adequacy of busbar sizes for the specified continuous and short time current ratings.

1.6.6 All busbars shall be colour coded for phase identification.

1.6.7 The temperature of the busbars and all other equipment, when carrying the rated current continuously shall be limited as per the stipulations of relevant 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 in no case exceed 55 deg.C for silver plated joints and 35 deg.C for all other type of joints. The temperature rise at the switchgear terminals intended for external cable termination shall not exceed 35 deg. C. Further the switchgear parts handled by the operator shall not exceed a rise of 5 deg.

## 1.7 Earthing and earthing device

1.7.1 A galvanized steel earthing bus shall be provided at the bottom and shall extend through out the length of each switch board. It shall be bolted/welded to the framework of each panel and each breaker earthing contact bar.

1.7.2 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.

1.7.3 Suitable arrangement shall be provided at each end of the earth bus for bolting to earthing conductors. All joint splices to the earth bus shall be made through atleast two bolts and taps by proper lug and bolt connection.

1.7.4 All non- current carrying metal work 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.

1.7.5 The truck and breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker contactor 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.

1.7.6 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.

1.7.7 VT and CT secondary neutral point earthing shall be at one plate 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.

1.7.8 Built-in /Trolley mounted earthing facilities for the busbars and outgoing incoming connections shall be provided. However, there should be facility for alarm before engagement of earthing contacts, in case of feeder/incomer being in energized condition.

1.7.9 Interlocks shall be provided to prevent:

Closing of the earthing switch if the associated circuit breaker truck is in Service position.

Insertion of the breaker truck to Service position if earthing switch is in closed position.

Closing of the earth switch on a live connection. Three nos. voltage capacitive dividers shall be provided on each phase of the section intended for earthing and three nos. "RED' Neon lamps connected to these on the panel front for visual indication.

1.7.10 Energising and Earthed Section: Complete details of arrangement offered shall be included in the bid describing the safety features and interlocks.

1.7.11 The earthing device shall have the short circuit withstand capability equal to that of associated switchgear panel suitable number of auxiliary contacts of the earthing device shall be provided for interlocking purpose.

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

**1.8 Painting**

All sheet steel work shall be pretreated in tanks, in accordance with IEC 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 phosphated coating shall be as per relevant IEC standards. The phosphated surface shall the rinsed and passivated prior to application of stoved lead oxide primer coating. After primer application, two coats of finishing synthetic enamel paint on panels shall be applied. Each coat finishing shall be properly stoved. The paint thickness shall not be less than 50 microns. Finished parts shall be coated by peel able compound by spraying method to protect, finished surfaces from scratches, grease dirts and oily spots during testing, transportation, handling and erection. Electrostatic painting shall also be acceptable.

**1.9 Instrument transformers**

1.9.1 All current and voltage transformers shall be completely encapsulated cast resin insulated type, suitable for continuous operation at the 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.

1.9.2 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 rating 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.

1.9.3 The parameters of instrument transformer specified in this specification are tentative and shall be finalised 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 and shall bring out this fact clearly in his bid.

1.9.4 All instrument transformers shall have clear indelible polarity markings. All secondary terminals shall be wired to separate terminals on an accessible terminal block.

1.9.5 Current transformers may be multi or single core and shall be located in the cable termination compartment. All voltage transformers shall be drawout type. The bus VTs shall be housed in a separate panel on a truck so as to be fully withdrawable.

1.9.6 All voltage transformers shall have suitable HRC current limiting fuses on both primary and secondary sides. Primary fuses shall be mounted on the withdrawable portion. Replacement of the primary fuses shall be possible with VT truck in ISOLATED position. The secondary fuses shall be mounted on the fixed portion and the fuses replacement shall be possible without drawing out the VT, truck from Service position.

## 1.10 Relays and protections

1.10.1 In addition to the requirements specified hereunder the relays, indicating instruments, recorders, transducers, terminal blocks, Mimic diagram, Name Plates, switches, indicating lamps, position indicators shall also meet the requirements of corresponding clauses in Chapter Section Control and Relay Panels.

1.10.2 **General Features**

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

b) All relays and timers shall be rated for control supply voltage as mentioned in Chapter – GTR with specified variation. Making, carrying and breaking current ratings of their contacts shall be adequate for the circuits in which they are used. Auxiliary seal in units if provided shall be of shunt reinforcing type.

c) The protective relays and timers shall have atleast two potential free output contacts in addition to scheme requirement for owner's use. Auxiliary relays, shall have contacts as required. Adequate number of terminals shall be available on the relay cases for applicable relaying schemes.

d) The relay and timers used in protective circuits shall be of reputed makes and proven types which have been in successful operation for atleast three (3) years and shall be subject to Employer/EDUTC's approval before procurement by the Contractor.

e) The Static / Numerical type relays are acceptable.

1.10.3 **Special Protection Features**

11 kV Line Protection shall have three over current and one earth fault element which shall be either independent or composite units and shall meet the following requirements

**a) Non directional over current relay**

(i) have IDMT characteristic with definite minimum time of 3.0 sec at 10 times setting
(ii) have a variable setting range of 50-200% of rated current.

**b) Non Directional earth fault relay**

(i) have IDMT characteristic with definite minimum time of 3.0 sec at 10 times setting.

(ii) have a variable setting range of 20-80% of rated current.

c) **Master Trip Relay** : Non directional over current and earth fault relays will be wired to trip the master trip relay during faults Master Trip relay should conform to the specification of Tripping Relay(86)as per section control and relay panel and also the ratings of the output contacts shall be suitable for 11 kV circuit breaker. This trip relay shall be electrical reset type.

## 1.11 Instruments and Meters

1.11.1 Indicating instruments shall be flush mounted on panel front. The instruments shall be of atleast 96mm square size with 240deg. scales and shall have an accuracy class of 1.5 or better. The covers and cases of instruments and meters shall provide a dust and vermin proof construction.

1.11.2 Instruments shall have white dials with black numerals and lettering. Black knife edged pointer with parallax free details will be preferred.

1.11.3 Instruments and meters shall be factory calibrated to directly read the primary circuit quantities. Means shall be provided for zero adjustment without dismantling the instruments.

## 1.12 Switchgear Wiring

1.12.1 All Switchgear panels shall be supplied completely wired internally upto the terminal block ready to receive external cabling. All inter cubicle wiring and connections between panels of same switchboard including all bus wiring for AC and DC supplies shall be provided by the Contractor.

1.12.2 All internal wiring shall be carried out with 650 V grade, single core, 1.5 sq.mm, stranded copper wires having minimum of seven strands per conductor and colour coded, PVC insulation. CT circuits shall be wired with 2.5 sq.mm. wires which otherwise are similar to the above. Extra flexible wires shall be used for wiring between fixed and moving parts such as hinged doors.

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

1.12.4 Internal wire terminals shall be made with solderless crimping type tinned copper lugs which shall firmly grip the conductor. Insulation sleeves shall be provided over the exposed parts of lugs.The lugs related to CT secondary circuit wiring shall be of hole type.

1.12.5 Engraved core identification plastic ferrules marked to correspond with panel wiring diagrams shall be fitted at both ends of each wire Number 6 and 9 shall not be used for wire identification. Ferrules shall fit tightly on wires and shall not fall off when wire is, disconnected from terminal. All wires directly connected to trip the circuit breaker shall be distinguished by the addition of a red coloured unlettered ferrule.

1.12.6 Inter connection to adjacent panels shall be brought out to a separate set of terminal blocks located near the slots or holes, meant for the interconnecting wires. Arrangement shall permit neat layout and easy inter connections to adjacent panels at site and wires for this purpose shall be provided by Contractor looped and bunched properly inside the panels. The inter panel wires shall be cross ferruled i.e it shall have details of emanating terminal and also where it is terminated.

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

1.12.8 The Contractor shall provide the necessary clamps wiring troughs etc. for all wiring in side the switchgear enclosed including the power and control cables.

### 1.13 Power Cable Termination

1.13.1 The Cable termination compartment shall receive the stranded Aluminium conductor, XLPE insulated, armoured, PVC jacketed, single core/three core unearthed/earthed grade power cable(s).

1.13.2 A minimum clearance of about 600 mm shall be kept between the cable lug bottom ends and gland plates for stress cone formation for XLPE cables. Interphase clearance in the cable termination compartment shall be adequate to meet electrical and mechanical requirement besides facilitating easy connections and disconnections 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 approval during detailed engineering.

1.13.2 Cable termination compartment shall be complete with power terminals, power lugs and associated hardware and removable undrilled gland plates. For all single core cables gland plates shall be of nonmagnetic material.

1.13.3 Supply of the cable termination kit and cable terminations shall be in scope of contractor.

### 1.14 Name Plates and Labels

1.14.1 Each switchboard shall have a name plate for its identification. All enclosure-mounted equipment shall be provided with individual engraved name plates for clear equipment identification. Each unit panel shall be identified on front as well as backside by large engraved name plates giving the distinct feeder description along with panel numbers. Back side name plates shall be fixed in panel frame.

1.14.1 Name plate shall be of non-rusting metal or 3-ply lamicoid with white engraved lettering, on black background. Inscriptions and lettering shall be subjected to Employer's approval.

1.14.2 Suitable stenciled paint mark shall be provided for identification of all equipment, located inside the enclosure, as well as for door mounted equipment, from the backside in addition to plastic sticker labels, if provided. These labels shall be located directly by the side of the respective equipment, shall be clearly visible and shall not be hidden by equipment wiring. Labels shall have device number as mentioned in wiring drawings. Type of labels and fixing of labels shall be such that they are not likely to peel or fall off during prolonged use.

**1.15 11 kV Indoor Switchgear panels as per quantity and details given below shall be offered:**

| S.No. | Description | Quantity in both Motipur & Sandhikharka S/S |
|---|---|---|
| 1. | Panel for 33/11 kV transformer incomer feeder type IP- 2, fault level of 25KA for 1 sec. **[Incoming]** | 1 |
| 2. | Panel for 11 kV feeders/LT Transformer type IP-1, Fault level of 25KA for 1 sec**[Outgoing]** | 3 |
| 4 | Panel for Bus PT with fuses and two nos. under voltage Relays Type IP-3, fault level of 25KA for 1 secs. | 1 |

**Detailed Description for each HT indoor panels:-**

| Sl.No | Equipment | IP1<br>O/G | IP2<br>I/C | IP3<br>PT |
|---|---|---|---|---|
| 1. | 12 kV, 1250A, 25KA for 1 sec, CB | - | 1 | - |
| | 12 kV , 800A, 25KA for 1 sec , CB | 1 | - | - |
| 2.a | 12 kV, 400-200/1 CT | 1 | - | - |
| 2.b | 12 kV, 800-400/1 CT | | 1 | - |
| 3 | PotentialTransformer,12 kV/110V, drawout type, cast resin type, dual accuracy 1.0/3.0, 100VA burden. | - | 1 | 1 |
| 3. | Ammeter | 1 | 1 | - |
| 4. | Voltmeter | - | 1 | 1 |
| 5. | Watt meter | 1 | 1 | - |
| 6. | Varmeter | - | 1 | - |
| 7. | Control switch for breaker | 1 | 1 | - |
| 8. | Green Indicating lamps | 1 | 1 | - |
| 9. | Red indicating lamps | 1 | 1 | - |
| 10. | DC healthy lamp (white) | 1 | 1 | - |
| 11. | Mimic to represent SLD | 1 | 1 | 1 |
| 12. | Voltmeter selector switch | - | 1 | 1 |
| 13. | Ammeter selector switch | 1 | 1 | - |
| 14. | Non directional protection consisting of 2 over current & 1 earth fault protection (set) | 1 | - | - |
| 15. | Trip relays | 1 | 1 | - |
| 16. | Directional backup protection consisting of 3 over current &1 earth fault protection (set) | - | 1 | - |
| 17. | Flag relays, trip relays, Auxiliary relays timers etc (as per scheme requirement) | Lot | Lot | Lot |
| 18. | Energy meters (0.2 class accuracy)* | 1 | 1 | - |

| | | | | |
|---|---|---|---|---|
| 19. | Annunciation Facia (as per requirement) | Lot | Lot | Lot |

Note: All indicating instruments are without transducers.

* Energy meter as per technical specification specified at Annexure-VII of Chapter-1 (PSR)

### 1.16 Tests

The Bidder shall submit the type test reports of following type tests for approval of the Employer for circuit breaker, circuit breaker panels, of each voltage class and current rating:

1 Short circuit duty test on circuit breaker, mounted inside the panel offered.
2 Short time withstand test- on circuit breaker, mount inside panel offered.
3 Power frequency withstand test on breaker and panel.
4 Lightning impulse withstand test on breaker and panel.
5 Temperature rise test on breaker and panel together.
6 Test to verify pressure relief devices operation of the panel. This shall be done on one panel of each voltage class.
7 Switching over-voltage test on each rating of breaker
8 Measurement of resistance of main circuit.
9 Mechanical endurance test on breaker.
10 Mechanical operation test.

For all important components like instrument transformers, relays, instruments, switches, bushings, wires, insulators, timers, annunciators, terminal blocks and fuses etc. the contractor shall furnish satisfactory type test reports for Employer's approval. Such reports shall cover all applicable type tests listed in relevant n Standards, for all components of type and rating being supplied.

### 1.17 Commissioning Checks/Tests

After installation of panels, power and Control wiring and connect Contractor shall perform commissioning checks as listed below to proper operation of switchgear/panels and correctness of all respects.

In addition the Contractor shall carry out all other checks and tests recommended by the manufacturers.

**General**

1 Check nameplate details according to specification.
2 Check for physical damage
3 Check tightens of all bolts, clamps and connecting terminal
4 Check earth connections.
5 Check cleanliness of insulators and bushings.
6 Check heaters are provided.
7 H.V. test on complete switchboard with CT & breaker/ contractor lubricated in position.
8 Check all moving Parts are properly lubricated.
9 Check for alignment of busbars with the insulators to ensure alignment and fitness of insulators.

10 Check for inter changeability of breakers.
11 Check continuity and IR value of space heater.
12 Check earth continuity of the complete switchgear board.

**Circuit Breaker**

1 Check alignment of trucks for free movement.
2 Check correct operation of shutters.
3 Check slow closing operation.
4 Check control wiring for correctness of connections, continuity and IR values.
5 Manual operation of breakers completely assembled.
6 Power closing/opening operation, manually and electrically at extreme condition of control supply voltage.
7 Closing and tripping time.
8 Trip free and anti-pumping operation.
9 IR values, resistance and minimum pick up voltage of coils.
10 Simultaneous closing of all the three phases.
11 Check electrical and mechanical inter locks provided.
12 Checks on spring charging motor, correct operation of limit switches and time of charging.
13 All functional checks.

**Current Transformers**

1 Megger between windings and winding terminals to body.
2 Polarity tests.
3 Ratio identification checking of all ratios on all cores by primary injection of current.
4 Magnetization characteristics & secondary winding resistance.
5 Spare CT cores, if any to be shorted and earthed.

**Voltage Transformers**

1 Insulation resistance
2 Ratio test on all cores.
3 Polarity test
4 Line connections as per connection diagram.

**Cubicle Wiring**

1 Check all switch developments.
2 It should be ensured that the wiring is as per relevant drawings. All interconnections between panels shall similarly be checked.
3 All the wires shall be meggered to earth.
4 Functional checking of all control circuit e.g. closing, tripping, interlock, supervision and alarm circuit including proper functioning of component/ equipment .
5 Check terminations and connections. To check wiring related to CT and PT circuits, carryout primary injection and then check for secondary value at relay and metering instrument terminals.
6 Wire ducting.
7 Gap sealing and cable bunching.

**Relays**

1 Check internal wiring.
2 IR of all terminal body.
3 IR of AC to DC terminals
4 Check operating characteristics by secondary injection.
5 Check minimum pick up voltage of DC coils.
6 Check operation of electrical/ mechanical targets.
7 Check CT connections with particular reference to their polarities for differential type relays.
8 Relay settings.

**Meters**

1 IR of all insulated portions.
2 Check CT & VT connections with particular reference to their polarities for power type meter.

1.18 Technical parameters for 11 kV Switchgear panel.

**1.18.1 Parameters common to all equipment:**

| | |
|---|---|
| a) Nominal System Voltage | 11 kV |
| b) Highest system Voltage | 12KV |
| c) Rated Frequency | 50Hz |
| d) No of phases | Three |
| e) System neutral earthing | Solidly Earthed |
| f) One minute Power Freq. withstand voltage | 28KV (rms) |
| g) Lighting Impulse withstand Voltage | 75KVp |
| h) System fault level | 25kA for 1sec |
| i) Auxiliary Supply Voltage | As mentioned in Section - GTR |

**1.18.2 Circuit Breaker**

| | |
|---|---|
| a) Rated continuous current at design ambient temp. | 800A for Line feeder & 1250A for Incomer |
| b) Rated short circuit current Breaking capacity at rated Voltage | 25kA with% of DC component as per IEC: 62271-100 corresponding to minimum opening time under operating conditions specified |
| c) Symmetrical interrupting Capability | 25kA (rms) |

| | | |
|---|---|---|
| d) | Rated short circuit making Current | 62.5 kAp |
| e) | Out of phase breaking Current capacity | As per IEC |
| f) | Rated line/cable charging Interrupting current at 90$^{o}$ Leading power factor angle | As per IEC |
| g) | Rated small inductive current Switching capability with over Voltage less than 2.3pu | 0.5 to 10 A |
| h) | Maximum allowable switching Over Voltage under any Switching condition | As per IEC |
| i) | First pole to clear factor | 1.5 |
| j) | Total breaking time as | 80ms |
| k) | Total closing time | Not more than 150ms |
| l) | Rated operating duty cycle | O-0.3sec-CO-3minCO |
| m) | Reclosing | 3 phase auto reclosing |
| n) | Max. difference in the instants Of closing/opening contacts Between poles at rated control Voltage and rated operating and Quenching media pressures | 3.3ms |
| o) | Trip coil and closing coil voltage | 110 V DC with variation indicated in Section - GTR |
| p) | Auxiliary contacts besides spec requirement | 2NO+ 2NC for Employer's use |
| q) | Temperature rise over the Design ambient temp | As per IEC: 62271-100/IEC: 60694 |

### 1.18.3 Current Transformer (Incomer Feeder)

| | | |
|---|---|---|
| a) | Rated primary current | 800-400/1A |
| b) | Max temp rise | As per IEC:44-1 |
| c) | Type of Insulation | Class E |
| d) | One minute power frequency Withstand voltage between Secondary terminal & earth | 2KV |

e) Detail of Secondary Cores

| | **Metering** | **O/C & E/F Protn.** | **Diff Protn.** |
|---|---|---|---|
| Current ratio | 800-400/1 | 800-400/1 | 800-400/1 |
| Accuracy class | 0.5 class | 5P20 | PS |
| Knee point Voltage (at minimum ratio) | -- | -- | 600V |
| Max. CT sec. Wdg. Resistance | -- | -- | 3.75ohm |
| Max excitation current | -- | -- | 45mA |

### 1.18.4 Current Transformer (Line Feeder)

a) Rated primary current 400-200/1A

b) Max temp rise As per IEC:44-1

c) Type of Insulation Class E

d) One minute power frequency Withstand voltage between Secondary terminal & earth 2KV

e) Detail of Secondary Cores

| | Metering | O/C & E/F Protn. |
|---|---|---|
| Current ratio | 400-200/1A | 400-200/1A |
| Accuracy class | 0.5 class | 5P20 |
| Knee point Voltage | -- | -- |
| Max. CT sec. Wdg. Resistance | -- | -- |
| Max excitation current | -- | -- |

### 1.18.5 Potential Transformer

a) Rated primary Voltage 12KV

b) Type Single Phase Potential Transformer

c) Voltage Ratio (kV) (11/√3)/(0.11/√3)/(110/√3)/ /(110/√3)

d) Rated voltage factor 1.2 continuous, 1.5 – 30seconds

e) One minute power freq. Withstand voltage for Secondary winding 2KV(rms)

| | | | |
|---|---|---|---|
| f) | Rated output burden | 150VA | |
| g) | Detail of secondary | Metering | Protection |
| | Accuracy | 0.5 | 3P |

**Note:**

1. The ratings indicated for instrument transformer are tentative only and may be changed to meet the requirements.

## 2. 11 kV Distribution

Both the 132/33/11 kV Motipur & Sandhikharka Substation shall have three 11 kV outgoing feeder and shall have the provision of 11 kV overhead line expansion for distribution purpose. The appropriate 12 kV, 3 Core XLPE Cables as mentioned in the bill of quantity to be used for the 3 number of outgoing feeders for distribution purpose. The scope of work shall be performed as per NEA Standard. The payment for the job shall be paid on running meter as mentioned in the bill of quantity.

# CHAPTER 19: SWITCHYARD ERECTION

## 1.0 GENERAL

The detailed Scope of work includes design, engineering , manufacture, testing at works, supply at site basis, insurance, handling, storage erection, testing and commissioning of various items and works as details 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
- 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 ion. 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 for 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 for 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 failure 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 relevant international standard.
b) Verification of Dimensions as per relevant international standard.
c) Galvanising/Electroplating tests as per relevant international standard.
d) Slip strength test as per relevant international standard.
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 ual 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 132kV |
|---|---|---|
| a) | Type of insulators | Anti Fog type |

| | | |
|---|---|---|
| b) | Size of insulator units (mm) | 255x145<br>or<br>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 ual wet flashover voltage |

1.4.2 **INSULATOR STRING**

| **Sl. No.** | **Description** | **132kV** |
|---|---|---|
| a) | Power frequency withstand voltage of the complete string with corona control ring (wet) – KV rms | 275 |
| b) | Lightning impulse withstand Voltage of string with corona control rings (dry) - kVp | ± 650 |
| c) | Switching surge withstand voltage of string with corona control rings (wet) - kVp | NA |
| d) | Minimum total creepage distance of the insulator string (mm) | 3625 |
| e) | Total no. of discs per strings | 10 |

For tension application, single insulator strings and for suspension purpose single suspension insulator string shall be used for 132 kV system.

1.4.2.1 **INSULATOR STRING ( 33 KV )**

a) Power frequency withstand voltage of the complete string with Corona Control ring (wet) - kV rms : 75

b) Lightning impulse withstand Voltage of string with corona control rings (dry) – kVp : ±170

c) Power frequency puncture with-stand voltage for a string insulator : 1.3 times wet flashover voltage of the unit

d) Total creepage distance of the complete insulator string (mm) : 900

f) Total no. of discs per strings : 5 ( S/T & S/S )

## *1.5 COMPOSITE LONG ROD INSULATOR*

As an alternative to disc insulator/long rod porcelain, Bidder can also offer composite long rod insulators with suitable hardware.

### *1.5.1 Details of Composite Long Rod Insulators*

*1.5.1.1* Contractor shall offer such composite insulators which have proven use under foggy/ humid operational conditions in polluted industrial environment combined with smoke and dust particles. The Bidder shall furnish evidence in the form of certification from the power utilities that the similar type of product supplied to them had been performing 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 for 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 failure 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 frure resistance test
The test arrangement shall be according to Damage limit proof test with simultaneous application of 1N-HNO3 acid directly in cont with naked FRP rod. The cont 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 frure 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 | **132** |
| *2.* | Maximum system voltage | kV | 145 |
| *3.* | BIL (Impulse) | kV (Peak) | ±650 |
| *4.* | Power frequency withstand voltage (Wet) | kV (rms) | 275 |
| *5.* | Switching surge withstand voltage (Wet) | kV (rms) | NA |

| | | | |
|---|---|---|---|
| *6.* | Minimum Corona extinction voltage at 50 Hz AC system under dry condition | kV (rms) phase to earth | NA |
| *7.* | Radio interference voltage at one MHz for phase to earth voltage of 508 KV under dry condition. | Micro Volts | NA |
| *8.* | Minimum creepage distance. | mm | 3625 |
| *9.* | Electromechanical strength of Insulator Unit. | kN | 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 19 – 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-B of the technical specification, Chapter 19 – 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.** | **Description** | **Unit** | **AAC** |
|---|---|---|---|

| No. | | | 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 Bear conductors shall be as per the standard guaranteed technical particulars as tabulated below:

| Item | Description | Unit | Data |
|---|---|---|---|
| 1. | ACSR "BEAR" | | |
| 1.1 | Conductor size | $mm^2$ | 326.1 |
| 1.2 | Conductor type | ACSR | Bear |
| 1.3 | Number and size of wires | | |
| 1.3.1 | Aluminum | No | 30 |
| | | dia. mm | 3.35 |
| 1.3.2 | Steel | No. | 7 |
| | | dia.mm | 3.35 |
| 1.4 | Cross section | | |
| 1.4.1 | Aluminum | $mm^2$ | 264.4 |
| 1.4.2 | Steel | $mm^2$ | 61.7 |
| 1.4.3 | Total | $mm^2$ | 326.1 |
| 1.5 | Conductor diameter | mm | 23.45 |
| 1.6 | Ultimate strength | kg | 11,340 |
| 1.7 | Modulus of elasticity final | kg/ $mm^2$ | 8,200 |
| 1.8 | Coefficient of linear expansion | per$^{O}$ C | 17.8x10-6 |
| 1.9 | Standard mass of conductor | kg/km | 1,214 |
| 1.10 | Electrical D.C. resistance at 20 degree C | ohm/km | 0.1093 |
| 1.11 | Standard unjointed length on reel | m | 2,000 |
| 1.12 | Every day stress | $N/mm^2$ | 60 |
| 1.13 | Standards | BS 215 PART 2/IEC1089 | |

**2.3 Workmanship**

2.3.1 The finished conductor shall be smooth, comp, 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 region 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 chareristics as prescribed in ASTM designation: B 498-74.

2.3.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands in the event of cutting of composite core wire. Care shall be taken to avoid, damages to galvanisation during pre-forming and post-forming operation.

**2.4 Joints in Wires**

**2.4.1 Aluminium Wires**

Joints in aluminium wires shall be as per relevant International standard.

**2.4.2 Steel Wires**

There shall be no joint of any kind in the finished wire entering into the manufacture of the strand. There shall also be no strand joints or strand splices in any length of the completed stranded steel core of the conductor.

**2.5 Tolerances**

The manufacturing tolerances shall be as per relevant International standard.

**2.6 Materials**

2.6.1 **Aluminium**

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity not less than 99.5% and a copper content not exceeding 0.04%.

2.6.2 **Steel**

The steel wire strands shall be drawn from high carbon steel wire rods and shall conform to the following chemical composition:

| Element | % Composition |
|---|---|
| Carbon | 0.50 to 0.85 |
| Manganese | 0.50 to 1.10 |
| Phosphorous | Not more than 0.035 |
| Sulphur | Not more than 0.045 |
| Silicon | 0.10 to 0.35 |

2.6.3 **Zinc**

The zinc used for galvanising shall be electrolytic High Grade Zinc of 99.95% purity.

**2.7 Standard Length**

2.7.1 The conductor shall be supplied as required. No joint shall be allowed within a single span of stringing, jumpers and equipment interconnection.

**2.8 Tests :**

2.8.1 The following type, acceptance & routine tests and tests during manufacturing shall be carried out on the conductor.

2.8.2 **Type Tests**

In accordance with the stipulation of specification, the following type tests reports of the conductor shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

a) UTS test on stranded conductor.
b) Corona extinction voltage test (dry)
(c) Radio Interference voltage test (dry)
(d) DC resistance test on stranded conductor

2.8.3 **Acceptance Tests**

a) Visual check for joints, scratches etc. and lengths of conductor
b) Dimensional check on steel and aluminium strands
c) Check for lay ratios of various layers
d) Galvanising test on steel strands
e) Torsion and Elongation test on steel strands
f) Breaking load test on steel and aluminium strands
g) Wrap test on steel and aluminium strands
h) DC resistance test on aluminium strands
i) UTS test on welded joint of aluminium strands

**NOTE:**

All the above tests except test mentioned at (a) shall be carried out on aluminium and steel strands after stranding only.

2.8.4 **Routine Tests**

a) Check to ensure that the joints are as per specification.
b) Check that there are no cuts, fins etc. on the strands.
c) All acceptance test as mentioned in Clause 2.7.3 above to be carried out on each coil.

2.8.5 **Tests During Manufacturer**

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-B of the technical specification, Chapter 11 – 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-B of the technical specification, Chapter 11 – 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 | 7/3.35 (steel) |
| 2. | Strands<br>a) Steel Core<br>b) Outer layer | <br>No.<br>No. | <br>1 (one)<br>6 (six) |
| 3. | Total sectional area | Sq. mm. | 61.7 |

### 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 chareristics 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 tolerances shall be as per relevant International standard.

**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 relevant international 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- B of the technical specification, Chapter 19 – 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- B of the technical specification, Chapter 19 – 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 | ALUMINUM TUBE |
|---|---|---|
| 1. | Diameter 132 kV | 100mm Outer 80 mm inner |
| 2. | Diameter 33 kV | 75 mm |
| 3. | Thickness | 10 mm for 132 kV |

## 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 relevant international standard.

## 6.0 BUS POST INSULATORS

The post insulators shall conform in general to latest IEC-60168, IEC 60273 and IEC-60815.

### 6.1 Constructional Features

6.1.1 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.

6.1.2 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.

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

6.1.4 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.

6.1.5 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 ion.

6.1.6 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.

6.1.7 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.

6.1.8 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.

6.1.9 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.

**6.2 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.

6.2.1 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.

6.2.2 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.

## 6.3 Technical Parameters of Bus Post Insulators.

| Sl. No. | Description | 145 kV |
|---|---|---|
| a) | Type | Solid Core |
| b) | Voltage Class (kV) | 145 |
| c) | Dry and wet one minute power frequency withstand voltage(kV rms) | 275 |
| d) | Dry lightning impulse withstand Voltage (kVp) | ±650 |
| e) | Wet switching surge withstand voltage (kVp) | —- |
| f) | Max. radio interference voltage (in microvolts) at voltage of 508 kV (rms) , 305 kV (rms) and 156 (rms) for 765 kV, 400 kV &220 kV respectively between phase to ground. | 500 |
| g) | Corona extinction voltage (kV rms) (min.) | 105 |
| h) | ***Cantilever Strength*** | |
| (i) | Total minimum cantilever strength (Kg) | 600 |
| ***(ii)*** | ***Total minimum breaking strength (Kg)*** | ***720*** |
| i) | Minimum torsional moment | As per IEC-273 |
| j) | Total height of insulator (mm) | |
| k) | P.C.D Top (mm) | ***127*** |
| | Bottom (mm) | ***254*** |

| | | |
|---|---|---|
| l) | No. of bolts | |
| | Top | ***4*** |
| | Bottom | ***8*** |
| m) | Diameter of bolt/holes (mm) | |
| | Top | ***M16*** |
| | Bottom dia | ***18*** |
| n) | Pollution level as per IEC-815 | Heavy(III) |
| o) | Minimum total creepage distance for Heavy Pollution (mm) | 3165 |

**6.3.1 33kV Bus Post Insulators.**

| | | |
|---|---|---|
| a) | Type | Solid Core |
| b) | Voltage class (kV) | 36 |
| c) | Dry and wet one minute power frequency withstand voltage(kV rms) | 70 |
| d) | Dry lightning impulse withstand Voltage (kVp) | ±170 |
| e) | Total minimum cantilever strength (Kg) | 450 |
| f) | Minimum torsional moment | As per IEC-273 |
| g) | Total height of insulator (mm) | As per requirement |
| h) | Pollution level as per IEC-815 | Heavy(III) |
| i) | Minimum creepage distance for Heavy Pollution (mm) | 900 |

6.3.2 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.

## 7.0 GROUNDING SYSTEM

### 7.1 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.

### 7.2 GROUNDING INSTALLATION FEATURES

7.2.1 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.

7.2.2 For all connections made to equipment or to the structures, the grounding conductor, connectors and equipment enclosures shall have good clean cont 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.

7.2.3 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.

7.2.4 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.

7.2.5 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 New Khimti Substations.

## 7.3 GROUNDING CONDUCTOR

7.3.1 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.

7.3.2 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.

7.3.3 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.

## 7.4 DESIGN REQUIREMENTS

7.4.1 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.

7.4.2 The Contractor shall calculate the cross-section considering the maximum fault level of 31.5 kA.

7.4.3 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.

## 7.5 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.

## 7.6 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.

## 7.7 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 |
| | | |

**8.0 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.

8.1 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.

8.1.1 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

8.1.2 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.

8.1.3 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.

8.1.4 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.

**9.0 BAY EQUIPMENT**

9.1 The disposition of various bay equipments shall be as per single line diagrams and layout drawings.

9.2 Bay Marshalling Kiosk:-

One no. of bay marshalling kiosk shall be provided for each 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.

## 10.0 EQUIPMENT ERECTION DETAILS

10.1 For equipment interconnection, the surfaces of equipment terminal pads, Aluminium tube, conductor & terminal clamps and connectors shall be properly cleaned. After cleaning, cont grease shall be applied on the cont 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.

10.2 Muslin or leather cloth shall be used for cleaning the inside and outside of hollow insulators.

10.3 All support insulators, circuit breaker interrupters and other fragile equipment shall preferably be handled with cranes having suitable booms and handling capacity.

10.4 Bending of Aluminum 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.

10.5 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.

10.6 Handling of equipment shall be done strictly as per manufacturer's/supplier's instructions/instruction manual.

10.7 Handling equipment, sling ropes etc. should be tested periodically before erection for strength.

10.8 The slings shall be of sufficient length to avoid any damage to insulator due to excessive swing, scratching by sling ropes etc.

## 11.0 STORAGE

11.1 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 state of nature or accidents. The storage instructions of the equipment manufacturer/Owner shall be strictly adhered to.

## 12.0 CABLING MATERIAL

### 12.1 CABLE TAGS AND MARKERS

12.1.1 Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.

12.1.2 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.

12.1.3 Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanised iron plate.

12.1.4 Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable joints".

12.1.5 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.

12.1.6 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.

### 12.2 Cable Supports and Cable Tray Mounting Arrangements

12.2.1 The Contractor shall provide embedded steel inserts on concrete floors/walls to secure supports by welding to these inserts or available building steel structures.

12.2.2 The supports shall be fabricated from standard structural steel members.

12.2.3 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.

12.2.4 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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12.3 **Cable Termination and Connections**

12.3.1 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.

12.3.2 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.

12.3.3 Supply of all consumable material shall be in the scope of Contractor.

12.3.4 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.

12.3.5 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.

12.3.6 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.

12.3.7 Spare cores shall be similarly tagged with cable numbers and coiled up.

12.3.8 All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively closed.

12.3.9 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.

12.3.10 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.

12.3.11 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.

12.3.12 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.

12.3.13 Crimping tool used shall be of approved design and make.

12.3.14 Cable lugs shall be tinned copper solderless crimping type conforming to relevant international standard. Bimetallic lugs shall be used depending upon type of cables used.

12.3.15 Solderless crimping of terminals shall be done by using corrosion inhibitory compound. The cable lugs shall suit the type of terminals provided.

## 12.4 STORAGE AND HANDLING OF CABLE DRUMS

12.4.1 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.

## 13.0 DIRECTLY BURIED CABLES

13.1 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.

13.2 The cable (power and control) between LT station, control room 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.

13.3 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.

## 14.0 INSTALLATION OF CABLES

14.1 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.

14.2 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.

14.3 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.

14.4 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.

14.5 Suitable arrangement should be used between fixed pipe / cable trays and equipment terminal boxes, where vibration is anticipated.

14.6 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.

14.7 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.

14.8 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.

14.9 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.

14.10 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

14.11 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.

14.12 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.

14.13 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.

14.14 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.

14.15 Metal screen and armour of the cable shall be bonded to the earthing system of the station, wherever required by the Owner.

14.16 Rollers shall be used at intervals of about two metres while pulling cables.

14.17 All due care shall be taken during unreeling, laying and termination of cable to avoid damage due to twist, kinks, sharp bends, etc.

14.18 Cable ends shall be kept sealed to prevent damage. In cable vault, fire resistant seal shall be provided underneath the panels.

14.19 Inspection on receipt, unloading and handling of cables shall generally be in accordance with relevant international standard.

14.20 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.

14.21 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.

14.22 Contractor shall furnish three copies of the report on work carried out in a particular week, indicating cable numbers, date on which laid, ual 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.

14.23 Contractor shall paint the tray identification number on each run of trays at an interval of 10 m.

14.24 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.

14.25 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.

14.26 **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.

14.27 **Conduits, Pipes and Duct Installation**

14.27.1 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.

14.27.2 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.

14.27.3 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.

14.27.4 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.

14.27.5 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.

14.27.6 Each conduit run shall be painted with its designation as indicated on the drawings such that it can be identified at each end.

14.27.7 Embedded conduits shall have a minimum concrete cover of 50 mm.

14.27.8 Conduit run sleeves shall be provided with the bushings at each end.

14.27.9 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.

14.27.10 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.

14.27.11 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.

14.27.12 For underground runs, Contractor shall excavate and back fill as necessary.

14.27.13 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.

14.27.14 All unarmoured cables shall run within the conduits from lighting panels to lighting fixtures, receptacles etc.

14.27.15 Size of conduit for lighting shall be selected by the Contractor during detailed engineering.

14.27.16 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.

14.27.17 Conduit supports shall be provided at an interval of 750mm for horizontal runs and 1000mm for vertical runs.

14.27.18 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.

14.27.19 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.

14.27.20 Spacing of embedded conduits shall be such as to permit flow of concrete

between them.

14.27.21 Where conduits are placed alongwith cable trays, they shall be clamped to supporting steel at an interval of 600mm.

14.27.22 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.

14.27.23 Conduit shall be installed in such a way as to ensure against trouble from trapped condensation.

14.27.24 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.

14.27.25 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 contrion of conduit run.

14.27.26 For long conduit run, pull boxes shall be provided at suitable intervals to facilitate wiring.

14.27.27 Conduit shall be securely fastened to junction boxes or cabinets, each with a lock nut inside and outside the box.

14.27.28 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.

14.27.29 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.

14.27.30 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.

14.27.31 After installation, the conduits shall be thoroughly cleaned by compressed air before pulling in the wire.

14.27.32 Lighting fixtures shall not be suspended directly from the junction box in the main conduit run.

## 15.0 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.

## 16.0 TESTING AND COMMISSIONING

16.1 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.

### 16.2 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.

### 16.3 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.

## 16.4 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.

## 16.5 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.

## 16.6 INSULATOR

Visual examination for finish, damage, creepage distance etc.

**16.7** All pre/commissioning invitees and works 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.

# CHAPTER 20: CIVIL WORKS

## 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 IS/ BS/ equivalent International Standards.

All civil works shall be carried out as per applicable Standards and Codes. All materials shall be of best quality conforming to relevant International Standards and Codes. In case of any conflict between Standards/ Code and Technical Specification, the provisions of Technical Specification shall prevail.

The Contractor shall furnish all design, drawings, labour, tools, equipment, materials, temporary works, constructional plant and machinery, fuel supply, transportation and all other incidental items not shown or specified but as may be required for complete performance of the Works in accordance with approved drawings, specifications and direction of NEA.

The work shall be carried out according to the design/drawings to be developed by the Contractor and approved by the NEA. For all buildings, structures, foundations etc. necessary layout and details shall be developed by the Contractor keeping in view the functional requirement of the substation facilities and providing enough space and access for operation, use and maintenance. Certain minimum requirements are indicated in this specification for guidance purposes only. However, the Contractor shall quote according to the complete requirements.

## 1.1 STANDARD AND REFERENCES

All equipment, materials, fabrication and tests under these Specifications shall conform to the latest applicable standards, manuals and Specifications contained in the following list or, to equivalent applicable standards, manuals and Specifications, established and approved in the country of manufacturer, and approved as equal by Employer.

| | |
|---|---|
| IS | Bureau of Indian Standard |
| BS | British Standard |
| ACI | American Concrete Institute |
| AISC | American Institute of Steel Construction |
| ANSI | American National Standard Institute |
| ASCE | American Society of Civil Engineers |
| ASTM | American Society for Testing Materials |
| AWS | American Welding Society |
| JIS | Japanese Industrial Standards |

Any details not specifically covered by these standards and specifications shall be subject to

approval of Employer. In the event of contradictory requirements between the standards and these Specification requirements, the terms of the Specifications shall apply.

Unless specifically mentioned, reference to standards and specifications or to equipment and materials of the particular manufacture shall be considered as followed by "or equivalent". The Contractor may propose equivalent specifications, materials or equipment, which shall be equal in every respect to that specified. If the Contractor, for any reason, proposes equivalents to or, deviates from, the above standard, he shall state the exact nature of the change and shall submit complete specifications of the materials, as well as copies of pertinent standards, for the approval of Employer and decision of Employer in the matter of quality shall be final.

## 1.2 SCOPE OF WORKS

The following works shall be carried out at new substation to be constructed at Motipur and Sandhikharka 132/33/11 kV substation under the BPTSG 132kV TL project so as to complete the civil and architectural works in all respects, as required for the proper functioning of the substation.

All offices, housing facilities, plants and equipment, temporary structures and works, temporary construction and access roads and everything else which will be used or needed for the performance of the works.

Together with the bid, the Bidder shall submit a drawing showing the overall layout of the proposed site installation. A final layout for site installation shall be prepared by the Contractor and approved by Employer before any construction work takes place at the site.

i. Site clearing and stripping
ii. Site grading
iii. Design, manufacture, supply, installation and testing of substation steel structures.
iv. Design of RCC foundations of steel structures, equipment and lighting fixtures.
v. Design and construction of approach roads.
vi. Construction of cable trench system, conduit, duct bank and hand hole.
vii. Design and construction of control room, staff quarter, guard house and store Buildings.
viii. Construction of crushed rock surfacing.
ix. Construction of drainage system.
x. Design, supply and installation of Illumination systems for all buildings including supply and installation of Fans in the staff quarter, guard and store buildings.
xi. Design and supply of furniture and miscellaneous indoor facilities for control, staff quarter, guard and store buildings.
xii. Supply and installation of miscellaneous outdoor facilities
xiii. Design and construction of protection works
xiv. Design and construction of switchyard fence
xv. All associated and necessary civil and architectural works to complete the specified scope of work

## 1.3 Working Schedule

A binding graphical working schedule with an explanatory report shall be submitted before the construction period. The working schedule and any amendments to it during the construction period will require Employer's approval.

## 2.0 GEOTECHNICAL INVESTIGATION

### 2.1 GENERAL

The Contractor shall perform a detailed soil investigation to arrive at sufficiently accurate, general as well as specific information about the soil profile and the necessary soil parameters of the site in order that the foundation of the various structures can be designed and constructed safely and rationally.

A detailed soil report including field data duly certified by site engineers of NEA will be submitted by the Contractor for specific approval of NEA**.** The report shall contain all soil parameters for type of foundation i.e. pile or open type, soil treatment if any etc. to be used for the design of civil foundations.

The Contractor may visit the site to ascertain the soil parameters. Any variation in soil data shall not constitute a valid reason for any additional cost & shall not affect the terms & conditions of the contract. Field tests must be conducted covering entire substation area including all the critical locations i.e. Control Room and other Buildings, Lightning Mast, Towers, transformers etc.

### 2.2 SCOPE OF WORK

This specification covers all the work required for detailed soil investigation and preparation of a detailed report. The work shall include mobilisation of necessary equipment, providing necessary engineering supervision and technical personnel, skilled and unskilled labour etc. as required to carry out field investigation as well as, laboratory investigation, analysis and interpretation of data and results, preparation of detailed Geo-technical report including specific recommendations for the type of foundations and the allowable safe bearing capacity for different sizes of foundations at different founding strata for the various structures of the substation. The Contractor shall make his own arrangement for locating the co-ordinates and various test positions in field as per the information supplied to him and also for determining the reduced level of these locations with respect to the benchmark indicated by the NEA. All the work shall be carried out as per latest edition of the corresponding relevant IS/ BS/ equivalent International Standards. The Agency carrying out the soil investigation work must have the experience of carrying out soil investigation successfully in the relevant field. NEA shall assess the capability of the agency for soil investigation work for which technical inputs may be furnished to NEA.

#### 2.2.1 Bore Holes

Bore holes of Minimum 150 mm diameter in accordance with the provisions of relevant IS/ BS/ equivalent International Standards at the rate of minimum one number bore hole per hectare up to 20 meter depth (Minimum) or to refusal which ever occur earlier shall be drilled for new areas (132 kV Yards and 33 kV yards wherever applicable). In any case number of boreholes shall not be less than five. By refusal it shall mean that a standard penetration blow count (N) of 100 is recorded for 30 cm penetration. Number of boreholes may be increased in case soil strata are

varying from borehole to borehole in order to have fair idea of soil profile. In case of deep pile foundations soil investigation is to be carried out up to 25 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.

Standard Penetration Tests shall be performed 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 IS/ BS/ equivalent International Standards.

Undisturbed samples shall be collected in accordance with the recommendation of relevant IS/ BS/ equivalent International Standards. Or an alternative recognize method as agreed by NEA. Undisturbed samples shall be taken in cohesive material or weak cemented granular material where ever possible at 1.0 m interval or at each change in stratum.

The depth of Water Table, if encountered, shall be recorded in each borehole. In case the soil investigation is carried out in winter/summer, the water table for rainy season shall be collected from reliable sources and recorded in the report.

All samples, both disturbed and undisturbed, shall be identified properly with the borehole number and depth from which they have been taken.

The sample shall be sealed at both ends of the sampling tubes with wax immediately after the sampling and shall be packed properly and transported to the Contractor's laboratory without any damage or loss.

The logging of the boreholes shall be compiled immediately after the boring is completed and a copy of the bore log shall be handed over to the Engineer-in-change.

### 2.2.2 Trial Pits

The Contractor shall excavate two number trial pits for each Motipur and Sandhikharka substation as and where directed by NEA, of Plan area 10 sq. m and not exceeding 4 m depth. Undisturbed samples shall be taken from the trial pits as per the direction of the NEA. All Trial Pits shall be re-filled with approved material after the tests are complete and shall be compacted in layers of not more than 500 mm.

### 2.2.3 Plate load test

Two number of Plate load tests shall be conducted each at the location of control room / Staff quarter, Guard and store building 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 IS/ BS/ equivalent International Standards. 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 IS/ BS/ equivalent International Standards.

Backfilling of the pit shall be carried out as per the directions of the NEA**.** Unless otherwise specified the excavated soil shall be used for this purpose. In cases of gravel-boulder or rocky strata, respective relevant codes shall be followed for tests.

### 2.2.4 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.

### 2.2.5 Back Filling of Bore Holes

On completion of each hole, the Contractor shall backfill all bore holes as directed by the NEA. The backfill material can be the excavated material.

### 2.2.6 Laboratory Test

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.

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 IS/ BS/ equivalent International Standards.

The following laboratory tests shall be carried out

i. Visual and Engineering Classification
ii. Atterberg's limits Tests.
iii. Natural moisture content, bulk density and specific gravity.
iv. Grain size distribution analysis.

v. Swell pressure and free swell index determination.

vi. California bearing ratio.

vii. Consolidated drained test with pore pressure measurement.

viii. 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.

ix. In case rock is encountered, the soil test required for rock as per relevant IS/ BS/ equivalent International Standards including following tests shall also be conducted.

a. UCC test.
b. Point load index test.

### 2.2.7 Test Results and Reports

The Contractor shall submit the detailed report in two (2) copies wherein information regarding the geological detail of the site, summarised observations and test data, bore logs, and conclusions and recommendations on the type of foundations with supporting calculations for the recommendations. The contractor shall also submit the bearing capacity calculation in editable soft copy to NEA. Initially the contractor shall submit draft report and after the draft report is approved, the final report in two (2) copies shall be submitted. The field and laboratory test data shall bear the signatures of the Investigation Agency, Contractor and also site representative of NEA.
The report shall include, but not limited to the following:-

i. 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.

ii. 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.

iii. Test results of field and laboratory tests shall be summarised strata wise as well in combined tabular form. All relevant graphs, charts tables, diagrams and photographs, if any, shall be submitted along with report. Sample illustrative reference calculations for settlement, bearing capacity, pile capacity shall be enclosed.

**Recommendations:** The report should contain specific recommendations for the type of foundation for the various structures envisaged at site. The Contractor shall acquaint himself about the type of structures and their functions from the NEA. The observations and recommendations shall include but not limited to the following:

i. 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.

ii. 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.

iii. 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.

iv. Recommendations regarding slope of excavations and dewatering schemes, if required.

v. 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.

vi. 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.

vii. Recommendations for additional investigations beyond the scope of the present work, if considered such investigation as necessary.

viii. In case of foundation in rocky strata, type of foundation and recommendation regarding rock anchoring etc. should also be given.

## 2.4 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 IS/ BS/ equivalent International Standards. The test shall be conducted using Wagner's four electrode method as specified in relevant IS/ BS/ equivalent International Standards. Unless otherwise specified at each test location, the test shall be conducted along two perpendicular lines parallel to the coordinate axis. On each line a minimum of 8 to 10 readings shall be taken by changing the spacing of the electrodes from an initial small value of 0.2 m up to a distance of 50.0 m.

# 3.0 CONTOUR SURVEY, SITE LEVELLING

## 3.1 GENERAL

Site shall be cleared, surveyed and levelled/sloped by the contractor as per approved general arrangement drawing or levelling area decided during detailed engineering after award of work.

Work covered under this clause comprises the site clearance, survey work/setting out and making profiles (preparation of plot plan, setting up Bench Mark and taking spot levels at 05m x 05 m interval, preparation of contour plan with contour interval of 0.50 m), Earth work in Excavation & filling in specified area with all lifts and leads and earth work in filling with borrowed earth with all leads and lifts (Borrow areas including payment of royalty for borrowed earth shall be arranged by the contractor at his own cost). During detailed engineering stage, the contractor will prepare the levelling proposal for optimum levelling and submit to NEA for approval. Contractor shall submit the hard copy and editable soft copy of levelling proposal (levelling quantity calculation in Excel form and levelling drawing in Auto CAD) to NEA for approval.

The land for construction of substation will be handed over to the successful bidder as on where basis progressively after award of work. The contractor shall carry out survey work by taking spot level at 05 m x 05 m grid interval with respect to temporary bench mark transferred from permanent bench mark in the locality if available either on bridge, government buildings of local authorities or any other permanent structure. The contractor shall submit the spot levels (in grid format) in editable soft copy in excel format and contour map with contour interval of 0.5 m in editable auto cad soft drawing.

The contractor will level the area required for construction of substation work either at single level, multi-level or gradual slope with the finished ground level as approved by NEA during detailed engineering based on highest flood level. The levelling area shall be decided by NEA during detailed Engineering stage.

The layout and levels of all structure etc. shall be made by the Contractor at his own cost from the general grids of the plot and benchmarks set by the Contractor and approved by NEA. The Contractor shall provide all assistance in instruments, materials and personnel to NEA for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

## 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 FILLING MATERIAL

Filling material shall conform to relevant IS/ BS/ 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 IS/ BS/ equivalent International Standards.

### 3.4 EXCAVATION MATERIAL

All materials involved in excavation shall be classified by NEA in the following groups:

**3.4.1 All kinds of soils and soft/disintegrated rocks (Not requiring blasting):** The material which can be quarried/excavated with pick, shovel, jumpers, scarifiers, crowbars and mechanical implements and will include various types of soils, plain cement concrete, shingle, river/nallah boulders, soling of road/foot path, stone masonry, soft conglomerate and laterite stone, lime stone and hard conglomerate etc.

**3.4.2 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.

### 3.5 MEASUREMENT

i. 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.

ii. The volume of hard rock shall be computed on the basis of stack of excavated rubble after making 50 % deduction for voids.

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. The Contractor shall give all help in instruments, materials and personnel to the NEA for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

### 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

i. 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 IS/ BS/ equivalent International Standards.

ii. 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.

iii. Material unsuitable for founding of foundations shall be removed and replaced by suitable fill material to be approved by the NEA.

iv. Backfill material around foundations or other works shall be suitable for the purpose for which it is used and compacted to the density described under Compaction. Excavated material not suitable or not required for backfill shall be disposed off in areas as directed by purchaser up to a maximum lead of 2 km.

## 4.4 EXCAVATION AND BACKFILL

### SCOPE

This clause covers excavation for foundation works of Towers, Equipment support structures, Transformer foundations, External Lighting poles, Cable trenches, Buildings, Fire Wall, etc. backfilling of Foundations Works.

i. Excavation and backfill for foundations shall be in accordance with the relevant IS/ BS/ equivalent International Standards.

ii. 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.

iii. 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.

iv. 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.

v. 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

i. The density to which fill materials shall be compacted shall be as per relevant IS/ BS/ equivalent International Standards or as per direction of NEA. All compacted sand filling shall be confined as far as practicable. Backfilled earth shall be compacted to minimum 95% of the Standard Proctor's density at OMC. The sub grade for the roads and embankment filling shall be compacted to minimum 95% of the Standard Proctor's density at OMC. Cohesion less material sub grade shall be compacted to 70% relative density (minimum).

ii. 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.

iii. 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.

## 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, SAND FILLING, PLASTIC LAYING & 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 sand and black plastic laying shall be done in the areas of the switchyard under present scope of work within fenced area.

## 5.2 GENERAL REQUIREMENT

The material required for site surfacing/stone filling shall be free from all types of organic materials and shall be of standard quality, and as approved by the NEA.

The material to be used for stone filling/site surfacing shall be uncrushed/crushed/broken stone of 40 mm nominal size (ungraded single size) conforming to relevant BS. Hardness, flakiness shall be as required for wearing courses shall be as are per relevant IS/ BS/ equivalent International Standards.

i. Hardness
ii. Abrasion value as per relevant IS/ BS/ equivalent International Standards.
iii. Impact value as per relevant IS/ BS/ equivalent International Standards.
iv. Flakiness Index

One test shall be conducted as per relevant IS/ BS/ equivalent International Standards.

After all the structures/equipment are erected, anti-weed treatment shall be applied in the switchyard where ever stone spreading along with fine sand filling followed by laying of plastic of suitable thickness is to be done and the area shall be thoroughly de-weeded including removal of roots. The recommendation of local agriculture or horticulture department may be sought where ever feasible while choosing the type of chemical to be used. The anti-weed chemical shall be procured from reputed manufacturers. The doses and application of chemical shall be strictly done as per manufacturer's recommendation. Nevertheless the effectiveness of the chemical shall be demonstrated by the contractor in a test area of 10M X 10M (approx.) 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. The final approval shall be given by NEA based on the results.
NEA shall decide final formation level so as to ensure that the site appears uniform devoid of undulations. The final formation level shall however be very close to the formation level indicated in the approved drawing.

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. The sub grade shall be consolidated by using one ton roller with suitable water sprinkling arrangement to form a smooth and compact surface. The roller shall run over the sub grade till the soil is evenly and densely consolidated and behaves as an elastic mass.

In areas that are considered by the NEA to be too congested with foundations and structures for proper rolling of the site surfacing material by normal rolling equipments, the material shall be compacted by hand, if necessary. Due care shall be exercised so as not to damage any foundation structures or equipment during rolling compaction.

After completion of the compaction inside the switchyard area, contractors has to fill the 100 mm fine sand and over which black plastic of suitable thickness shall be laid before spreading the stones of first layer.

A final layer of 150 mm thickness of uncrushed/crushed/broken stone of 40 mm nominal size (ungraded size) shall be spread uniformly over sand and plastic cover layer.

## 6.0 ROADS INSIDE/OUTSIDE NEA BOUNDARY

### 6.1 GENERAL

i. All the roads required 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.

ii. All black top (Bituminous/Asphalt) roads within substation boundary wall and outside shall be with 3.75 m asphaltic pavement of suitable thickness and 1.3 m wide earthen shoulder on either side of the road. Below black top pavement, water bound macadam of adequate thickness as per design (WBM) shall be laid.

iii. Strengthening of existing roads as applicable (as shown in General Arrangement Drawing) shall be carried out with 2.5 cm thick premix carpet and 100 mm thick compacted layer of WBM (Water Bound Macadam) after filling the pot holes of existing roads with WBM material.

iv. All roads shall be designed as per relevant IS/BS/ equivalent International Standards. All drawings of road and culverts shall be prepared by the contractor.

v. All the culverts and allied structures (required for road/rail, drain, trench crossings etc.) shall be designed as per relevant IS/BS/ equivalent International Standards.

### 6.2 OTHER ROAD WORKS

Other works like grading, stone soling, graveling at river protection zone shall be done as instructed by site engineer and payment will be based on quoted price per unit measurement as explained in bid price schedule (BPS).

### 6.3 ASPHALT PAVEMENT

Pavement Materials

Sub-base

Sub-base shall be a non-plastic, sandy, granular material with a C.B.R. value greater than 15. It shall be free of deleterious material and subjected to the Employer's approval. Thickness of sub-base course shall be 30cm compacted.

Base course

Base shall be of WBM (water bound macadam) using crushed aggregate with a CBR value greater than 80. The filler material for WBM shall be stone dust. It shall be free of deleterious material and subjected to the Employer's approval. Thickness of base course shall be 15cm compacted.

It shall conform to following gradation:

| Sieve size | Percentage passing |
|---|---|
| 1 1"/2 | 100 |
| 3/4" | 90 - 100 |
| 3/8" | 50 - 80 |
| No.4 | 35 - 55 |

| | |
|---|---|
| No.30 | 10 - 30 |
| No.200 | 2 – 9 |

Wearing course

Wearing course shall be of asphalt concrete mixture (minimum 50mm 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 100 mm.

## 7.0 TRANSFORMERS FOUNDATION & TRANSFORMER SHIFTING RAIL FOUNDATION

The Contractor shall design, prepare drawing and provide a RCC Rail cum road system integrated with the Transformer foundation to enable installation and the replacement of any failed unit. The transfer track system shall be suitable to permit the movement of any failed unit fully assembled (including OLTC, bushings) with oil. This system shall enable the removal of any failed unit from its foundation to the nearest road. If trench/drain crossings are required then suitable R.C.C. culverts shall be provided in accordance with relevant BS. The Contractor shall provide a pylon support system for supporting the fire fighting system.

Each Transformer including oil conservator tank and cooler banks etc. shall be placed in a self-sufficient pit surrounded by retaining walls (Pit walls). The clear distance of the retaining wall of the pit from the Transformer shall be 20% of the Transformer height or 0.8m whichever is more. The oil collection pit thus formed shall have a void volume equal to 130% for 132 kV & below of total oil in the Transformer. The minimum height of the retaining walls shall be 15 cm above the finished level of the ground to avoid outside water pouring inside the pit. The bottom of the pit shall have an uniform slope towards the sump pit. While designing the oil collection pit, the movement of the Transformer must be taken into account.

The grating shall be made of MS flat of size 40 mm x 5 mm placed at 30 mm center to center and 25 mm x 5 mm MS flat at spacing of 150 mm at right angle to each other. Maximum length of grating shall be 2000 mm and width shall not be more than 500 mm. The gratings, supported on ISMB 150 mm, shall be placed at the formation level and will be covered with 100 mm thick layer of broken/crushed/non-crushed stone having size 40 mm to 60 mm which acts as an extinguisher for flaming oil. All steel works used for grating and support in transformer foundation shall be painted with Zinc phosphate primer (two packs) conforming to relevant IS/ BS/ 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.

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.

**8.0 SUBMISSIONS**

The following information/documents/drawings shall be submitted for review and approval:

i. Structural design calculations, Structural drawings (including construction/ fabrication), both in hard and soft copies, for all reinforced concrete and structural steel structures.
ii. Fully dimensioned and detailed floor plans, cross-sections, longitudinal sections and elevations identifying the major building components.
iii. Product information of building components and materials, including walls, partitions, flooring, ceilings, roofing, doors, wall panelling and windows and building finishes along with BOQ.
iv. A detailed schedule of building finishes including colour schemes along with item description.
v. 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.

**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 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 2.0 meter clearance shall be provided between the equipments (e.g. Transformer 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 IS/ BS/ equivalent International Standards.

No separate measurement and payment for fire wall/ partition wall shall be made.

## 10.0 FOUNDATION / RCC CONSTRUCTION
## 10.1 GENERAL

i. Work covered under this Clause of the Specification comprises the design, drawing and construction of foundations and other RCC constructions for buildings foundation, switchyard tower structures, bus supports, equipment supports, cable trenches, Transformer, jacking pad, pulling blocks, fire protection walls, control cubicles, marshalling kiosks, auxiliary equipments, Control, Staff quarter, Guard and store building, water tanks, Panel room, 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.

ii. Concrete shall conform to the requirements mentioned in relevant IS/ BS/ equivalent International Standards. And all the tests shall be conducted as per relevant IS/ BS/

equivalent International Standards. However, a minimum grade of **M20 (design Mix) concrete** shall be used for all foundations and structural/load bearing members as per relevant IS/ BS/ equivalent International Standards.

iii. 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.

iv. The switchyard foundation's plinths and building plinths shall be minimum 300 mm and 500 mm above finished ground level respectively.

v. Minimum 75 mm thick lean concrete (1:3:6) shall be provided below all underground structures, foundations, trenches etc. to provide a base for construction.

vi. The cement shall be ordinary Portland cement of approved brand and manufacture and shall comply in all respects with the I.S. 269-1967 for ordinary Portland cement. It shall be delivered on the site in packages with an unbroken seal fixed by the manufacturer and plainly marked with the name of brand and the manufacture. It shall be stored in a dry place, in regular piles not exceeding six bags high and in such a manner that it will be efficiently protected from moisture and contamination, and that the consignments can be used up in the order in which they are received. Set cement shall be immediately removed from the work and replaced by the Contractor at his own expense. If desired, tests shall be made by taking samples of cement from stores or elsewhere from the works. The selection of samples and procedure for testing shall comply with appropriate I.S. specification.

vii. 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.

viii. 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 IS/ BS/ 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.

ix. 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.

x. All aggregates shall conform to I.S. 383 - 1970. Aggregate shall, where possible, be derived from a source that normally produces aggregate satisfactory for concrete, and if requested by the Employer/ Engineer, the Contractor shall supply evidence to this effect. If instructed to do so, the contractor shall supply samples of the aggregate for the purpose of making preliminary concrete test cubes as herein-after specified. Aggregate shall consist of naturally occurring sand and gravel or stone crushed or uncrushed, or a

combination thereof. They shall be hard, strong, dense, durable, clean and free from veins and adherent coating. As far as possible, flaky and elongated pieces should be avoided. Aggregate shall not contain any harmful materials, such as iron pyrites, coal, mica, shale or similar laminated materials, clay, alkali, soft fragments, organic impurities etc. in such quantity as to affect the strength or durability of the concrete or in addition to the above for reinforced concrete, any material which attack the reinforcement. Aggregate which are chemically reactive with the alkalis of cement are harmful, as cracking of concrete may take place. These aggregate shall be protected from spilling oils, mobiles, diesels over it on site.

xi. The fine aggregate shall be natural sand or sand derived by crushing suitable gravel or stone and shall be free from coagulated lumps. Sand derived from a stone unsuitable for coarse aggregate shall not be used as the fine aggregate. The fine aggregate shall conform to the requirements of I.S. 383 - 1970. Fine aggregate shall not contain more than 3% of material removable by decantation test, nor more than 1% dry lumps. The total of coal, clay lumps, shale, soft fragments and other deleterious substance shall not be more than 5%. The percentage of clay lumps shall be determined by examining the various fractions that remain after the material has been tested for grading. Any particles that can be broken with fingers shall be classified as clay lumps and the total percentage of clay lumps shall be determined on the basis of the total original weight of the sample. Blending will be permitted in order to meet the gradation requirements for the fine aggregate. The fine aggregate shall be well graded from fine to coarse and shall meet the following gradation requirements:

**Table - 1 GRADATION FOR FINE AGGREGATE**

Percentage by weight passing required as per IS 383:1970

| Sieve Designation | 10mm | No.4 | No.16 | No.30 | No.50 | No.100 |
|---|---|---|---|---|---|---|
| Fine Aggregate | 100 | 90-100 | 30-70 | 25-55 | 5-20 | 0-10 |

xii. The coarse aggregate shall be crushed stone aggregate. The pieces of aggregates shall be angular. Friable, flaky and laminated pieces, mica, shale shall only be present in such quantities as not to affect adversely the strength and durability of the concrete as ascertained by tests on concrete cubes. After twenty four hours immersion in water, a previous dried sample shall not have gained in weight more than 5% and not more than 10% if it is to be used in plain concrete or elsewhere as described. The coarse aggregate shall conform to the requirements of I.S. 383 - 1970. The percentage of wear at 500 revolutions of Los Angeles Rattler Test shall not be more than 50%. The coarse aggregate shall meet the gradation of Table-2. Moreover it should conform previous specification on coarse aggregate.

**Table - 2 GRADATION FOR COARSE AGGREGATE.**

Percentage by weight passing required as per IS 383:1970

| Sieve Designation | 40mm | 20mm | 10mm | 4.75mm |
|---|---|---|---|---|
| 40mm down | 95-100 | 30-70 | 10-35 | 0-5 |
| 20mm down | 100 | 95-100 | 25-55 | 0-10 |

xiii. All R.C.C. work shall be carried out in strict accordance with this specification, I.S. Specifications and the working drawings. Any discrepancies in the dimensions on the drawings or any points not clear to the Contractor shall be brought to the notice of the Employer/ Engineer or clarified in advance before proceeding with the work.
The Contractor shall allow for all wastage in all materials. He shall also allow for all tests of concrete materials and if required produce manufacturer's certificate for cement and steel unless issued by the Owner. All form work should be get checked for levelling and dimensions as well as all necessary supporting spouts from the Employer/ Engineer. Only after getting the formwork checked, reinforcement should be placed properly as according to the drawing and detailing.
The date and time of any casting of concrete should be informed to the Engineer/Employer's 2 days in advance. No concrete work shall be cast in the absence of the Employer/ Engineer. The Contractor shall personally check that both the formwork and reinforcement have been correctly placed and fixed and satisfy himself that all work preparatory to casting is completely ready, before requesting the Employer/ Engineer for final inspection and approval.

xiv. The materials used in the works shall be of the qualities and kinds specified. Materials delivered to the works shall be equal to the approved samples which shall be deposited with the Employer/ Engineer at least 30 days before it is required for use in work. The quantity of all necessary materials should be checked by the Employer/ Engineer for any casting. Delivery shall be made sufficiently in advance of constructional requirements to enable further samples to be selected and tested if so desired by the Employer/ Engineer. No material shall be used in the works until approved. Materials failing to comply with the approved samples and specification shall be immediately removed from the works at the Contractor's Cost.

xv. In general, water cement ratio (w/c ratio) of the concrete mix shall be kept minimum during casting. Generally one bag of cement concrete mix shall use 35.6 litres of water or as necessary. As moisture content of fine and coarse aggregate varies, for workability of concrete mix, the Employer/ Engineer may vary the water quantity and once the water quantity to be placed for one bag of cement concrete mix, is fixed by the Employer/ Engineer, the Contractor shall follow it strictly. As information to the Contractor, the Employer/ Engineer will depute one checking supervisor to the mixing batch, the quantity of water used shall be varied to suit the moisture content of the aggregate, and shall be just sufficient to produce a dense concrete, consistent with practical workability.

xvi. The interval between adding the water to the dry mix and completion of the concrete placing operation shall not exceed 20 minutes nor, when an approved admixture that accelerates the initial setting of the cement be used, exceed ten minutes or as directed by the Employer/ Engineer. Except where otherwise approved for slabs and large sections

concrete shall be placed in the formwork by shovels or other approved implements and shall not be dropped from height more than 1.5 m nor handled in a manner to cause segregation. Accumulations of hardened concrete dropping on the reinforcement shall be avoided. Concrete shall be sorted along the formwork to that position.

Each layer of concrete while being placed shall be compacted by approved methods of ramming or mechanical vibrations to form a dense surface free from honey combing and tolerably free from water marks and air holes or other blemishes. The concrete shall be tamped against the face of the formwork so as to produce dense fair surface. The number and type of mechanical vibrations shall be approved before compacting by vibration. Placing and compaction of concrete shall be done in such a manner as not to disturb concrete already placed, and reinforcement projecting from concrete already placed shall not be vibrated or jarred. For concreting reinforced concrete walls and other structures having least lateral dimensions of 13mm. or under, each layer of concrete while being placed shall be properly compacted by approved methods of mechanical vibrations produced by internal or external mechanical vibration.

The laying of concrete over slabs should be uniform thick of required thickness after vibration. This can be confirmed by dipping wooden pegs of required length. The level of all slabs should be in level unless otherwise specified and directed by the Employer/ Engineer. If required, the Employer/ Engineer will check the thickness and give order to the contractor to fill up the newly vibrated slab concrete surface. Any slab thickness after construction, if found less thickness than specified, the contractor will be responsible for above job.

xvii. Any water accumulating on the surface of the newly placed concrete shall be removed by approved means and no further concrete shall be placed thereon until such water is removed. No fresh concrete shall be brought into contact with the concrete containing cement of different type. Unless otherwise approved or instructed, concrete shall be placed in a single operation to the full depth of slabs, beams, and members similar thereto and shall be placed in horizontal layers not exceeding 0.50m deep in walls, columns until completion of the part of the work between construction joints as specified hereafter or of a part of approved extent. At the completion of a specified or approved part of a construction, joints of the form and in the position herein after specified shall be made. If a temporary cessation of concrete placing be unavoidable elsewhere, a construction joint shall likewise be made.

xviii. The contractor must use vibrator on beams and slabs to compact the newly laid concrete. Generally two types of vibrator shall be used.

a. NEEDLE OR IMMERSION TYPE OF VIBRATOR

Casting fall beams and columns shall be compacted by means of needle type of vibrator. 4" diameter needle type vibrator shall be used over beam section more than 350mm x 400mm and rest of section need only 2" diameter needle type vibrator.

b. FLAT BOTTOM VIBRATOR FOR SLABS

The contractor shall require flat bottom type of vibrator to compact all concrete over slabs. No immersion type of vibrator will be allowed to compact the concrete over slab.

Moreover, the contractor shall require at least two number of vibrator for one casting and other should kept in standby position. In case vibrator got damaged or not in working condition during casting, the vibrator shall be immediately replaced. If the contractor shall fail to replace another vibrator during casting, no further casting of concrete will be permitted. The contractor shall in that case, immediately remove the remaining concrete mix from the site of work.

Segregation is likely to take place when the concrete is tipped into the form work and this should be avoided. The concrete mix should not contain surplus water and sand which will develop segregation under influence of vibratory compaction. The distribution of new concrete should be uniform over the whole section and the surface kept horizontal all the time thus ensuring the movement of concrete is downward only. Vibrators shall not be used as a spreading or distributing agent.

The vibrators shall be of rotary out of balance immersion type or the electro-magnetic type and operate at a frequency of not less than 4,000 cycles per minute. The vibration shall be of such a power - input as to produce an acceleration of 1 to 3 m/sec in the mass of the compacted concrete. The vibrators shall be provided for continuous operation.

Vibration shall continue during the whole period occupied by placing the concrete, the vibration being adjusted so that the centre of vibration approximates to centre of the mass being compacted at the time of placing. The concrete should not be over vibrated and the period of insertion of internal vibrator should be about 15 seconds at any point.

The concrete shall be judged to be compacted when the mortar fills the spaces between the coarse aggregate so as to form a glistening and even surface except for slight irregularities where the coarse aggregate breaks this smooth surface. When this condition has been attained, the vibrators shall be withdrawn slowly.
The vibrator must not be placed against the steel or the formwork, the minimum distance being 8 mm. It must be placed in such a position that formwork, reinforcement and recently laid concrete are subjected to the minimum amount of vibration.

xix. Construction joints shall be made in the positions hereinafter specified or elsewhere as approved. Such joints shall be truly vertical or horizontal as the case may be, except that in an inclined or curved members the joint shall be strictly at right angles to the axis of the member.
Construction joints shall be made horizontally at the top of the foundations and horizontally 8 mm. below the lowest beam soffit at the head of columns. Concrete in the ribs and slabs of small tee, all beams shall be placed in one operation, but, for large beams concrete in the rib upto a level 2.5 mm. below the slab soffit shall be placed first. Concrete in haunches or splays on the beams or braces and concrete in the head of adjoining portion of the columns shall be placed at the same time as that in the beams or braces. Concrete in splays at the junction of walls and slabs shall be placed at the same time as that in the slab. Construction joints in the length of a beam shall be avoided where practicable, but where joints are unavoidable they shall be made as previously approved by the Employer/

Engineer. Construction joints in slabs shall be made parallel to the main reinforcement, and where required at right angles to the main reinforcement, they shall be made at a place previously approved by the Employer/ Engineer.

Before placing new concrete against concrete already set, the face of the old concrete shall be cleaned and scum removed. The face shall be roughened and any loose aggregate removed there from. Immediately before placing the new concrete the face of the old concrete shall be thoroughly wetted and a coating of neat cement grout applied. The new concrete shall be well rammed against the prepared face before the grout sets. Construction joints will not be paid separately.

xx. Immediately after placing or finishing, concrete surface not covered by forms shall be protected from loss of surface moisture for at least seven days when the average daily temperature is at least 21$^{o}$C, where Portland cement has been used. Protection from loss of surface water shall be done by any of the following methods where applicable to the type of work involved:

a. By water covering.
b. By covering of surfaces with water impervious paper.
i. By application of approved impervious membrane.

Surfaces from which forms have been removed before the curing period has elapsed shall be protected as specified for surfaces not covered by forms. Membrane curing shall not be used on surfaces required to receive additional concrete / concrete fill or on cement finish coats that are to receive dust proofing or hardening treatments, during hot weather.

Water curing shall be performed by keeping the concrete surface wet by ponding, by continuous spraying or by covering the surface with an approved water-saturated covering such as 2.5 mm. of sand or sawdust, or by one or more layers of burlap. The exposed concrete surfaces shall be saturated with water throughout the full stipulated curing period. Where forms remain in place during the curing period, they shall be kept sufficiently wetted with clean water to reduce cracks and to prevent joints from opening in the forms.

The impervious membrane curing compound shall be an approved non-bituminous, colourless, liquid sealing compound in atomized form so as to preserve the natural colour of the concrete. The curing compound shall be applied as soon as surface water has disappeared from concrete surfaces with approved pressure spraying equipment in accordance with the manufacturer's directions and in sufficient thickness to form an effective water seal. No compounds shall be used which will adversely affect the subsequent installation of finished flooring.

Joints of sheet membrane used for curing shall be lapped at least 150mm and sealed with water proof tape as recommended by the manufacturer. Polyethylene sheet shall be considered the water-impervious paper for purposes of interpretation of this item. No liquid curing compound may be used without specific written approval of the Employer/ Engineer regarding type, manufacturer, location and extent of use and application procedures.

xxi. The concrete surface shall in general be smooth finish. However, immediately after stripping form work, minor defects and honey combed areas shall be patched and holes filled before the concrete is thoroughly dry, patch areas shall be chipped away to 2.5 mm depth, with regular edges perpendicular to the surface. Area to be patched shall be

thoroughly wet including the areas at least 150 mm. wide entirely surrounding them, just prior to placing the patching mortar. Mortar shall be of the same material and proportions as used for the concrete, without coarse aggregate. A sufficient quantity of white cement shall be substituted for part of the ordinary cement so that the patching mortar, when dry, will match the surrounding concrete. Water in the mix shall be kept to a minimum and mortar shall be re-tempered without adding water and shall be allowed to stand for one hour prior to use during which time it shall be mixed to prevent setting. The mortar shall be thoroughly compacted into place, screeded so as to leave the patch slightly higher than surrounding surfaces, left undisturbed for one to two hours to permit initial shrinkage and finished to match the adjoining work. Where patches exceed 2.5 mm. deep, they shall be trimmed and wet as specified, after which the opening shall be filled to within 2.5 mm. of the surface. After sufficient shrinkage time has elapsed, the patching shall proceed as described above.

Patches shall be kept wet for five days. Tie holes left by the withdrawal of rods, or holes left by removal of ends of ties shall be filled solidly with mortar. For holes passing entirely through the wall, plunger-type grease gun or other device to force mortar through the wall, starting at the back face, shall be used. When a hole is completely filled, excess mortar shall be struck off with a cloth flush with the surface. Holes not passing entirely through walls shall be filled solidly with mortar. Any excess mortar shall be struck off with a cloth on the wall surface. The surface of non-shuttered faces concrete work other than slabs shall be smoothed with a wooden float (or if approved with a steel trowel) to give a finish equal to that of the rubbed down shuttered faces. Concealed concrete faces shall be left as it is except that honeycombed surfaces shall be made good.

The top faces of slabs not intended to be surfaced shall be levelled and floated to a smooth finish at the levels or falls shown on the drawings or elsewhere.

The floating shall not be executed to the extent of bringing excess fine material to the surface. Ribbed surfaces of slabs shall where instructed be formed at the time of taming and levelling. Indentation in slab or stair surfaces shall be formed by approved implements giving the depth and patterns instructed. The top faces of slabs intended to be covered with screed, granolithic or similar surfacing shall be left with a spade finish.

The soffits of slabs and faces of walls intended to be rendered shall be roughened by approved means to form a key. Concrete surfaces to take finishes other than those specifically referred to herein shall be prepared in an approved manner to suit the finish as instructed.

xxii. The Employer/ Engineer shall instruct that a loading test be made on the works or any part thereof if in his opinion such a test be deemed necessary for one or more of the following reasons:

a. The site - made concrete test cubes failing to attain the specified strength.
b. Over - loading during construction of the works or part thereof.
c. The shuttering being prematurely removed.
d. Concrete improperly cured.
e. Any other circumstances attributable to alleged negligence on the part of the Contractor which in the opinion of the Employer/ Engineer may result in the works or part thereof being less than the expected strength.

f. Any reason other than the foregoing.

The test shall be made at the contractor's own cost. If the test be instructed to be made for one or more of the reasons from (a) to (e) inclusive, and If the test be instructed to be made for the reason (f), the contractor shall make the test and shall be reimbursed for all cost relating thereof irrespective of the result of the test.

For the purpose of the load test on floors, roofs and similar structures and their supports, the test load shall be equivalent to 1 and 2/3 times the superimposed load for which the works or part thereof to be tested have been designed. The test load shall not be applied within 90 days (or 28 days if rapid hardening Portland cement be used) of the completing of placing of the concrete in the part of the works to be tested, and the latter shall not be supported during the test by shuttering or other non-permanent support. Means shall be taken to ensure that in the event of a failure under the test temporary support of the loaded member shall be immediately available. The test shall proceed strictly as instructed. For the loading test on floors, roofs or similar structures the result shall be deemed satisfactory if upon removal of the test load the residual deflection does not exceed one - quarter of the maximum deflection after 24 hours loading. If the residual deflection exceeds this amount the test loading shall be repeated, and the result shall be deemed to be satisfactory if the residual deflection after removal of the second test load does not exceed one-quarter of the maximum deflection occurring during the second test.

If the result of the loading test be not satisfactory, the Employer/ Engineer shall instruct that part of the works concerned shall be taken down or removed and reconstructed to comply with this specification, or that such other remedial measures shall be taken as to make the works secure. If the test be instructed to be made for one or more of the reasons (a) to (e) inclusive as herein before specified, the Contractor shall take down or remove and reconstruct the defective work or shall take the remedial measures instructed at his own cost.

## 10.2 REINFORCEMENT

### 10.2.1 INSTALLMENT OF REINFORCEMENT STEEL

Supplying and fixing tor steel reinforcement in RCC work including bending, binding with GI wire, placing in position including the cost of binding wire, as per drawing

Reinforcement shall be free from pitting due to corrosion, loose rust, mill scale, paint, oil, grease, adhering earth, or other materials that may impair the bond between the concrete and the reinforcement or that may in the opinion of the Employer/ Engineer cause corrosion of the reinforcement or disintegration of the concrete.

### 10.2.2 BAR REINFORCEMENT

Bar reinforcement described as "TOR steel" shall be hot rolled deformed bars or cold twisted steel bars. With respect to manufacture, quality, physical properties and related requirements, reinforcement of the fore-going descriptions shall comply with appropriate parts of IS Standards Nos. 432-1966, 1139-1966 and IS 1786-1966 for mild steel and tor steel respectively.

### 10.2.3 CERTIFICATES AND TESTS FOR REINFORCEMENT

For each consignment of bar reinforcement used in the works, the Contractor shall, if required, supply a certificate giving the ultimate strength, yield stress and elongation and the result of the cold bend test for each type and each size of bar. Tests for the purpose of obtaining the information shall conform to relevant I.S. specification.

The reinforcements supplied for which the Manufacturer's test sheets or other records are not available, or where in the opinion of the Employer/ Engineer has been subject to corrosion or other bad effects, the Employer/ Engineer shall select as many test pieces as he deems necessary, and the Contractor shall supply and deliver the test pieces free of cost without reimbursement and pay the cost of preparing and testing them as well. This test shall be performed in presence of the Employer/ Engineer.

### 10.2.4 DIMENSIONS OF REINFORCEMENT

The size of reinforcement bar described in the working drawings or elsewhere shall be the minimum and the rolling margin and other tolerances shall be wholly above this size. The length of a reinforcement bar shall not be less than the length on the drawing or elsewhere and shall not be more than 50 mm in excess of that length. Bar bending schedule shall be prepared by the Contractor and submitted for approval of the Employer/ Engineer. Such schedules shall be prepared based on reinforcement details, prior to the execution of the work. Nothing extra shall be paid for this.

### 10.2.5 BENDING REINFORCEMENT

Reinforcement bars shall be bent by approved means producing a gradual and even motion. Bars shall comply with the dimensions described in the drawings. Overall dimensions of bent or internal dimensions of bending or the like shall be within a tolerance of 30 mm. Any discrepancies or inaccuracies found by the Contractor in the drawings or other documents shall be immediately reported to the Employer/ Engineer whose interpretation and requirements relating there to shall be accepted. The internal radius of bends shall be not less than twice the size of the bars unless described to the contrary on the bending lists or elsewhere in the drawing. Hooks and other anchorage bends for tor steel shall be bent to an internal radius of the twice diameter of the bar. This internal radius of the bends of corners of binders or stirrups or links shall be half.

### 10.2.6 FIXING REINFORCEMENT

Reinforcement shall be accurately fixed and by approved means maintained in the position described in the drawings. Bars intended to be in contact shall be securely wired together at all such points with 16 gauge soft iron tying wire. Binders, stirrups and links shall tightly embrace the bars with which they are intended to be in contact and shall be securely wired or, if approved, spot welded thereof.

Reinforcement shall be lapped, joined or spliced only at the positions described. Splices and the like found to be necessary elsewhere shall be formed only if and as instructed. Lapping shall be provided as shown in the drawing and as permitted. Where practicable bars in each member shall be assembled and fixed in the form of a rigid cage or skeleton before placing in the moulds or formwork. For this, all lapping bar on beams and slabs shall be scattered i.e. as far as possible

minimum number of laps shall be permitted in one section of slab and only one lap will be permitted at one section in case of beams. In case of columns the lapping of bar shall be permitted only at the centre zone of column.

### 10.2.7 LAPPING LENGTH

i. In case of beams and slabs, lapping length shall be 57 dia. of designed bar.
ii. In case of columns the lapping length shall be 45 dia. of the designed bar.

Immediately before concreting, the reinforcement shall be checked for position, cleanliness, free from rust or retarding liquid. Means shall be taken to ensure that reinforcement remains correctly in position with required cover during the placing and compacting of the concrete.

Reinforcement projecting from work being concreted or already concreted shall not be bent out or its correct position for any reason unless approved and shall be protected from deformation or other damage. Reinforcement left projecting for bending with future extensions shall be thoroughly coated with cement grout wash or encased in concrete or other-wise protected from corrosion as instructed.

### 10.2.8 COVER OF CONCRETE AND SPACING OF BARS

Unless otherwise described, the clear cover of concrete to the reinforcement shall be as follows:

#### 10.2.8.1 Horizontal, Vertical or Inclined Slabs

15 mm or the size of the bars whichever is greater.

#### 10.2.8.2 Lintels

20 mm or the size of the bar whichever is greater.

#### 10.2.8.3 Beams

25 mm or the size of the main bars whichever is greater. Binders and the like 15 mm minimum.

#### 10.2.8.4 Columns

Cover for main bars for columns not exceeding 20 mm diameter shall be 25 mm and the main bars in columns exceeding 20 mm diameter shall be 40 mm or the size of the main bars whichever is greater, 15mm minimum for rectangular binders or links or helical binding.

### 10.2.9 CHAIRS AND SUPPORTS FOR REINFORCING BARS

Chairs of appropriate depth in suitable form shall be installed on all top bars in case of slab. The shape of chair shall be checked by the Employer/ Engineer. The spacing for slab top bar chairs will be such that during casting time, the reinforcement shall not get disturbed.

### 10.2.10 CONCRETE CHAIR BLOCK FOR BOTTOM BARS

All bottom bars in slabs shall be raised as accordance with cover for concrete by means of small concrete blocks tied with binding wires. These blocks shall be placed at sufficient intervals during casting time, to maintain the cover for reinforcement.
In case of beams, the bottom blocks as well as side reinforcement shall be provided with concrete chair blocks so that the reinforcement shall not get disturbed during casting.

## 10.3 DESIGN

While designing foundations, following may be taken care of:

i. All foundations except for external lighting poles shall be of reinforced cement concrete. The external lighting pole shall be embedded in plain cement concrete (1:1.5:4) foundation. The design and construction of RCC structures shall be carried out as per relevant IS/BS/ equivalent International Standards 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.

ii. Limit state method or any other method as per relevant IS/BS/ equivalent International Standards of design shall be adopted unless specified otherwise in the specification.

iii. For detailing of reinforcement relevant IS/BS/ equivalent International Standards followed. Cold twisted deformed bars conforming to relevant IS/BS/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 IS/BS/ equivalent International Standards.

iv. RCC water retaining structures like storage tanks, etc. shall be designed as uncracked section in accordance with relevant IS/BS/ equivalent International Standards. However, water channels shall be designed as cracked section with limited steel stresses as per relevant IS/BS/ equivalent International Standards.

v. 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 IS/BS/ 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.

vi. Design shall consider any sub-soil water pressure that may be encountered following relevant standard strictly.

vii. 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.

viii. RCC columns shall be provided with rigid connection at the base.

ix. 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 IS/BS/ 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.

x. 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.

xi. 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.

xii. Following conditions shall be considered for the design of water tank in sumps, trenches and other underground structures:

a. Full water pressure from inside and no earth pressure & ground water pressure & surcharge pressure from outside (application only to structures which are liable to be filled up with water or any other liquid).

b. Full earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.

c. Design shall also be checked against buoyancy due to the ground water during construction and maintenance stages. Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the superimposed loadings.

xiii. 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.

xiv. 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.

xv. 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.

xvi. The foundations of transformer/reactor and circuit breaker shall be of lock type foundation. Minimum reinforcement shall be governed by relevant IS/BS/ equivalent International Standards.

xvii. The tower and equipment foundations shall be checked for a factor of safety as per

relevant IS/BS/ 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.

## 10.4 ADMIXTURES & ADDITIVES

i. 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.

ii. Admixtures in concrete shall conform to relevant IS/BS/ equivalent International Standards. The water proofing cement additives shall conform to relevant IS/BS/ equivalent International Standards. Concrete Admixtures/ Additives shall be approved by NEA.

iii. The Contractor may propose and the NEA may approve the use of a water-reducing set-retarding admixture in some of the concrete. The use of such an admixture will not be approved to overcome problems associated with inadequate concrete plant capacity or improperly planned placing operations and shall only be approved as an aid to overcoming unusual circumstances and placing conditions.

iv. The water-reducing setting-retarding admixture shall be an approved brand as per relevant IS/BS/ equivalent International Standards.

v. The water proofing cement additives shall be used as required/advised by NEA.

## 10.5 FORMWORK

### 10.5.1 CENTERING AND SHUTTERING

Centering and shuttering of plywood and steel formwork in slabs, walls, beams etc. including propping, strutting etc. and removal of forms including applying form oil to shuttering.

### 10.5.2 DESIGN

Formwork shall be designed and constructed for removal so that the concrete can be properly placed and thoroughly compacted. Formwork shall be firmly supported and adequately strutted, braced, or tied. It shall be capable of adjustment to the lines and dimensions of the finished concrete and it shall be sufficiently strong to resist without distortion, the pressure of concrete during its placing and compaction, and other loads to which it may be subjected. It shall not be liable to suffer distortion under the influence of the weather. When concrete is to be vibrated, special care shall be taken to ensure that the formwork will remain stable and the joints tight. The safety and adequacy of centering and shuttering shall be the sole responsibility of the Contractor. The Contractor shall if required supply to the Employer/ Engineer drawings and calculations for the formwork he proposes to use, for the concrete work.

### 10.5.3 MATERIAL FOR FORMWORK

All surface of the formwork shall be of plywood or steel plate which shall give uniform concrete surface after removal. No wooden planks or other means of form work shall be acceptable. For struts and props the Contractor shall use sal wood 75mm x 100mm props or Iron lifting type strut over form base i.e. it shall not get depressed at the time of loading or casting. Any strut, if found defective shall be replaced as directed by Employer/ Engineer.

### 10.5.4 DEFLECTION AND CAMBER

The Contractor shall make allowance for any settlement or deflection of the formwork that is likely to arise during Construction, so that the hardened concrete conforms accurately to the specified line and level. The Contractor shall also make allowance in the formwork for any camber specified by the Employer/ Engineer to allow for the elastic deflection of structural members and deflection due to creep of the concrete. In the absence of any specified camber, the soffit of all beams and slabs shall be given a camber equal to 1/240 of the span length to ensure that the structure has the prescribed shape after removal of the forms.

### 10.5.5 SUPPORTS

Formwork shall be constructed so that the formwork to the sides of members can be removed without disturbing the soffit formwork or its supports. Props and supports shall be designed to allow the formwork to be adjusted accurately to line and level and to be erected and removed in an approved sequence without damage to the concrete. Supports shall be carried out which is sufficiently strong to afford the necessary support without damage to any portion of the structure. This may mean in some cases that it be carried down to the foundations or other suitable base. Props and bracing shall be provided for the temporary support of composite construction where separately specified.

### 10.5.6 JOINTS AND EDGES

All joints in the formwork shall be close-fitting to prevent leakage of cement slurry from the concrete. At construction joints, formwork shall be tightly secured against previously cast or hardened concrete to prevent the formation of stepping or ridges in the concrete. Formwork shall be constructed to provide straight and true angles, arises or edges. Where cambers are shown on the Drawings, the fillets shall be accurately cut to size to provide a smooth and continuous chamfer. Formwork panels shall have true edges to permit accurate alignment at sides and provide a clean line at construction joints in the concrete which shall be fixed with their joints either vertical or horizontal, unless otherwise specified.

### 10.5.7 SUNDRIES

Formwork shall be provided to the top surface of concrete where the slope or the nature of the work requires it. Provision shall be made for forming holes and chases for services and for building in pipes, conduits and other fixings, as shown on the drawings. The material and position of any ties passing through the concrete shall be as directed by the Employer/ Engineer. Except where corrosion of a metal tie is unimportant, it shall be possible to remove a tie so that no part of it remaining embedded in the concrete shall be nearer to the finished surface of the concrete than the specified thickness of cover to the reinforcement. Any holes left after the removal of ties shall be filled with concrete or mortar of approved mix.

### 10.5.8 CLEANING AND TREATMENT OF FORMWORK

Spaces to be occupied by concrete shall be free from all rubbish, chipping, shavings, sawdust, dirt and tying wire etc., before concrete is placed. The formwork to be in contact with the concrete shall be cleaned and treated with a suitable non-staining form oil or other approved material. Care shall be taken that oil or composition is kept away from contact with the reinforcement or with concrete at any construction joints. Surface retarding agents shall not be used except with the permission of the Employer/ Engineer. Formwork shall be thoroughly cleaned after each use. Damaged or distorted formwork shall not be used.

### 10.5.9 PAINTING ON FORMWORK

The concrete repellent painting on all contact surface of the formwork shall be of approved non bituminous colourless form oil so as to preserve the natural colour of the concrete. The repellent compound shall be applied so as to effect quick removal of form work. It shall be applied as per the manufacture's direction. No compound shall be used which will adversely affect the concrete work or surface. No form repellent compound may be used without specific written approval of the Employer/ Engineer regarding type, manufactures, location and extent of use and application procedures.

### 10.5.10 REMOVAL OF FORMWORK

All formwork shall be removed without shock or vibration that might damage the concrete. Before the soffit and props are removed the surface of the concrete shall be exposed where necessary in order to ensure that the concrete has hardened sufficiently. In no circumstances shall formwork be struck of until the concrete reaches cube strength of at least three times the stress to which the concrete may be subjected at the time of striking. The formwork to vertical surfaces such as walls, columns and sides of beams may be removed after 24 hours in normal weather conditions although care must be taken to avoid damage to the concrete, especially to arises and features. In cold weather a longer period may be necessary before striking. Suitable curing methods should immediately follow the removal of the formwork. The following minimum times shall elapse before removal of formwork for OPC is used:

| SN. | MEMBERS | TIME(DAYS) |
|---|---|---|
| 1. | Wall, Columns, vertical sides of Beams | 1-2 |
| 2. | Slab soffit (Props left under) | 3 |
| 3. | Beam soffit (Props left under) | 7 |
| 4. | Removal of props of slab, L<=4.5m | 7 |
| 5. | Removal of props of slab, L>4.5m | 14 |
| 6. | Removal of props of Beams and Arches, L<=6m | 14 |
| 7. | Removal of props of Beams and Arches, L>6m | 21 |

The times given for the removal of props are based on the assumption that the total live load plus

dead weight to be supported at the time of removal is not more than one half the total design load. For horizontal members where the loading is a higher proportion of the total design load these times may need to be increased.

## 11.0 CHAINLINK FENCING AND GATE

### 11.1GENERAL

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:

### 11.2 AREAS REQUIRING FENCING

11.2.1 Fencing shall be provided for complete switchyard as per specification. Separate gate shall be provided for men and equipment.

11.2.2 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.

### 11.3 PRODUCT MATERIALS

The minimum requirements are as follows: Chain link fence fabric (galvanization) in accordance to relevant IS/BS/ equivalent International Standards.

### 11.4 POSTS

The posts shall be of medium M.S. tubes of 50mm diameter conforming to grade as per relevant IS/BS/ equivalent International Standards. The tubes shall also conform relevant IS/BS/ equivalent International Standards. The length of tubular post shall be 2700 mm.

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 IS/BS/ equivalent International Standards.

### 11.5 FENCE FABRIC & FENCE PANEL

**Chain link** fencing shall be made of 5 mm diameter wire with 50 X 50 mm mesh size. Fence fabric shall be galvanised. Chain link fencing shall be fabricated in the form of panel 2275 X 2950 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 MS 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.

### 11.6 INSTALLATION

i. Fence shall be installed along the switchyard line as shown in the approve drawings.
ii. Post holes shall be excavated by approved method.
iii. All posts shall be 3.0m apart measured parallel to ground surface.
iv. Posts shall be set in 1:1.5:3 Reinforced Cement Concrete block of minimum (0.40x0.40x 0.8) m depth and (0.8x0.8x0.2) m. 100mm thick plain cement concrete 1:3:6 shall be provided below concrete blocks. Posts shall be braced and held in plumb position and true alignment and elevation until concrete has set.
v. Fence fabric shall not be installed until concrete has cured a minimum of 7 days.
vi. 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.

**11.7 GATE**

i. 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 50mm angle. Gate leaves shall be fixed with a vertical post of 2700 mm long two steel channels welded together.
ii. 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.
iii. The gates shall be provided with suitable locking arrangement welded on 4 mm thick MS plate on the gate leaf.
iv. The main gate shall be 5.0m wide and shall be of double leaf type (as approved in the drawing). Next to the main gate, a men gate (1.25m wide single leaf) shall also be provided.
v. Steel roller shall be provided with the gate.
vi. Gate shall be installed in location as approved by the employer.
vii. The vertical post of gate shall be embedded in RCC foundation of (0.40x0.40x 0.8) m depth and (0.8x0.8x0.2) m deep size.

Measurement for payment of item 'Switchyard fence including entrance gate/s' shall be made on the basis of running meter (including gate) of actual quantities performed and be made at the unit price bid. Therefore, in the Price Schedule, the unit price bid shall include the cost of all labour, all material, civil works, etc.

## 12.0 SUBSTATION STEEL STRUCTURES

### 12.1 GENERAL REQUIREMENTS

The major works involving steel structures are as follows:

a. Gantry structures
b. Equipment structures

The Contractor shall assume full responsibility for design and details of the steel structures and for

their satisfactory performance. All designs and details shall be subject to the approval of the Employer. The Employer shall have the right to instruct the Contractor to make any changes to conform to the Contract Document. Elevations of all structures to be erected in the existing substation shall be compatible with the existing structures.

No omissions or ambiguities on the drawings or in this Specification shall relieve the Contractor from furnishing first class materials and workmanship. Should any inaccuracies be found, the Contractor shall notify the Employer and any further work done before these discrepancies are corrected shall be at the Contractor's risk.

## 12.2 MATERIALS

The materials shall conform to the following requirements as regards to the quality of steel used for support members:

| Item | Description | Unit | Minimum Value |
|---|---|---|---|
| 1.1 | Mild steel Grade E275 to ISO630 or equivalent | | |
| | (a) Tensile strength | $kg/mm^2$ | 24 |
| | (b) Yield strength | $kg/mm^2$ | 14 |
| 1.2 | High strength steel Grade E355 to ISO630 or equivalent | | |
| | (a) Tensile strength | $kg/mm^2$ | 36 |
| | (b) Yield strength | $kg/mm^2$ | 20 |

## 12.3 DESIGN OF STEEL STRUCTURES

Design Methods: The stress analysis shall be conducted by the force diagram method for all type of steel structures. Any computer program to be employed shall be prepared or approved by a recognized institute and be submitted to the Employer.

Loading Conditions: In additions to dynamic loads imposed by equipment, steel work shall be design to withstand simultaneously wind and other loads as follows:

Design Load:

a. Wind Load:

| | |
|---|---|
| On flat steel surface | 121 $kg/m^2$ |
| For lattice structures | (121 $kg/m^2$ on 1.71 times the projected area of the members of one face of the structure) |
| On line trap, disconnecting switches | 50 $kg/m^2$ |
| On overhead ground wire, conductors | 75 $kg/m^2$ |
| On porcelain insulator Strings and all other sections | 50 $kg/m^2$ |

b. Human Load: 240 kg at the center of the beam.

c. Load due to conductor and weight of equipment and accessories:

Load due to the ACSR conductor shall be wind load, dead weight and short circuit forces.

Weight of equipment including insulator string shall be according to actual installation.

Normal Working Condition: The normal working condition for various loads shall be deemed to work simultaneously. The take-off structures shall be subjected to a vertical uplift of 500 kg at each supporting point of overhead ground wire and conductor. The tension for conductor and ground wire will be 750 and 350 kg respectively and angle of deviation will be $15^0$.

Combination of loads: The Contractor shall calculate the maximum and minimum stresses at any combinations of loading conditions.

Safety Factors: The safety factors shall be not less than two (2) times that the normal working conditions and 1.5 in combination with short circuit forces.

Design and Ultimate Stresses Allowed in Design: For tensile members of steel structures the design stresses shall not exceed the yield point of materials even under test loading conditions. For compressive members, the design stresses shall not exceed the value of the ultimate buckling stress.

Ultimate stress allowed in design shall be as follows:

| Members | |
|---|---|
| Buckling: | As per ASCE Manuals and Reports on Engineering Practice-No. 52. |
| Tension: | less than 1.00 Fy |
| Bearing : | Less than 1.80 Fy |
| **Bolts** | |
| Shear: | less than 0.60 Fu |
| Bearing: | less than 1.00 Fu |

Where: Fy : Yield point of steel member materials
Fu : Ultimate tensile stress of bolt materials

Limit of Effective Slenderness Ratio: The effective slenderness ratio (L/r) of members shall meet the following limits:

| | |
|---|---|
| Leg member, main compression member and ground wire peaks | = 120 |
| Other members having computed compressive stresses | = 200 |
| Secondary members without computed compressive stresses | = 250 |
| Tension member | = 350 |

Where: L: Length of the unsupported panel of member
r: Radius of gyration of members.

In determining the slenderness ratio for various members, suitable provisions shall be taken into

consideration for various types of end connections, eccentricity of load transfer in the members etc. The unsupported length "L" shall be considered from center to center of intersections or working lines at both ends of members. A single bolt connection shall not be considered as offering restraint against rotation. A multiple bolt connection with minimum two (2) bolts, properly detailed to minimize eccentricities shall be considered to offer partial restraint, if such connection is to a member having adequate strength to resist rotation of joint. Points of intermediate supports shall not be considered as offering full restraint to rotation, if the same is provided only on one flange of the member. For members of double-diagonal web system which are bolted at their point of intersection, max. L/r shall be determined from the following criteria:

'L' is the greatest distance from the point of the intersection to either of the end connections and 'r' is the minimum radius of gyration of the member.

'L' is equal to 0.75 times the distance between the end connections and 'r' is the radius of gyration of the member for its axis parallel to the plane of connected leg.

Minimum Thickness and Size of Steel Members**:** Minimum thickness and size of steel members of structures shall be as follows:

| | | |
|---|---|---|
| Calculated members | | 40x5 mm |
| All other stressed members and secondary members | not less than | 40x4 mm |
| Gusset plates | not less than | 5 mm |
| Bolts and nuts | | M-12 mm |

In computing the net section of tension members, the diameter of the bolt holes shall be taken as 3.0 mm greater than the nominal diameter of the bolts. Net section on both straight and zigzag sections across the members shall be as specified in IS/ ASCE or BS.

**CONNECTIONS**

i. Bolts: All connections shall be bolted and all stressed members shall be connected by at least one (1) bolt. For structural connections, a maximum of two bolt sizes may be used for each tower type, provided the quantity of each size is not less than 20 per cent of the total requirement for the tower and the bolts in any one connection are uniform in size.

ii. Splices: The number of splices shall be practically minimum. Splices shall develop the maximum stress in member or seventy percent (70%) of compressive strength of gross section or tensile stress of net section. No credit shall be allowed for bearing on abutting areas.

Design Drawings and Calculation. The design drawings shall show the following data and information:

Scaled line diagram of the steel structures showing all redundant bracing members and their sizes completely dimensioned and proving compliance with all clearance requirements.

All loadings and their manners of application including the determination of wind load (wind load on structure shall be applied at each panel point along the height of the steel structure.)

Calculations showing:

i. Total stresses in each member for each loading case and the critical case.

ii. The effective slenderness ratio, calculated stress ratio of maximum total stress to calculated stress for each member and strength of connection.

iii. The estimated weight of the complete galvanized steel structures.

iv. Size and type of steel for each member and number of bolts required for its connection.

v. The compression and uplift reactions and corresponding horizontal shears at each leg of all steel structures (column and equipment supports) for all loading cases.

**12. 4 DETAILING**

Detailing shall be as follows:

General: Steel structure dimensions, framing, member sizes and length, number, size and length of bolts, thickness of each filler, and other necessary details to fabricate each piece shall be shown on the approved detail drawings. No change shall be made without the written approval of Employer.
All web members shall be in one piece where practicable. All double-diagonal web system members shall be connected at their point of intersection by at least one bolt.

Step Bolts: Step bolts shall be of 16 mm diameter and shall have round or hexagonal head. Each step bolt shall be provided with two hexagonal nuts. The minimum bolt length and length of unthreaded portion shall be 180 and 125 mm respectively. Step bolts shall not be used as connection bolts.

The step bolts shall be spaced alternately on the inner gauge line on each face of the angle about 40 cm from centers. They shall be furnished for one leg of each steel tower from the base elevation of the steel tower.

Step bolts for lattice single pole or H-frames are not required.

U-Bolts: U-bolts shall be suitably furnished on steel structures to suspend or terminate insulator strings or ground wire assemblies. Size of U-bolts shall withstand all loads acting on it.

Detail Drawings: Detail drawings shall be complete with sizes and detail dimensions of all steel structure members. At each joint, there shall be the number, size and length of bolts, number and size of fillers and detail dimensions of gusset plate, if any.

Bill of Material: Bill of materials shall give the size, length and galvanized weight of each member and the total weights of steel structures. It shall also include the number of bolts, nuts and washer per structure.

**12. 5 FABRICATIONS**

Workmanship: Workmanship shall be first class throughout. All pieces must be straight, true to detail drawings and free from lamination flaws and other defects. All clipping, back cuts, grindings, bends, holes and etc. must be true to detail drawings and free of burrs.

All identical pieces bearing the same erection number must be exactly interchangeable with each other and interchangeable in their relative position in all towers or structures of which they form a part.

Threads of bolts and nuts shall be cleanly rolled or cut and the face and head of nut shall be truly at right angle to the axis of the bolt.

Cleaning and Galvanizing

i. Cleaning: After fabrication has been completed and accepted, all materials shall be clear of rust, loose scale, dirt, oil, grease and other foreign substances.

ii. Galvanizing: All materials shall be hot-dip galvanized after fabrication and cleaning. Retapping of nuts after galvanizing is not required.
Galvanizing for structural mild steel products shall meet the requirements of ASTM A123. All holes in materials shall be free of excess shelter after galvanizing.

Galvanizing for bolts, nuts, washers, lock nuts, step bolts and similar hardware shall meet requirements of ASTM A153. Excess shelter on bolts, nuts, washers, locknuts, step bolts and similar hardware shall be removed by appropriate means acceptable to the Employer.

Finished materials shall be dipped into the solution of dichromate after galvanizing for white rust protection during sea transportation.

iii. Uniformity of Coating: The uniformity of coating test shall be made in accordance with ASTM A239. The minimum repetition times for one minute dip in uniformity test shall be as follows:

a. Steel shapes and plates.....6
b. Bolts, nuts and similar hardware.....4

c. Galvanizing Coating Weight

| Description | Coating Weight (g/sq.m) | | Uniformity Test |
|---|---|---|---|
| | Thickness | | Time |
| | Avg. Value | Min. Value | (1 min./1 time) |
| Shaped steel Over 6mm | more than 700 | more than 610 | more than 6 |
| Steel plates Under 6mm | more than 610 | more than 550 | more than 6 |
| Bolts, Nuts & washers etc. | more than 470 | more than 400 | more than 4 |

iv. Straightening after Galvanizing: All plates and shapes which have been warped by the galvanizing process shall be straightened by being re-rolled or pressed. The materials shall not be

hammered or otherwise straightened in a manner that will injure the protective coating. If, in the opinion of the Employer, the material has been hard fully bent or warped in the process of galvanizing or fabrication, such defects shall be cause for rejection.

v. Repair of Galvanizing: Materials on which galvanizing has been damaged, shall be acid stripped and re-galvanized, unless, in the opinion of Employer, the damage is local and can be repaired by zinc spraying or by applying a coating of galvanizing repair compound. Where re-galvanizing is required, any member which becomes damaged after having been dipped twice shall be rejected.

vi. Shop Assembly: One of each type of steel structures shall be assembled in the shop to such an extent as to insure proper field erection. Reaming of untrue holes will not be permitted. A reasonable amount of drifting will be allowed in assembling. Shop assembled parts shall be dismantled for shipment.

### 12.6 SHOP TESTS

The following shop tests shall be performed with relevant provisions of the ASTM.

i. General inspection
ii. Material tests
iii. Assembly test
iv. Galvanizing test

The Contractor shall conduct the above mentioned tests in presence of Employer before dispatch of the steel structures. All the cost of tests including cost of travelling, lodging and fooding of two NEA personnel shall be borne by the Contractor. Within seven days after the completion of tests the contractor has to furnish the four certified copies of report of all tests to the Employer.

### 12.7 PAYMENT

Payment for the Contract item "Steel Structures" will be made at the unit/lump sum price per steel structures as per BOQ. Therefore, in the Price Schedule, such unit/lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment and labour and all other operations related to steel structure design, fabrication, installation etc.

## 13.0 BUILDINGS (Control, Staff Quarter, Guard and Store)

### 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, staff quarter building, guard and store building. Electrification and air conditioning of building shall be provided as detailed in other sections of electrical portion. 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 building from Nepal Authority. The buildings

shall be designed for loads as applicable in accordance to relevant standards. The plumbing and sanitary works including overhead water tanks placed on terrace of Staff quarter building and other building ( Control, Guard and store) 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.

This specification is intended to cover the complete construction of control building, Staff quarter building and furnishing of the indoor facilities for the project including all design, supervision, materials, equipment, labour and services necessary for or incidental to the construction of control building and other building units as specified above. The entire floor shall be constructed on one plain level.

The rooms within the control building shall have area sufficient to install the equipment supposed to be installed (including for the spare bays) with adequate space for service. In any case the plinth area shall not be less than the typical building plan of respective building provided with this tender.

## 13.2 SCOPE OF WORKS

Based on the drawing provided, the Contractor shall perform the design, supply, deliver, construction and installation of the equipment, materials and all accessories for the control building / other building units as listed below.

i. Cleaning and stripping, Excavation, Backfilling and compaction
ii. Concrete work
iii. Plinth level flooring treatment
iv. Brick and Stone Masonry Works
v. Plaster and Tile Works
vi. Door and Windows
vii. False Ceiling in the control building
viii. Heat Insulation and Water Proofing
ix. Water supply, Plumbing (Sanitation), Sewerage and Sanitary Fixtures
x. Indoor Cable Trench
xi. Paint and Glazing
xii. All required Electrical Installation
xiii. Ventilation
xiv. Fire Fighting and smoke detector System
xv. Furniture and Miscellaneous Indoor Facilities shall be as specified in their individual sections:
xvi. Supply and installation of ceiling FANs for Staff quarter, control room and guard house.

**Control Room Building:**

The Control Room Building shall be of size 20m X 16.25 m approximately and suitable to house all the requirements. It will be a single storied RCC Framed structure, constructed near by the

switchyard. It shall be so designed that most of the area of switchyard is visible from the Control Room. The building shall have 11 kV indoor switchgear room. The internal cable trenches, panel etc. shall be designed by the contractor as per requirement. Layout of these cable trenches, panel layout shall also be prepared by the contractor as per requirement. The 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. Tentative carpet area requirement for different rooms of control room cum administrative building is shown in the drawing of control building as guidance to the contractor.

**Staff Quarter building:**

Staff Quarter building shall be three storied reinforced cement concrete framed structure building. The size of building shall be about 19.45 m X 10.3 m approximately in each floor (Ground, First and second). A RCC platform (600 mm wide) at window sill level shall be provided with suitable tiles in every kitchen.

**Store Building:**

The size of store house shall be about 14.35 m X 8.25 m approximately

**Guard House:**

Similarly Guard and store building shall be single storied reinforced cement concrete framed structure building. The size of building shall be about 7.651m x 7.35 m approximately.

All finish details like floor details, door, windows, ventilator, internal finish details etc. shall match with other buildings mentioned elsewhere in the technical specification.

Contractor shall develop the layout in such a way that its aesthetic look is pleasant. The design of buildings shall be carried out as per relevant IS/BS/ equivalent International Standards.

All the works for the control building and Staff quarter building shall be subject to approval of the Employer. The Employer shall have the right to require the Contractor to make any changes on designs, construction works, materials and equipment to make the structures conform to the Specification, without any additional cost. The Contractor shall prepare the design drawings including all facilities based on attached architectural building drawings and submit the design drawings to the Employer for approval.

## 13.3 DESIGN CRIRETIA:

The Building shall be designed:

i. To the requirements of the IS/BS/ equivalent International Standards.

ii. For the specified climatic and loading conditions.

iii. 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.

iv. With a functional and economical space arrangement.

v. To be aesthetically pleasing. Different buildings shall show a uniformity and consistency in architectural design, as far as possible.

vi. To allow for easy access to the equipments as well as maintenance of the equipments.

vii. Wherever access to the roof is required, RCC stair case shall be provided.

viii. 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 after the approval of employer.

ix. Suitable Expansion joints, wherever required, shall be provided as per Codal Provisions.

x. All the members of the buildings frame shall be designed for the worst combination of loads as per relevant IS/BS/ equivalent International Standards.

xi. Permissible stresses for different load combinations shall be taken as per relevant IS/BS/ equivalent International Standards.

xii. Seismic coefficient Method or Response spectrum method shall be used for seismic analysis of the building for Earthquake forces, as per relevant IS/BS/ equivalent International Standards.

xiii. The architecture design of the buildings shall be as per the Nepalese Architecture & Style.

## 13.4 DESIGN LOADS

i. 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.

ii. Dead loads shall include the weight of structures complete with finishes, fixtures and partitions, and shall be taken as per relevant IS/BS/ equivalent International Standards.

iii. 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. Corridors/Walkways. | 3.0 kN/m2 |
| 7. Accessible Roofs. | 1.5 kN/m2 |
| 8. Non-accessible Roofs. | 0.75 kN/m2 |

iv. Wind load shall be calculated as per relevant IS/BS/ equivalent International Standards. The Factors affecting the wind speed shall be taken based on the site conditions.

v. Earthquake loads shall be calculated as per relevant IS/BS/ equivalent International Standards.

vi. Wind forces and Seismic forces shall not be considered to act simultaneously.

All the load combinations to create worst combinations of loads shall be as per relevant IS/BS/ equivalent International Standards.

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 IS/BS/ equivalent International Standards. Cable and piping loads shall also be considered in addition to the live loads for floors where these loads are expected.

The Contractor shall use an allowable soil bearing pressure of 8 ton /$m^2$ for the design of foundation for bidding purpose. But this is only reference value. After award of Contract, the Contractor shall carry out detail soil test. There may be variation in the volume of work in final design compared to the bidding design, for which the Contractor will not get any extra payment.

### 13.5 Excavation and Backfilling

The detail specification for the excavation and backfilling work shall be as specified in Concrete and Foundation works of this section.

### 13.6 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.

## 13.7 CONCRETE WORK

The detail specification for the concrete work shall be as specified herein Article 10 Foundation/RCC works. Concreting in all building shall be done in foundation, tie beam, floor/roof slab, steps, column, beam etc.

## 13.8 STEEL REINFORCEMENT WORKS

The Contractor shall place all the reinforcement bars in the concrete structures as shown on the approved drawings, bar bending schedules and as directed by the Employer. The reinforcement bars shall be furnished by the Contractor.

## 13.9 FLOORS, WALLS & ROOFS

i. 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 1:4 cement sand mortar. Partition walls if any shall be of 115 mm (half brick) thick with cement sand mortar (1:4).

ii. All Floor/Roof slabs shall be regular beam slab construction.

iii. False ceiling as per requirement shall be provided as detailed in Table-1 (Detailed Finish Schedule).

iv. Minimum height of skirting above finished floor level shall be 150 mm. The skirting material shall match with the floor finish.

v. Minimum height of the parapet walls shall be 750 mm.

vi. Ground floor finish shall be laid over 20 mm thick cement sand mortar,100 mm thick plain cement concrete (PCC) 1:4:6 (1 cement: 4 sand : 6 stone aggregates), 100 mm thick local sand filling. The earth below ground floor shall be well rammed before laying sand filling.

Concrete Laying:

Concrete work shall be done as specified under Article 10 Foundation/RCC works. The flooring shall consist of minimum (For each square meter)

a. Concrete mix: (1:2:4), thickness 150 mm with 2 % waterproofing compound,

b. Steel bar as required

c. Gravel layer 100 mm thick

vii. First floor details shall comprise of finish as per detail finish schedule, 20 mm cement sand mortar and 50 mm thick PCC(1:4:6) over RCC slab.

## 13.10 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 IS/BS/ equivalent International Standards. The water proofing treatment shall be of following operations:

a. coat of polymer slurry of Sika-top seal for water proofing directly above roof slab
b. 50 mm ( average) thick layer of screed concrete of Cement Lime Surkhi(1:2:4) mix and
c. 25 mm thick machine made clay tiles in (1:3) cement sand mortar

2 coat of polymer slurry of Sika-top seal for water proofing directly above roof slab shall also be provided to the Staff quarter, guard and store buildings.

Necessary slopes in water proofing treatment towards the rain water down take pipes shall be provided. The above treatment shall be extended on the adjoining walls up to 300 mm height including rounding of junctions of walls and slab. The whole terrace so finished shall be flooded with water for a minimum period of two weeks for curing and for final test. All the work and testing shall be done as instructed by the Employer.

### 13.11 STAIRCASE

The roof of the control, Staff quarter, Guard and store Buildings shall be made accessible by means of a steel spiral stair case which shall be structural mild steel tube of 150mm diameters (Heavy) as a supporting column rest on the RCC foundation, death of which shall be 1.2 meter below the ground level. The steps of the staircase shall be checker plate of thickness not less than 6 mm with steel angle section and plates. The hand rail shall be structural mild steel tube of 50 mm diameter (Light). The whole part of the staircase shall be painted as per specification. No separate payment for the Contract item “STAIRCASE" will be made. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, machines, labour and other operations related to staircase of respective buildings. Wooden staircase railing shall be also be provided by the contractor.

### 13.12 PLASTERING

External surfaces of buildings shall have 18 mm thick plaster in two layers, with the under layer 12mm thick 1:4 cement sand plaster and the top layer 6 mm thick 1:5 cement sand plaster. Inside wall surfaces shall have 12/15 mm thick 1:5 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.

### 13.13 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.

## 14.0 BRICK MASONRY WORK

### BRICK MASONERY WORK IN FOUNDATION

Chimney made first class brick work in foundation and plinths in cement mortar 1:4 (1cement: 4sand).

**BRICK WORK IN SUPERSTRUCTURE**

Chimney made first class brick work in super structure in cement mortar 1:4 (1cement: 4 sand).

**14.1 MATERIALS**

i. The bricks shall be table moulded with sand from good brick earth and shall be of uniform size, unless otherwise specified. They shall be uniform deep red, cherry or copper colour, thoroughly well burnt without being vitrified, regular in shape and size, and shall have sharp and square sides and edges and parallel faces to ensure uniformity in the thickness of the courses of brick work. The bricks shall be free from cracks, chips, flaws stones or humps of any kind. They shall not show appreciable signs of efflorescence either dry or subsequent to soaking in water. The bricks shall be sound, hard, homogeneous in texture and produce a clear ringing sound when struck with a trowel. In no case, the minimum crushing strength of bricks shall be less than 7 N/sq. mm. The bricks shall be provided with frogs. All bricks which absorb water more than one-sixth of their own dry weight after being soaked for one hour by immersion in water shall be rejected.

ii. Cement shall be ordinary Portland as per ASTM C150 Type I or equivalent.

iii. Sand shall be clean, fine, sharp granules, free from foreign or deleterious matter.

iv. Water shall be clean and free from acid, alkalis, oil or organic matter.

The Contractor should submit samples of cement, sand, lime and locally manufactured brick samples of six pieces for Employer's approval.

**14.2 MORTAR MIXTURES**

The type of mortar mixture for brick masonry shall be in 1:4(cement:sand) ratio. All brick work shall be laid with specified mortar of good workable consistency.
Cement mortar shall be prepared by mixing cement and sand in the specified proportions the mixing shall be done in a mechanical mixer or by hand mixing as directed by Employer/ Engineer. Water shall be added as required during mixing. Care shall be taken not to add more water than what is actually needed to bring the mortar to the consistency of a stiff paste. Only the quantity of mortar, which can be used within 2 hours of its mixing shall be prepared at a time. Mortar unused for more than 2 hours shall be rejected and removed from the site of work.

**14.3 BRICK MASONRY LAYING**

i. Bricks shall be laid in English bond, unless otherwise specified. Half or cut bricks shall not be used except where necessary to complete the bond. Closer in such cases shall be cut to the required size and used near the ends of the walls.

ii. Lay brick masonry in accurately spaced courses, level, plumb and true to line. The walls

shall be taken up truly plumb. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. Vertical joints in alternate courses shall come directly one over the other. The thickness of brick courses shall be kept uniform and for this purpose straight edge with graduations showing the thickness of each brick course including joint shall be used. Bricks shall be laid with frogs upwards.

iii. The walls of a structure shall be carried up regularly and nearly at one level and no portion of the work shall be left more than 3 ft. below the rest of the work. Where this is not possible, the work shall be raked back according to bond (and not left toothed) at an angle not exceeding 45 degree.

iv. All iron fixtures, pipes, outlets of water, hold fasts of doors and windows, etc. which are required to be built in walls, shall be embedded in cement mortar or in cement concrete bed as specified, in their correct positions as the work proceeds. Nothing extra shall be paid for such extra cement mortar or cement concrete to be used for embedding the fixtures of the nature stated above.

v. When brick masonry walls cross the recessed floor cable trenches provide and install cast-in-situ concrete lintels of sufficient size and strength to support and carry masonry walls across the trench sprays.

vi. Reinforce all masonry walls with cast-in-situ reinforced concrete formed flush with the masonry surfaces for cement plaster-finish.

vii. Provide concrete pilasters and horizontal tie for every 9 square meters of masonry wall surface, plus at all corners and door jambs.

viii. Size of Wall

a. The entire periphery wall shall be constructed in 230 mm thickness.

b. The entire partition wall shall be constructed in 110 mm thickness. But it shall be constructed at less than 2 m span only.

## 14.4 CURING

Brick masonry with cement mortar shall be kept constantly moist on all faces. Spray masonry surfaces with water twice daily for a period of 10 days, or until the surface receives a plaster finish.

## 14.5 PROTECTION

Green work shall be protected from rain by suitable covering. Where exposed to weather, protect top of masonry with water tied material in such a way that it will protect the completed work. Masonry wall shall set for 48 hours before any load is applied on the completed work.

## 14.6 SOAKING OF BRICK

All bricks required for masonry in cement mortars shall be thoroughly soaked in clean water for at least one hour in tanks of sufficient size immediately before use. The cessation of bubbles when the bricks are immersed in water is an indication of through soaking of bricks.

## 14.7 JOINTS

Bricks shall be so laid that joints are quite full of mortar. The thickness of the bed joints shall in no case exceed 10 mm unless otherwise specified. The face of joints shall be raked to a minimum depth of 10 mm by raking tool daily during the progress of work when the mortar is still green, so as to provide proper key for the plaster or pointing to be done. Where plastering or pointing is not required to be done, the joints shall be struck flush and finished at the time of laying. The face of brick work shall be cleaned daily and all mortar drippings removed.

## 14.8 BRICK-ON-EDGE COPING

The top course of all plinths, parapets, steps and tops of walls below R.C.C. slabs or beams shall be laid with brick on edge, unless otherwise specified. Proper care shall be taken that the bricks forming the top corners and ends of walls shall be properly radiated and keyed into position.

## 14.9 SCAFFOLDING

Double scaffolding having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal pieces over which the scaffolding planks shall be fixed. In buildings upto two stories, single scaffolding shall be allowed. In this case, the inner end of the horizontal scaffolding pole shall rest in a hole provided in the header course only. Only one header for each pole shall be left out. The holes left in masonry work for supporting the scaffolding shall be filled and made good, before plastering. The contractor shall be responsible for providing and maintaining sufficiently strong scaffolding so as to withstand all loads likely to come upon it.

## 14.10 BRICK WORK HALF BRICK THICKNESS

First class chimney made half brick masonry in cement mortar 1:4 (1 cement: 4 sand) with 4.75 mm diameter Torkari steel reinforcement placed horizontally at every fourth course. It shall be laid in stretcher course as for brickwork specification. Horizontal reinforcement of 5 mm diameter with proper anchorage to adjoining wall/walls shall be provided at every fourth course.

## 14.11 BRICK ON EDGE SOLING

For that brick soling, the brick shall be Chimney made and will be laid as directed by the Employer/ Engineer.
The base on which brick is to be laid on edge shall be levelled or sloped as required and compacted properly. The bricks shall be laid on edge true to line, slope and pattern as required. The line, level etc. shall be checked by pegging. The brick shall be closely packed to each other as far as practical and the gaps shall be filled with sand for compaction. The workmanship shall be to the approval of the Employer/ Engineer.

## 14.12 STONE WORK IN FOUNDATION AND IN SUPERSTRUCTURE

All stone work shall be made with random rubble stone from the best quarry and built in 1:4

cement mortar (1 cement: 4 sand). The stones must be approved by the Employer/Engineer before using in the construction work.

The stone shall be hard, tough sound and durable. No stone shall be less than 6" and more than 18". Face stone should be comparatively larger and uniform in size and colour to with a good appearance. Breadth of face stone should be greater than height. All the stones shall be wetted thoroughly before laying.

The joints should not be thicker than 3/4". Face joint should be thinner. No pointing shall be allowed afterwards. In the corners, the stones should be chiselled at both sides and also on the top of the stone walls where the wall is ending and such surfaces being built up. Not more than 2 feet height of masonry shall be constructed at one time.

## 15.0 DETAILED FINISH SCHEDULE

The detailed finish schedule for Control, Staff Quarter, Guard and store Building is given below:

**Table- 1: DETAILED FINISH SCHEDULE**

| SN. | LOCATION | FLOORING AND SKIRTING 150 MM HIGH | WALL (INTERNAL) | CEILING | DOOR, WINDOWS & VENTILATOR |
|---|---|---|---|---|---|
| 1. | Control Room (132, 33, 11 kV) | 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 thick glazing. |
| 2. | Office 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 5.5mm thick glazing |

| SN. | LOCATION | FLOORING AND SKIRTING 150 MM HIGH | WALL (INTERNAL) | CEILING | DOOR, WINDOWS & VENTILATOR |
|---|---|---|---|---|---|
| 3 | Communication 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 5.5mm thick glazing. |
| 4. | Work shop 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 5.5mm thick glazing. |
| 5. | 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. |
| 6. | Reception / Barandas | 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 5.5mm thick glazing. |
| 7. | Corridor | Vitrified tiles 8mm | Premium acrylic | Oil bound washable | Windows shall be of powder coated aluminium |

| SN. | LOCATION | FLOORING AND SKIRTING 150 MM HIGH | WALL (INTERNAL) | CEILING | DOOR, WINDOWS & VENTILATOR |
|---|---|---|---|---|---|
| | | thick size 600 x 600mm | emulsion paint on smooth surface applied with plaster of paris (2 mm thick) | distemper on smooth surface applied with plaster of paris putty | with 5.5 mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5mm thick glazing. |
| 8. | Store rooms | Normal cement plaster | Plastered & Painted OBD Over 2mm POP Finish | Plastered & Painted with OBD Over 2mm POP Finish | Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5mm thick glazing. |
| 9. | Other rooms of Guard and store buildings | Normal cement plaster | Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick) | | 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. |
| 10. | Kitchen | Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M IS 15622 | Plastered & Painted OBD Over 2mm POP Finish. Ceramic Tiles UP to 1.0M Above Kitchen Platform (Granite with modeling) | Plastered & Painted with OBD Over 2mm POP Finish | 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. |
| 11. | Bed /Living Room | Antiskid Vitrified Tiles | Plastered & Painted OBD Over 2mm POP Finish | Plastered & Painted with OBD Over 2mm POP Finish | Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters made of pre- |

| SN. | LOCATION | FLOORING AND SKIRTING 150 MM HIGH | WALL (INTERNAL) | CEILING | DOOR, WINDOWS & VENTILATOR |
|---|---|---|---|---|---|
| | | | | | laminated particle board with powder coated aluminium frame. |
| 12. | Toilet /Bathroom | Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M | Ceramic Tiles (0.2x0.3)m up to 2.1m. Area Above 2.1m Plaster & Painted OBD over 2mm thick POP Finish. | Plastered & Painted with OBD Over 2mm POP Finish | 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, open able 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.

## 16.0 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 IS/ BS/ 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.

The schedule of windows and ventilators of the Staff Quarter, Guard and store Building shall be as per the detailed finish schedule given in Table-1 (Detailed Finish Schedule).

All doors and windows shall be of aluminium types. Each window shall consist of a unit including frame, mullions where indicated or required, and anchors. Main entrance doors of Staff quarter, Guard and store building shall be single panel wooden (SAL wood). Windows shall be provided with top removable ventilation. The contractor shall have to provide the mosquito (Fly) net in the door and windows of the Buildings. Additionally, the contractor has to provide grill in the ground and first floor of the Staff Quarter Building.

## 16.1 CARPENTRY

### 16.1.1 Materials

Lumber (Timber) shall be subjected to Employer's approval.

Sal wood:

a. Sizes and Pattern: Lumber shall be surfaced- four-sides, and worked according to patterns as are indicated or specified on the drawings. Exposed members for transparent finish shall be matched for compatibility of grain and colour between adjoining members; for paint finish, is not required.

b. Moisture Content: At the time of delivery, the moisture content shall not exceed 15% for material of 2.5cm or less in thickness, and shall not exceed 19% for material over 2.5 cm in thickness.

Teak Plywood: All interior plywood for transparent finish shall be of equal and uniform of colour and graining, such as for door panels. Hardwood plywood shall be of premium grade. Plywood for paint finish matching for compatibility is not required, such as for ceiling.

Veneers: Veneers on wood doors, panels and other exposed wood works shall be of 4mm thick.

The Bidder shall furnish satisfactorily functioning installations. All items of labour, material of equipment not specifically mentioned herein, but incidental to or required for a complete installation and proper operation of the above-mentioned systems, shall be included.

## 17.0 CABLE TRENCH INSIDE CONTROL ROOM BUILDING

The detail design of the cable trench shall be the responsibility of the Contractor. All designs and details shall be subject to approval of the Employer.

Cable trench shall be of reinforced concrete trench with one or more layer of hot dip galvanized light gauge shape steel tray. The cover of trench shall be min. 6 mm thick-chequered plate with steel frame and shall be galvanized.

Drainage outlet from the cable trench shall be connected to switchyard drainage system.

No separate or direct payment will be made to the Contractor for Indoor cable trench works. Therefore, in the Price Schedule, the lump sum price of control building shall include full compensation for all costs incurred in furnishing all materials, equipment, labour and other operations related for Indoor cable trench work of control building.

## 18.0 PAINT AND GLAZING

### 18.1 PAINTING

#### 18.1.1General

All surfaces of the control room and staff quarter shall be painted except the following:

Exterior: Roofing, paving, concrete, nonferrous metals, glass, pre-finished items.

Interior: Ceramic tile, glass, pre-finished surfaces, non-ferrous metals, stainless steel, attic surfaces.

**18.1.2 Materials**

A list of the painting materials and their colours which are to be applied to the specified surfaces shall be submitted to the Employer for approval.

**18.1.3 Paint Application**

The finished surface shall be free from runs, drops, ridges, waves, pales, brush marks, and variations in colour, texture, and finish. The hiding shall be complete, and coat shall be so applied as to produce firm of uniform thickness. Special attention shall be given to insure that all surfaces including edges, corners, crevices, welds, and rivets receive a film thickness equivalent to that of adjacent painted surfaces.

Adjacent areas and installations shall be protected by the use of drop clothes or other approved precautionary measures.

Metal or wood surfaces adjacent to surface to receive water-thinned paints shall be primed and/or touched up prior to the application of water-thinned paints. The first coat on plaster shall include such repeated touching up of suction spots or overall applications of primer sealer as necessary to produce a uniform colour and gloss. The first coat on both faces of wooden doors shall be applied at essentially the same time.

Coating Progress: Sufficient time shall elapse between successive coats to permit proper drying. This period shall be modified as necessary to suit adverse weather conditions.

Oil base or oleoresinous solvent-type paints shall be considered dry for recoating when the paints feel firm, does not deform or feel sticky under moderate pressure of the thumb, and the application of another coat of paint does not cause lifting or less of adhesion of the undercoat.

Coating shall be as follows:

i. Control room, Office room and Corridor shall be finished with 1 coat of Plaster of Paris, two coats cement primer whitening and filling up and finally two coats of acrylic emulsion

ii. The exterior top of the Control building shall be finished with texture mat coating.

iii. All other interior and exterior plastered surfaces excluding as mention herein above shall be finished with one coat of cement primer and two coats of acrylic emulsion.

iv. Gloss Finish Wood:

First coat: 1 coat of Wood Primer.
Second coat: 2 coats of Synthetic Super Gloss.

v. Interior Transparent Finish Wood:

First coat: 1 coat of Wood Primer
Second coat: 2 coats of Teak Oil

vi. Metal Surface:

First coat: 1 coat of Metal Primer Chromate
Second coat: 2 coats of Aluminium Paint

### 18.1.4 STORAGE, MIXING AND THINNING:

At time of application, paint shall show no signs of hard settling, excessive skinning, livering, or other deterioration. Paint shall be thoroughly stirred, strained, and kept at a uniform consistency during application.

Where necessary to suit conditions of surface, temperature, weather, and method of application, package paint may be thinned immediately prior to application in accordance with the manufacturer's directions, but not excess of 0.5 litre of suitable thinner per 4 litre. The use of thinner for any reason shall not relieve Contractor from obtaining complete hiding.

Samples shall be clearly identified by designated name, specification number, batch number, project Contract number, intended use, and quantity involved. At the discretion of the Employer, samples may be tested before approval, or materials may be approved for use based on the test reports furnished. In the latter case, the samples will be retained by the Employer for possible future testing should the material appear to be defective during or after application.

Payment will be made to the Contractor for Painting works at per square meter as per BOQ. Therefore, in the Price Schedule, the unit price shall include full compensation for all costs incurred in furnishing all materials, equipment; labour and other operations related to Panting work of respective buildings.

## 18.2 GLASS AND GLAZING

i. Sheet glass to be used for doors, windows and partitions shall be 6mm thick, tinted glass or low E glass except as otherwise specified. It shall be of the best quality, free of unevenness, stain or bubbles, and where so required, figured glass shall be used. The glazing for the bathroom door shall be aluminium alloy of thickness not less than 6 mm. Glass glazing for the bathroom window shall be of the non-see-through type.

ii. Glazing compounds shall be of suitable type approved for the application. The use of non-skimming compounds, non-resilient type preformed sealers, and preformed impregnated type gaskets will not be permitted. Metal sash putty will not be permitted. Materials used with aluminium frames shall be aluminium coloured, non-

staining, and not require painting.

iii. Channel glazing compound shall be equal in performance, but not limited, to the following:

Non-drying, knife grade polybutene sealant
One-part acrylic terpolymer sealant

iv. Shop-Painted Items: Surfaces of fabricated and assembled items that are finish painted by the manufacturer, or specified to be finish painted under other sections of the Specifications, are exempted from the following schedule requirements for surface preparation and painting, shop primed items shall receive surface preparation and finish painting as required by this section.

v. Colours and tints, including shades of stain, shall match the respective colour specimens selected by the Employer. Stains shall conform in shade to manufacturer's standard colour. Undercoats shall vary slightly from the colour of the next coat.

vi. Surface Preparation and Pre-treatment: Cleaning and pre-treatment of surface prior to painting shall be accomplished in accordance with the detailed requirements specified.

vii. Cleaning: Clots and cotton waste that might constitute fire hazard shall be placed in closed metal containers or destroyed at the end of each day. Upon completion of the work, staging, scaffolding, and containers shall be removed from the site or destroyed in an approved manner. Paint spots, oil, or stains upon adjacent surface shall be removed and the entire job left clean and acceptable.

Payment will be made to the Contractor for Glass and glazing works at per square meter as per BOQ. Therefore, in the Price Schedule, the unit price shall include full compensation for all costs incurred in furnishing all materials, equipment; labour and other operations related to Glass and glazing work of respective buildings.

## 19.0 ILLUMINATION

The Contractor shall design and provide illumination system for the control, staff quarter, guard and store buildings according to the requirements. The Contractor's designed drawings shall be submitted to the Employer for approval.

The design of illumination works shall be subjected to employer's approval before executing the works.

## 20.0 WATER SUPPLY, PLUMBING & SANITARY FIXTURES

### 20.1 GENERAL

i. Water shall be made available by NEA 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.

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 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.

vi. 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.

vii. The control building and other building unit shall have an adequate water supply system as approved by the Employer. The Staff Quarter Building unit shall have an underground RCC water tank (min. thickness 150 mm) shall be provided of inner dimensions 4m * 3m * 2m. For Staff quarter building at least three numbers of 1000 litre rooftop water tanks shall be provided. Two numbers (two) 2 HP heavy-duty water-pump shall be used for pumping water from ground-tank to roof-tank. The ground water tank shall be connected to the public water-supply system by a one inch pipe.

viii. Contractor has to construct/make water supply arrangement for Control, Guard and store buildings through the rooftop water tank located at roof of respective building by 1000 litre rooftop tank. All the necessary pipe lines for water supply including two half inches tap points for external use shall be provide by the contractor.

ix. All plumbing works shall be concealed and performed with ½" & 1" GI pipes to the approval of the Employer. Two ½" tap points for external use shall be provided outside the control building as directed by the Employer.

x. Chlorinated Polyvinyl chloride (CPVC) pipes having thermal stability for hot and cold water supply including all CPVC plain and brass threading conforming to relevant IS/BS/ equivalent International Standards shall be used for internal piping works for water supply.

xi. HDPE pipes conforming to relevant IS/BS/ equivalent International Standards shall be used for sanitary works above ground level and RCC pipes shall be used for sanitary works below ground.

xii. Each toilet shall have the following minimum fittings:
   a. WC (Western type) along with toilet paper roll holder and all other fittings, in staff quarter; and WC (Squatting pan type) with all fittings shall be provided in other building.
   b. Wash basin (550 x 400 mm) with all fittings.
   c. Bathroom mirror (600 x 450 x 6 mm thick) with hard board backing, Chrome Plated (CP) brass towel rail (600 x 20 mm) with CP brass brackets.
   d. Soap holder and liquid soap dispenser.
   e. Automatic Hand Dryer.

xiii. 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.
One no. stainless steel kitchen sink with Drain board (510 x 1040 x 178 mm bowl depth) for pantry shall be provided.

xiv. All fittings, fasteners, gratings shall be chrome plated.

xv. All sanitary fixtures and fittings shall be of approved quality, size and type, manufactured by reputed manufacturers. All items brought to site must bear identification marks of the Manufacturer.

xvi. Contractor shall provide necessary number of septic tank and soak pit of adequate capacity to treat the sewage/sullage from the buildings.

xvii. Contractor shall undertake all other activities required to complete and commission the building.

## 20.2 BUILDING STORM WATER DRAINAGE

i. 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.

ii. Cast Iron Rainwater down comer pipes conforming to relevant IS/BS/ equivalent International Standards with water tight lead joints or medium class galvanized mild steel pipes conforming to relevant IS/BS/ 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 IS/BS/ equivalent International Standards.

iii. 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.

iv. Suitable arrangements for draining out water collected from equipment blow downs, leakages, floor washings, fire fighting etc. shall be provided for each floor.

## 20.3 WORKMANSHIP

The installation shall be made in neat, orderly and workmanlike manner, conforming in every way to the accepted standards of the best commercial practice.

### 20.4 PAYMENT

Payment for the Contract item "Construction of Water tank, Water supply from source to storage tank and Supplying and fitting of pipe and accessories for water supply, sanitary ware, sewer pipe and fittings including overhead tank" in the buildings will be made in lump sum basis as per BOQ. Therefore, in the Price Schedule, the lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment; labour and other operations related to above mentioned work of respective buildings.

## 21.0 FURNITURE AND MISCELLANEOUS INDOOR FACILITIES

The Contractor shall provide furniture and office equipment/goods/material for Motipur and Sandhikharka substation. Without limiting the generality of the foregoing, the following shall be provided for the substation.

**For Control Room:**

i. Two big size Tables.
ii. Two (2) sets of chairs.
iii. Two (2) set of minimum 4 shelves vertical filing cabinet.
iv. One (1) set of minimum 4 shelves drawing cabinet.
v. Two (2) sets of electric clocks, quartz wall hung type.
vi. Two (2) sets of desk telephones
vii. Kitchen pantry
viii. One set 43 inches SAMSUNG, LG or equivalent, energy efficiency television set with Disc home connection.
ix. One set steel cup board of 6' x 4' size
x. One Automatic electric kettle with cup and plate set (12 nos.)
xi. One set vacuum cleaner (1600 W)
xii. One set Aluminium frame notice board
xiii. One set Key hanging board
xiv. Two sets box type bench with back support & Cushion.

**For Staff Quarter:**

i. 1 wooden bed of standard quality & size (4 x 6.5) including clothing set in each flat.

ii. 4 numbers of wooden chairs of standard size with cushion in each flat.

iii. 1 big size Table in each flat.

iv. Curtain of standard quality for each window of staff quarter and guard house with wooden curtain support.

v. Two sets of sofa of standard quality with two T-tables.

**For Guard House:**

i. 1 wooden bed of standard quality & size (4 x 6.5) including clothing set.

ii. 2 numbers of wooden chairs of standard size with cushion.

iii. 1 small size Table.

### 21.1 Payment

No separate payment for the Contract item "Furniture and miscellaneous indoor facilities" in the buildings will be made. Bidders are instructed to include all the above mentioned to complete the specified job in the bid price of respective buildings.

## 22.0 FALSE CEILING, UNDER DECK INSULATION AND ELECTRIFICATION

### 22.1FALSE 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. The rate includes for all necessary cutting of ceiling for the fixing of complete fixtures.

### 22.2 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.

### 22.3 ELECTRIFICATION

All electrification shall be executed as per details specified in the technical specification. All details shall be as per relevant IS/BS/ equivalent International Standards.

No separate measurement and payment shall be made to contractor for **false ceiling, under deck insulation, electrification system works** to be carried out for all buildings. Bidders are instructed to include all the above mentioned to complete the specified job in the bid price of respective buildings.

## 23.0 FIRE FIGHTING SYSTEM

### 23.1 GENERAL

The control building shall be equipped with a fire alarm / fighting system as approved by the Employer to suit its application and size. But the number of fire-extinguisher and gas quantity shall not be less than four numbers and the net weight of each cylinder shall not be less than 10 kg.

The fire fighting system shall be essential for 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 inside building shall be prepared by the contractor as per requirement of proposed fire fighting system.

### 23.2 EXTERNAL PAINTING

External surfaces of the Building shall be painted with acrylic exterior flat paint as per manufacturer's specification and approval of NEA. Acrylic Fire Resistant Paint is a water base, general purpose fire resistant paint, designed for use on all Interior and Exterior surfaces, except floors, where maximum durability coupled with fire resistance is required.

Separate or direct Payments for fire fighting equipment shall be made as per bid price (BOQ). The unit/lump-sum price shall include full compensation for all costs incurred in furnishing all design, materials, equipment, labour and all other related works.

## 24.0 DRAINAGE AND SEWAGE SYSTEM

### 24.1 GENERAL REQUIREMENT

The drainage system is to drain all the storm run-off water and all other water by using pipe converting system, open gutter and cable trench system to the public drainage pit outside the substation in accordance with the instructions of Employer. The Contractor shall perform and be responsible for drainage system according to the following specified items. The Contractor shall study and divert the existing drainage system. Septic tank and soak pit shall be constructed for the sewage system of control and other buildings. All the Contractor's designed drawings shall be submitted to Employer for approval.

## 24.2 PRINCIPAL AREAS OF DRAINAGE

i. Switchyard area and cable trench
ii. Road surface
iii. Control building
iv. Compound periphery
v. Staff quarter and its periphery
vi. Store, guard house and other buildings(if any) and their periphery

## 24.3 DRAINAGE PIPE

The Contractor shall design, furnish and install all pipes for drainage system as shown in the drawing for approval.

i. All drains must be built with proper gradient. Excavation must give allowance to formwork, which shall be refilled with proper compaction.

ii. Concrete Pipes: Concrete pipes shall be of Np-3 class or equivalent in required size. Closed pipes shall be used at road crossing.

iii. The perforated type pipes of 150mm dia shall be used for switchyard area. Perforated pipes shall be made of R.C.C hume pipe Np-2 class or equivalent. These pipes shall be protected with screened gravel of 25mm-4-mm size.

iv. Mortars for drainage channel shall be a mixture of cement and sand mortar with a ratio of 1:3.

## 24.4 OPEN CHANNEL TYPE DRAINAGE

The surface shall be made as smooth as possible with plasterwork. Side and base shall be constructed in Brick masonry wall. The function of the gutter is to drain the surface run-off from the road surface and nearby area. The size and slope of the gutter shall have adequate capacity for drainage of the area.

## 24.5 SUMP, SEPTIC TANK AND SOAK PIT

Sump shall be provided for pipe changes in size, direction, and inspection and at inlet of nearby area. The maximum distance at road inlet sump shall not be more than 30 meters. The sump shall be of reinforced concrete type. The sump cover shall be of either steel grating or cast iron.

Only cast iron cover shall be used for inspection sump. The inspection or manhole sump shall be provided at maximum distance of 40 meters. The steel grating shall be strong enough for the load of AASHO H 20-S16.

Septic tank and Soak pit shall be constructed for approximately 25 people for the sewage system of control building, Staff quarter, guard and store building. 50 mm diameter CI pipe shall be connected from kitchen & bathroom and 100 mm diameter CI pipe shall be connected from toilet to the septic tank. Overflow from septic tank shall be connected to the soak pit, which is ultimately

drained to the natural drainage system.

### 24.6 PAYMENT

Payment for the Contract item Switchyard Drainage system will be made at Lump Sum bid as per BOQ and other drainage shall be included within the cost of construction of road. Similarly cost of Septic tank and soak pit shall be included in the building cost.

## 25.0 OUTDOOR CABLE TRENCH, DUCT BANK, CONDUITS AND HAND HOLE

### 25.1 GENERAL REQUIREMENT

The detail design of the cable trench shall be the responsibility of the Contractor. All designs and details shall be subject to approval of the Employer. The inside depth of the trench shall be minimum 0.6 m.

### 25.2 TYPE OF CABLE TRENCH

Concrete cable trenches of adequate size shall be designed and constructed in accordance with the approved drawings and as directed by Employer.
Cable trench shall be reinforced concrete trench with one or more layer of hot dip galvanized light gauge shape steel tray. The cover of trench shall be 80 mm thick pre cast RCC slabs with the provision of handles of approved design. The top surface shall be smooth finished. The trench and cover where it crosses the road shall be calculated safe for the load of AASHO H20-S16.

Trenches shall be designed with floor drains. Reinforced concrete, cast iron or heavy-duty PVC pipe of minimum 15-centimeter diameter shall be installed in the cable trench sump pit to nearest drainage sump to drain the water in the cable trench.

### 25.3 CONDUIT AND HAND HOLE

The Contractor shall provide the conduit and hand hole for the cable from the main trench to the steel structure or equipment foundation. The hand hole shall be reinforced concrete with galvanized steel chequered plate cover. The size of the hand hole shall be large enough to pull the cable from the conduit to the foundation.

### 25.4 PAYMENT

Payment for the Contract item, "Cable Trench, Duct Bank, Conduit and Hand hole and Cable Tray", will be made at the lump sum bid. Therefore, in the Price Schedule, such lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment and labour and all other operations related to cable trench design and construction, including but not limited to:

i. Performing detail designs and preparation of construction drawings.
ii. Supplying transporting all materials to job site.
iii. Excavating and backfilling for the cable trenches
iv. Constructing the cable trenches with floor drains, reinforced concrete wall, base, cable tray and removable cover.
v. Providing road crossing conduit and conduit pipe at foundation block.

## 26.0 MISCELLANEOUS OUTDOOR FACILITIES.

### 26.1 GENERAL

The proposal shall include all miscellaneous outdoor facilities. The miscellaneous outdoor facilities shall comprise of switchyard fence with entrance gate, access and internal roads, car parking shed etc. Works other than car parking shed are described above and shall be dealt accordingly.

Prior to execution of the works, the Contractor shall prepare and submit design and detailed drawings of such works to Employer for approval. All works shall be executed in accordance with the stipulations of the relevant articles of the Specifications.

### 26.2 CAR PRKING SHED

Car parking shed shall be constructed within the compound of substation for at least 4 cars.
No separate payment for car parking shed shall be made to contractor.

## 27.0 OTHER GENERAL REQUIREMENTS

i. Dense concrete with controlled water cement ratio as per IS/BS/equivalent International standards 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.

ii. 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.

iii. 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.

iv. All mild steel parts used in the water retaining structures shall be hot-double dip galvanised. The minimum coating of the zinc shall be 750gm/ sq. m. for galvanised structures and shall comply with relevant IS/BS/equivalent International standards. Galvanizing shall be checked and tested in accordance with relevant IS/BS/equivalent International standards. The galvanizing shall be followed by the application of an etc.

hing primer and dipping in black bitumen in accordance with BS: 3416.

v. A screed concrete layer not less than 100 mm thick and of grade not weaker than M10 conforming to relevant IS/BS/equivalent International standards 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.

vi. 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.

vii. 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.

viii. 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.

ix. 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.

x. Anti-termite chemical treatment for buildings shall be given to all column pits, wall trenches, foundations, filling below the floors etc. as per relevant IS/BS/equivalent International standards.

xi. 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 IS/BS/equivalent International standards). All rungs for ladder shall also be galvanised as per relevant IS/BS/equivalent International standards. For RCC stairs, hand railing with 20 mm square MS bars, balustrades with suitable MS flats & aluminium handrails shall be provided.

xii. For all civil works covered under this specification, design Mix of Minimum M25 grade as per relevant IS/BS/equivalent International standards 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 IS/BS/equivalent International standards.

**xiii. 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.**

xiv. Requirement of sulphate resistant cement (SRC) for sub structural works shall be decided in accordance with the IS/BS/equivalent International standards based on the findings of the detailed soil investigation to be carried out by the Bidder.

xv. 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.

xvi. All water retaining structures designed as uncracked section shall also be tested for water tightness at full water level in accordance with relevant IS/BS/equivalent International standards.

xvii. Construction joints shall be as per IS/BS/equivalent International standards.

xviii. 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 IS/BS/equivalent International standards for repairing the leakage.

xix. All building/construction materials shall conform to the best quality specified in relevant IS/BS/equivalent International standards.

## 28.0 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, 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.

## 29.0 STATUTORY RULES

i. Contractor shall comply with all the applicable statutory rules pertaining to factories act (as applicable for the Nepal).

ii. 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.

## 30.0 FIELD QUALITY PLAN

All tests as required in accordance to IS/BS/equivalent International standards have to be carried out. The contractor shall prepare field quality plan for civil works as per relevant IS/BS/equivalent International Standards during detailed engineering stage and submit to NEA for approval within ONE month after award of work.

## 31.0 MODE OF MEASUREMENT

i. 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 or as per BOQ.

ii. Contour survey and site levelling.

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 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.

iii. 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, 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 meters.

iv. 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.

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.

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.

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.

v. 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.

vi. 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 tons on the basis of sectional weights as adopted by IS/ BS/ 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.

vii. Stone filling over grating in Transformer 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 $m^3$.

viii. Miscellaneous structural steel

Measurement for Supply, fabrication, transportation and erection of all miscellaneous structural steel work for rails alongwith rail fixing details and gratings with supports for transformers/ reactors, Cable trenches with covers (Chequered plate covers, cable supports, earthing cleats and edge protection angles etc.), all other steel fittings and fixtures, inserts and embedment in concrete of transformer/reactor foundation and cable trenches shall be made as per approved drawings. The unit rate for this item shall be inclusive of cutting, grinding, drilling, bolting, welding, pre-heating of the welded joints, applying a priming coat of steel primer and anti-corrosive bituminous 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 tons.

ix. Roads inside S/S compound

The measurement for the concrete road shall be made on the basis of area in square meter ($M^2$) 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 Bid price schedule (BPS)

The measurement of bituminous road shall be made on the basis of area in square meter ($M^2$), 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. The unit price bid in the Price Schedule shall include the cost of design, all labour, all material, civil construction works, etc.

The measurement of strengthening of existing road (bituminous road) shall be made on the basis of area in square meter ($M^2$), 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.

x. 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. 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.

xi. 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 also be included within fencing.

xii. 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 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.

xiii. Drains & Culverts

PCC (1:2:4 and 1:4:8) for drains and culverts shall be measured under respective items of Bid price schedule (BPS) as described in clauses of aforesaid paras. All other items like excavation, brick work, plaster and stone pitching except RCC Hume pipes required for completion of drains and culverts shall be deemed to be included in the quoted rate of drain. The quantity for each type of drain section shall be measured in running meters. However, RCC Hume pipes used in culverts shall be measured under respective item of Bid price schedule (BPS) as described in clause of Hume pipes.

xiv. 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).

xv. 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.

## 32.0 PAYMENTS

### 32.1 PAYMENT FOR CIVIL WORKS

Payment for the Buildings shall be made on the basis of actual quantity approved by Employer as shown on approved drawings. The method of measurement shall be of required accuracy and shall be approved by Employer.

Payments will be made in the following manner:

Different milestones have been set dividing the total work in four stages. Upon completion of each milestones payment shall be made as per price quoted by the bidder.

i. Payment for the items that can be measured shall be made on monthly progress basis according to the unit cost quoted in the Price Schedule.

ii. Payment against unit price for 'Concrete Foundation for Equipment and Steel Structures complete with excavation, backfilling, form works, concrete works and reinforcement Bars' shall be made upon completion of whole works

i. Payment for the lump sum items of 'Construction of Buildings' shall be paid of work in percentage after the work that has been approved by Employer as mentioned below with provision of retention as mentioned in the SCC.

| Stage | Milestones Achieved | Percentage Payment |
|---|---|---|
| I | Excavation and backfilling, Concrete M20 in foundation footings, columns and tie beams, Flooring lean concrete M15, Brick masonry work in foundation walls etc. | 25% |
| II | Concrete M20 in superstructure columns, slabs, beams, roof slabs and parapet walls etc. | 25% |
| III | Brick masonry works in superstructure walls | 25% |
| IV | Doors and windows, Water supply, plumbing and | 25% |

| | | |
|---|---|---|
| | sanitary fixtures, Plaster and tile works, Illumination works, Painting and glazing, Furniture and miscellaneous indoor facilities | |

In addition to above, for Control Building stage I shall include cable trench and other related works, Stage II shall include water proofing and stage IV shall include air conditioning facilities.

# CHAPTER 21

# INSPECTION, TESTING AND COMMISSIONING

## 1 SCOPE OF WORK

The whole of the Works supplied under the Contract shall be subject to inspections and tests by the Employer or their Representatives during manufacture, erection and after completion. The inspections and tests shall include, but not be limited to, the requirements of this section of the Specifications.

The Contractor shall provide all costs, appliances, apparatus, supervision, labor and services necessary to carry out all tests, unless specifically stated otherwise.

The Contractor shall furnish the detailed schedule of his commissioning plan at least one month prior to the scheduled date. The schedule shall include the commissioning procedures, testing sequences and details of special testing equipment, tests and commissioning record formats, information about relevant standards etc.

The scope of the commissioning program includes the site testing and putting into successful operation of all the equipment supplied under the Contract, for 132kV, 33kV, 11kV, AC & DC plants and all secondary voltages systems. Testing of energy meters and certification of their accuracy shall also be included.

## 2 OBJECTIVES

The objectives of commissioning work, prior to the successful energization of Plant at full voltage and connection to the system, are the following:

- Confirm the integrity (correctness) of installation.
- Confirm the integrity of insulation, connections and phasing.
- Ensure proof of equipment characteristics.
- Review workmanship.
- Confirm the correct implementation of the design.
- Check equipment ratings.
- Check settings and operation of protective relays.
- Check and measure resistivity of earthing grid and earthing system.

- Confirm the proper functioning of SCADA and Substation Automation system.

## 3 QUALITY ASSURANCE, INSPECTION AND TESTING

To assure that the supply and services under the scope of this Contract whether manufactured or performed within the Contractor's works or at his subcontractor's premises or at the Site or at any other place of work, are in accordance with the Specifications, the Contractor shall adopt suitable quality assurance program to control such activities at all points necessary. Such program shall be outlined by the Contractor and shall be finally accepted by the Employer after discussions before the award of the Contract. A quality assurance program of the Contractor shall generally cover, but not be limited to the following:

(a) His organization structure for the management and implementation of the proposed quality assurance program.

(b) Documentation control system.

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

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

(e) System for shop manufacturing including process controls and fabrication and assembly controls.

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

(g) Control of calibration and testing of measuring and testing equipment.

(h) Inspection and test procedure for manufacture.

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

(j) System for quality audits.

(k) System for authorizing release of manufactured products to the Employer.

(l) System for maintenance of records.

(m) System for handling storage and delivery.

(n) A quality plan detailing out the specific quality control procedure adopting for controlling the quality characteristics relevant to each item of supply.

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

- Quality Assurance Documents

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

The Employer, through his duly authorized representatives, reserves the right to carry out Quality Audit and Quality Surveillance of the systems and the procedures of the Contractor's and the subcontractor's Quality Management and Control Activities.

- Inspection, Testing and Inspection Certificates

The provisions of the clauses on Test and Inspection of the General Conditions of Contract and Special Conditions of Contract shall be applicable to the supply and erection portions of the Works. The Employer shall have the right to re-inspect at his expenses, any material though it would have been previously inspected and approved by him at the Contractor's works before, and if, after the same are inspected at Site following the latter, material is found defective, then the Contractor shall bear the cost of this inspection and reinstatement according to specification.

## 4 TESTS AT MANUFACTURERS WORKS

### 4.1 General

Where no specific test is specified, then the various items of materials and equipment shall be tested in accordance with the relevant IEC Standards. Where no appropriate standard is available, tests shall be carried out in accordance with the maker's standard practice, which shall be subject to the Employer's approval.

At least fourteen days' prior notice, in writing or by telefax, shall be given to the Employer of the readiness of the plant for test or inspection and every facility shall be provided by the Contractor and subcontractor (s) to enable the Employer or their Representative to carry out the inspections and witness the tests. This includes progress, test rig and packing inspections also.

Inspection of equipment will not be carried out unless the Employer has approved copies of the relevant sub-orders, drawings and test procedures.

No equipment shall be packed, prepared for shipment, or dismantled for the purpose of packing for shipment, unless it has been satisfactorily inspected, or inspection has been waived by the Employer.

Functional electrical and mechanical tests shall be carried out on the completed plant after assembly in the Works. The extent and method of recording the results shall be agreed by the Employer in sufficient time to enable the tests to be satisfactorily witnessed or to make any changes to the proposed program of tests.

All instruments and apparatus used in the performance of the tests shall be subject to the approval of the Employer and, if required by the Employer, shall be calibrated to an agreed standard at a laboratory of national standing to be nominated by the Contractor and approved by the Employer.

The costs of carrying out such calibration shall be borne by the Contractor in all cases.

The costs of making any test shall be borne by the Contractor. This shall apply to tests performed at the site or elsewhere.

After receiving the prior information about the completion of manufacturing at the factory, the Employer will depute his personnel to the Contractor's factory to witness the fabrication, assembly and testing of any or all parts of major equipment. The number of the Employer's personnel and equipment to be witnessed will be as listed below. The duration of such visits shall be as per inspection/testing requirements.

| | |
|---|---|
| -145 kV Circuit Breakers | 2 persons, 1 visit |
| -145 kV outdoor switchgear | 2 persons, 1 visit |
| -36 kV Circuit Breakers | 2 persons, 1 visit |
| -Power transformers | 2 persons, 1 visit |
| -Control & Relay Panels | 2 persons, 1visit |
| -Substation Automation System | 2 persons, 1visit |
| -Disconnecting Switch | 2 persons, 1 visit |
| -Instrument transformers | 2 persons, 1 visit |
| -12 kV Switchgear system | 2 persons, 1 visit |
| -Lightning arresters | 2 person, 1 visit |
| -110 V & 48 V Battery and Battery charger | 2 persons, 1 visit |

4.2 Test Certificates

Within 30 days of the completion of any test, triplicate sets of all principal test records, test certificates and performance curves shall be supplied to the Employer.

These test records, certificates and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Employer or his representative. The information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificate refers and should also bear the Contract reference title. Specified requirements shall be shown on each certificate for comparison with actual test results.
When all equipment has been tested, test certificates of all factory and site tests shall be compiled by the Contractor into volumes and bound in an approved form complete with index. Two copies of each volume shall be supplied to the Consultant and five copies to the Employer.

4.3 Type Tests

Type tests are required to prove the general design of the equipment and the Contractor may submit certificates of such design tests, which have been carried out on identical equipment. Notwithstanding any provision in BS, IEC or ANSI Standards, the Employer shall have the right to accept such certificates in lieu of the specified type tests or to reject them.

The type tests prescribed shall be carried out at the Contractor's cost in all cases, where either such certificates are not available or are rejected by the Employer.

## 5 RESPONSIBILITIES

To ensure that the test jurisdiction and transfer of responsibilities is regulated by strict safety and handover procedures, the Contractor agrees the interface with the Employer to establish and implement handover procedures consistent with the terms of these Specifications.

The Employer shall retain full jurisdiction over all commissioning activities, which may affect the operation of the existing system. In these circumstances and when so requested, shall provide technical advices and assistances.

The Contractor shall be responsible for technical guidance and assistance in establishing the scope and method of tests, witnessing of the testing, assessment of results, and re-negotiation of the changes in test schedules which may be necessary as a result of other circumstances, such as delays in the delivery, possible equipment failures.

## 6 SAFETY PROCEDURES

The Contractor shall share the responsibility for safety procedures with the Employer.
The Contractor shall establish and implement a work permit and tagging system and associated safety procedures (subject to the review of Employer) for all equipment, systems and areas not covered by the Employer's safety procedures.

The Employer will assume responsibility for the establishment and implementation of tagging, safety and work permit procedures for the protection of personnel and equipment, as soon as equipment and systems are connected to or are energizeable from the existing system.

## 7 TRAINING OF THE EMPLOYER'S STAFF

The Contractor shall plan for the Employer's staffs' participation, either continuously or on a regularly recurring basis, in the commissioning work and:

Allow the Employer's staffs to become familiar with the operating and maintenance aspects of the new equipment supplied by him,

Maintain a continuing assessment with the Employer of the precautions required in, or possible consequences of, initial energisation of equipment,

Allow for the above two necessary objectives in the preparation of schedules.

The Contractor shall station at site, at least, one technical expert for a minimum of six months continuously after commissioning to rectify any problems, as well as train the Employer's attending staffs. If required, the length of his stay shall be extended as per requirement, which shall be at the Employer's discretion.

## 8 COMMISSIONING STAFF

The Contractor shall provide commissioning personnel including skilled and unskilled labor as required. Submit a list with names, experience and proposed duration of the stay of key personnel on site, consistent with the construction schedule, along with the commissioning program.

Ensure that only staffs assigned to commissioning fulfills that duty for the duration of the assignment.

Ensure that commissioning staffs have authorization, and the competence, to undertake minor repairs or to make temporary redesigns and to reconnect systems to meet the specified system performance to preclude delays in energization and putting into commercial service of any part of the works.

## 9 TEST EQUIPMENT

The Contractor shall ensure that all instruments, tools and other equipment required for testing and commissioning are available on site, ensure that the test equipment is of satisfactory quality and condition and, where necessary, is calibrated by an approved authority or standard.

Make arrangements for the provision of power supplies for testing with necessary vector configuration, voltage and current rating.

## 10 COMMISSIONING PROGRAM

Prepare a commissioning program for approval by the Employer and for incorporation into the Project master construction program. Allocate adequate time in this program to permit full commissioning of all components.

Carry out all testing during normal working hours as far as practicable. Tests, which involve existing apparatus and system outages, may be carried out outside normal working hours. Give the Employer sufficient notice to allow for the necessary outage arrangements to be made in conformity with the testing program.

Note that no tests listed in the agreed program will be waived except upon the instructions or consent of the Employer in writing.

### 10.1 Test Procedures

The following basic tests, in addition to others, shall be carried out:

- Measurement of insulation resistance.
- AC withstand voltage test

### 10.2 Requirements for Field Tests

The field tests shall be carried out in presence of Employer under the following conditions:

AC withstand test voltages for conductors and outdoor equipment shall be normal operation voltage of the transmission line and, withstand voltage test shall be carried out for ten (10) minutes by the normal voltage mentioned above.

The field tests shall be carried out by the Contractor after adjustment of all the equipment have been completed.

Expandable and lead wires and other materials required for the field tests shall be arranged by the Contractor. The Contractor shall be responsible for providing all measuring instruments, test equipment and tools required for the tests.

Preparation of the test record sheets and test reports shall be the responsibility of the Contractor and the results of the field tests shall be submitted by the Contractor for Employer's approval.
Measurement of insulation resistance of the equipment shall be performed by at least 1000 V Insulation tester.

After completion of the measurement of insulation resistance mentioned above, ac withstand voltage test shall be performed by the normal operation voltage of the existing power system in accordance with the following procedure:

- 11, 33 and 132 kV Main Circuit: The 11 kV, 33 kV and 132 kV circuit breakers and disconnecting switches, except for circuit breakers receiving power for the test from the existing power system through a transmission line, shall be closed, succeeding, normal operation voltage shall be charged on the equipment and bus conductors for ten (10) minutes for ac withstand voltage test. The indication value of meters mounted on the board during the ac withstand voltage test shall be recorded on the test record sheets prepared by the Contractor.

Submit test procedures, consisting of detailed test methods and samples of the related test record forms, for all equipment to be tested, to the Employer for approval along with the commissioning program. Strictly adhere to these procedures for the commissioning tests.

10.3 Records

Maintain an up-to-date record of all commissioning activities on site.

Record the results of the tests clearly on forms and formats approved by the Employer and with clear references to the equipment and items tested, so that the record can be used as the basis for maintenance tests, in future. Submit the required number of site test records to the Employer as soon as possible after completion of the tests.

Record the details of the test equipment and instruments used in the test sheets, in those cases where the instrument or equipment characteristics can have a bearing on the test results.

10.4 "As-Built" Drawings

Keep an ongoing record of all changes on a master set of drawings. Produce and supply a minimum of five complete sets of marked-up "As Constructed/As-Built"

drawings before leaving the Site. Correct and re-issue the original drawings as soon as possible as per this specification.

10.5 Test Methods

Carry out all necessary tests for commissioning the substations. The following clauses detail the tests which are considered to represent the minimum required in addition to those specified under the appropriate IEC Publications, other approved standards and the manufacturer's instructions for each item of equipment.

Strictly adhere to the methods of testing approved by the Employer.

A) Site and Commissioning Tests for Main and Auxiliary Equipment

General Checks

Make a general check of all main and auxiliary equipment. Include a check of the completeness, correctness and condition of ground connections, labeling, arcing ring, paint surfaces, cables, wiring, pipe-work, valves, blanking plates and all other auxiliary and ancillary items.

Check for oil and gas leaks and that insulators are clean and free from external damage. Check that loose items, which are to be handed over to the Employer, e.g., blanking plates, tools, spares, etc. are in order and are correctly stored or handed over.

Power Transformers

Make all tests as per commissioning tests called for in the Manufacturers' instructions manual.

Record and submit to Employer in a hardcover binder, all test data obtained.

**Circuit Breaker Tests**

For the SF6 circuit breakers, test the gas system to prove the gas density, its dryness and its di-electric strength. Measure the gas leakage rate.

Check and set pressure switches settings when required. Also test mechanical operating systems.

Carry out contact resistance tests. In the case of multi-interrupter circuit breakers, perform resistance tests at each interrupter or pair of interrupters as well as through the series of interrupters on each pole.

Test local and remote trip/close operation and perform circuit breaker and auxiliary contact timing tests on all circuit breakers.

Control/ Relay Panels, energy meters and Switchboards

Carry out general testing and inspection, as referred to above. The Contractor shall also carry following tests: a) Carrier signal testing b) protective relay testing c) Instrument transformers testing c) Phase correcting testing. Functionally test and perform the timing tests on circuit breakers and AC and DC circuits, associated with stand-by auxiliary supplies and stand-by generating sets, particularly where automatic operation is defined.

Carry out insulation measurement tests of secondary circuits with a 1000 V DC Insulation tester before and after high voltage testing.

Check shutters, interlocking, earth procedures and the inter-changeability of components.

Carry out a high voltage 50 Hz dielectric test on each bus at 75% of the specified value for the equivalent factory test.

Disconnecting Switch and Earth Switches

Test all disconnecting switch and earth switches operationally to confirm contact pressures, contact resistance, simultaneous-operation of all phases and the ease of operation.

Check the local and remote indications and the operation of auxiliary contacts. Check the earthing mat at the operating positions and check the availability of connecting points for maintenance earthing arrangements.

Test the earth switches and maintenance earthing devices to confirm the opening and closing sequences and check the ground mat connections, indications and manual locking devices.

Lightning Arresters

Inspect and verify the condition and satisfactory mounting of the arresters and their earth connections, electrodes and operation counters. Note the counter readings.

Busbars and Connections

Test flexible busbars and connections to ensure that the correct tensions, sags and clearances will be maintained over the range of environmental

conditions and loads without stress to other equipment. If dynamometers are used to check the sags and tensions, check them before and after use.

Check rigid busbars and connections to ensure that the busbars will not cause overloading of the supporting insulators under load conditions and under the range of climatic variations applicable to the Site. Ensure that expansion and contraction of the equipment is fully accommodated by flexible connections.

Test conductivity on selected connections and joints.

Perform high voltage DC tests on all HV cables and isolated phase bus bars at 75% of the specified value for the equivalent factory test. Carry out with at least 1000 V DC megger the insulation measurement test, before and after high voltage tests.

**Batteries and Battery Charging Equipment**

Test the insulation to earth of the complete DC system.

Test the batteries and chargers to confirm the charger ratings, adjustment, alarm systems and battery capacity for the specified length of time at maximum expected loading.

Record the specific gravity and cell voltages of the batteries during the initial charge and when fully charged and maintain proper regular records until the battery is taken over by the Employer.

Interlocking

Check all interlocking arrangements, both electrical and mechanical.

B) Earthing System

Carry out the tests and measurements in accordance with IEEE Standard 80.

Test the effectiveness of the bonding and earthing and make conductivity tests on selected joints on the main earthing system and at the connections to equipment and structures. Check the precautions taken to avoid corrosion attack on the earthing system.

Measure the resistance of the earthing system to the remote earth indicating method and equipment used. Separate test probes of minimum 300 to 600 meters length to effectively test the earthing system.

Perform earthing resistance measurements with the transmission line earth wires disconnected from the grounding grid.

C) Area Lighting

Check all lighting circuits including the operation of relevant photoelectric cells and remote/local commands.

Measure the lighting levels throughout the substation on horizontal surface 800 mm above ground level and on all vertical surfaces of transformers, marshaling kiosks, etc.

Measure the lighting levels in the area surrounding the substation up to 20 m from the fence.

D) Particular Constraints and Special Tests

The Contractor shall be prepared to cooperate with any special tests requested by the Employer.