

# NEPAL ELECTRICITY AUTHORITY

(An Undertaking of Government of Nepal)

## PROJECT MANAGEMENT DIRECTORATE



## SASEC Power System Expansion Project MARSYANGDI-KATHMANDU 220kV T/L PROJECT

### BIDDING DOCUMENT FOR

**Procurement of Plant for 220 kV Air Insulated Substation (AIS) in Matatirtha,  
Kathmandu and 220kV Gas Insulated Substation (GIS) in Markichowk,  
Marsyangdi  
(Design, Supply and Installation and Commissioning)**

**Single-Stage, Two-Envelope  
Bidding Procedure**

<b>Issued on:</b>	.....
<b>Invitation for Bids No.:</b>	<b>ICB-PMD-MKTLP-076/77 - 02</b>
<b>ICB No.:</b>	<b>ICB-PMD-MKTLP-076/77 - 02</b>
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## Volume-II

### (Technical Specifications for Substation)

### (Chapter 12 to 22)

	Chapter 12 : Switchyard Erection	Rev. 00 (NEA)
	Chapter 13 : Structure	Rev. 00(NEA)
	Chapter 14: Civil Works	Rev. 00 (NEA)
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	Chapter 19: GENERAL TECHNICAL REQUIREMENT (GTR)-TRANSFORMER & REACTOR	Rev 00 (NEA)
	Chapter 20: 220KV CLASS SPECIFICATIONS FOR TRANSFORMER (Transformer up to 220 kV class)	Rev 00 (NEA)
	Chapter 21: Gas Insulated Switchgear (GIS) (Supply has been done by previous contractor and only Erection and Commissioning is remaining)	Rev 00 (NEA)
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## **CHAPTER: SWITCHYARD ERECTION**

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## **CHAPTER 12-(SE)** **SWITCHYARD ERECTION**

### **1.0 GENERAL**

The detailed scope of work includes design, engineering, manufacture, testing at works, supply on FOR destination site basis, insurance, handling, storage, erection testing and commissioning of various items and works as detailed herein.

This Chapter covers the description of the following items.

#### **A. Supply of**

- String insulators and hardware
- AAC / ACSR conductor
- Galvanised Steel Earthwire
- Aluminium Tubular Bus Bars
- Spacers
- Bus post insulators
- Earthing & Earthing materials
- Lightning protection materials
- Cabling material
- Other items

#### **B. Erection Of all items**

##### **1.1 String Insulators & Hardware**

The insulators for suspension and tension strings shall conform to IEC-60383 and long rod insulators shall conform to IEC-60433. Insulator hardware shall conform to equivalent international standard. Composite long rod insulator shall conform to IEC: 61109.

##### **1.1.1 Construction Features**

###### **1.1.1.1 For porcelain insulators**

- a) Suspension and tension insulators shall be wet process porcelain with ball and socket connection. Insulators shall be interchangeable and shall be suitable for forming either suspension or tension strings. Each insulator shall have rated strength markings on porcelain printed and applied before firing.
- b) Porcelain used in insulator manufacture shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and



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impervious to moisture.

- c) Glazing of the porcelain shall be uniform brown colour, free from blisters, burrs and other similar defects.

#### **1.1.1.2 For glass insulators**

It shall be made of toughened glass. Glass used for the shells shall be sound, free from defects, flows bubbles, inclusions, etc and be of uniform toughness over its entire surface. All exposed glass surfaces shall be smooth.

- 1.1.1.3 When operating at normal rated voltage there shall be no electric discharge between conductor and insulator which would cause corrosion or injury to conductors or insulators by the formation of substances due to chemical action. No radio interference shall be caused when operating at normal rated voltage.

- 1.1.1.4 The design of the insulator shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. All ferrous parts shall be hot dip galvanized. The zinc used for galvanizing shall be of grade Zn-99.95. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains bulky white deposits and blisters.

- 1.1.1.5 Bidder shall make available data on all the essential features of design including the method of assembly of discs and metal parts, number of discs per insulator string insulators, the manner in which mechanical stresses are transmitted through discs to adjacent parts, provision for meeting expansion stresses, results of corona and thermal shock tests, recommended working strength and any special design or arrangement employed to increase life under service conditions.

- 1.1.1.6 Clamps for insulator strings and Corona Control rings shall be of aluminium alloy as stipulated for clamps and connectors.

- 1.1.1.7 Insulator hardware shall be of forged steel. Malleable cast iron shall not be accepted except for insulator disc cap. The surface of hardware must be clean, smooth, without cuts, abrasion or projections. No part shall be subjected to excessive localized pressure. The metal parts shall not produce any noise generating corona under operating conditions.

- 1.1.1.8 The tension Insulator hardware assembly shall be designed for minimum 12000 kg tensile load for below 765kV. Earth wire tension clamp shall be designed for minimum 1000 kg tensile load with a factor of safety of two (2).

- 1.1.1.9 The tension string assemblies shall be supplied alongwith suitable turn buckle. Sag compensation springs if required may also be provided.

- 1.1.1.10 All hardware shall be bolted type.

#### **1.2 Long Rod Porcelain Insulators**

- 1.2.1 As an alternative to disc insulator, Bidder can offer long rod porcelain insulators strings, with suitable hardware. The combination should be suitable for application specified and should offer the identical/equivalent parameters as

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would be available from insulator string comprising disc insulators and hardware combination.

- 1.2.2 All constructional features specified at Clause 1.1.1 of this Chapter shall also apply to the long rod insulator string.

#### **1.3 Tests**

In accordance with the stipulations of the specification, the suspension and tension strings, insulator and hardware shall be subjected to the following type tests, acceptance tests and routine tests:

- 1.3.1 **Type Tests on Insulator Strings:** The test reports for following type tests shall be submitted for approval as per clause 9.0 of Chapter 2 - GTR.

- a) Power frequency voltage withstand test with corona control rings under wet condition as per IEC- 60383.
- b) Lightning Impulse voltage withstand test with corona control rings under dry condition as per IEC-60383
- c) Voltage distribution test (Dry)

The voltage across each insulator unit shall be measured by sphere gap method. The result obtained shall be converted into percentage. The voltage across any disc shall not exceed 13% for 220KV suspension and tension insulator strings, 20% and 22% for 132KV suspension and tension insulator strings respectively.

- e) Corona Extinction Voltage test (Dry) :- (As per Annexure – C)

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 156kV (rms) for 220kV line to ground under dry condition. There shall be no evidence of Corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC 60383.

- f) RIV Test (Dry)

Under the conditions as specified under (e) above the insulator string alongwith complete hardware fittings shall have a radio interference voltage level below 1000 microvolts at 1 MHz when subjected to 50 Hz AC line to ground voltage of 156kV for 220kV string under dry conditions. The test procedure shall be in accordance with IEC 60437.

- g) Mechanical strength test

The complete insulator string alongwith its hardware fitting excluding arcing horn, corona control ring, grading ring, tension/suspension clamps shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five

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minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to dismantle them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

#### **1.3.2 Type Tests on Insulators**

Type test report for Thermal Mechanical Performance tests as per IEC - 60575, Clause 3 / IEC: 61109, clause 5.1 (for composite long rod insulators) shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

#### **1.3.3 Acceptance Tests for Insulators:**

- a) Visual examination as per IEC-60383/ IEC-61109 clause no. 7.2 (for composite long rod insulators).
- b) Verification of Dimensions as per IEC- 60383.
- c) Temperature cycle test as per IEC- 60383.
- d) Puncture Test as per IEC-60383 (Applicable only for porcelain insulators).
- e) Galvanizing Test as per IEC- 60383.
- f) Mechanical performance test as per IEC-60575 Cl. 4 / IEC-61109 clause no. 7.2 (for composite long rod insulators).
- g) Test on locking device for ball and socket coupling as per IEC-60372(2).
- h) Porosity test as per IEC- 60383 (Applicable only for porcelain insulators).
- i) Thermal shock test as per IEC-60383 (Applicable only for glass insulators)

#### **1.3.4 Acceptance Test on Hardware Fitting**

- a) Visual Examination as per Cl. 5.10 of IS:2486 (Part-I).
- b) Verification of Dimensions as per Cl. 5.8 of IS : 2486 (Part-I)
- c) Galvanising/Electroplating tests as per Cl. 5.9 of IS : 2486 (Part-I).
- d) Slip strength test as per Cl 5.4 of IS-2486 (part-I)
- e) Shore hardness test for the Elastometer (if applicable as per the value guaranteed by the Bidder).
- f) Mechanical strength test for each component (including corona control

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rings and arcing horns).

The load shall be so applied that the component is stressed in the same way as it would be in actual service and the procedure as given in 1.2.13.1 (g) above should be followed.

- g) Test on locking devices for ball and socket coupling as per IEC -60372(2).

### **1.3.5 Routine Test on Insulator**

- a) Visual Inspection as per IEC-60383
- b) Mechanical Routine Test as per IEC-60383
- c) Electrical Routine Test as per IEC-60383

### **1.3.6 Routine Test on hardware Fittings**

- a) Visual examination as per IEC-61109 (for composite long rod insulators).
- b) Mechanical strength Test as per IEC-61109 (for composite long rod insulators).

### **1.3.7 Test during manufacture on all Components as applicable on insulator**

- a) Chemical analysis of zinc used for galvanising:

Samples taken from the zinc ingot shall be chemically analyzed. The purity of zinc shall not be less than 99.95%.

- b) Chemical Analysis, mechanical hardness tests and magnetic particle inspection for malleable casting:

The chemical analysis, hardness tests and magnetic particle inspection for malleable casting will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding tests will be as discussed and mutually agreed to by the Contractor and Owner in Quality Assurance Program.

### **1.3.8 Test during manufacture on all components as applicable on hardware fittings:**

- a) Chemical analysis of zinc used for galvanising:

Samples taken from the zinc ingot shall be chemically analyzed. The purity of zinc shall not be less than 99.95%

- b) Chemical analysis, hardness tests and magnetic particle for forgings:

The chemical analysis, hardness tests and magnetic particle inspection for forgings will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat

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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**

<b>Sl. No.</b>	<b>Description</b>	<b>For 220/132kV</b>
a)	Type of insulators	Anti Fog type
b)	Size of insulator units (mm)	255x145 or 280x145
c)	Electro mechanical strength	120 kN
d)	Creepage distance of individual insulator units (minimum and as required to meet total creepage distance)	430 mm
e)	Markings	
i)	For Porcelain insulators	Markings on porcelain
ii)	For toughened glass insulators	Markings shall be done on initial parts
f)	Power frequency puncture withstand voltage	1.3 times the actual wet flashover voltage

#### **1.4.2 INSULATOR STRING**

<b>Sl. No.</b>	<b>Description</b>	<b>220kV</b>	<b>132kV</b>
a)	Power frequency withstand voltage of the complete string with corona control ring (wet) – KV rms	460	275
b)	Lightning impulse withstand Voltage of string with corona control rings (dry) - kVp	± 1050	± 650
c)	Switching surge withstand voltage of string with corona control rings (wet) - kVp	NA	NA
d)	Minimum corona extinction voltage level of string with Corona Control rings (dry) -	156	NA

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	kV rms		
e)	Maximum RIV level in micro volts of string with Corona Control rings at 508 kV (rms) for 765 kV, 320 kV (rms) for 400 kV string and 156 kV for 220 kV string across 300 Ohms resistor at 1 MHz	1000	NA
f)	Minimum total creepage distance of the insulator string (mm)	6125	3625
g)	Total no. of discs per strings	15	10

For tension application, double insulator strings for 220 KV and single insulator strings for 132 kV system shall be used. For suspension purpose single suspension insulator string shall be used for 220 KV & 132 kV system.

### **1.4.2.1 INSULATOR STRING ( 33 KV )**

- a) Power frequency withstand : 75  
voltage of the complete string with Corona Control ring (wet) - kV rms
- b) Lightning impulse withstand :  $\pm 170$   
Voltage of string with corona control rings (dry) – kVp
- c) Power frequency puncture with- : 1.3 times actual wet flashover  
stand voltage for a string insulator voltage of the unit
- d) Total creepage distance of the : 900  
complete insulator string (mm)
- 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.

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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

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malleable cast iron/ spheroidal graphite or forged steel. They shall be connected to the rod by means of a controlled compression technique. The manufacturer shall have in-process Acoustic emission arrangement or some other arrangement to ensure that there is no damage to the core during crimping. This verification shall be in-process and done on each insulator. The system of attachment of end fitting to the rod shall provide superior sealing performance between housing and metal connection. The gap between fitting and sheath shall be sealed by a flexible silicone rubber compound. The sealing shall stick to both housing and metal end fitting. The sealing must be humidity proof and durable with time.

End fittings shall have suitable provisions for fixing grading rings at the correct position as per design requirements.

#### **1.5.4.4 Grading Rings**

Grading rings shall be used at both ends of each composite insulator unit for reducing the voltage gradient on and within the insulator and to reduce radio and TV noise to acceptable levels. The size and placement of the metallic grading rings shall be designed to eliminate dry band arcing/corona cutting/ exceeding of permissible electrical stress of material.

#### **1.5.2 Tests and Standards**

##### **1.5.2.1 Type Tests**

The test reports for following type tests on long rod units, components, materials or complete strings shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

##### **1.5.2.1.1 On the complete composite Long Rod Insulator String with Hardware Fittings:-**

- a) Power frequency voltage withstand test with corona control rings/grading ring and arcing horns (if provided) under wet condition as per IEC:60383-1993/
- b) Switching surge voltage withstand test under wet condition as per IEC:60383-1993.
- c) Impulse voltage withstand test under dry condition as per IEC:60383-1993
- d) Corona and RIV test under dry condition.

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 156kV (rms) for 220kV line to ground under dry condition. There shall be no evidence of Corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC 60383.

Under the conditions as specified above the insulator string alongwith complete hardware fittings shall have a radio interference voltage level below 1000 microvolts at 1 MHz when subjected to 50 Hz AC line to ground voltage of 156kV for 220kV under dry conditions. The test procedure shall be in accordance with IEC 60437.

- e) Mechanical Strength test



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The complete insulator string alongwith its hardware fitting excluding arcing horn, corona control ring, grading ring, tension/suspension clamps shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to dismantle them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

- f) Salt-fog pollution withstand test as per IEC: 60507. The salinity level for composite long rod insulators shall be 160 Kg/m<sup>3</sup> 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 fittings and insulator housing as per IEC: 61109-2008
- d) High Pressure washing test

The washing of a complete insulator of each E&M rating is to be carried out at 3800 kPa with nozzles of 6 mm diameter at a distance of 3m from nozzles to the insulator, The washing shall be carried out for 10minutes. There shall be no damage to the sheath or metal fitting to housing interface.

- e) Brittle fracture resistance test

The test arrangement shall be according to Damage limit proof test with simultaneous application of 1N-HNO<sub>3</sub> acid directly in contact with naked FRP rod. The contact length of acid shall not be less than 40mm and thickness around the core not less than 10mm. The rod shall withstand 80% of SML for 96 hours.

- f) Dye penetration test as per IEC: 61109-2008
- g) Water diffusion test as per IEC: 61109-2008
- h) Tracking and erosion test as per IEC: 61109-2008.
- i) Hardness test as per IEC: 61109-2008.
- j) Accelerated weathering test as per IEC: 61109-2008.
- k) Flammability test as per IEC: 61109-2008.
- l) Silicone content test

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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

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f.	Silicone content test	As per above
g.	Brittle fracture resistance test	As per above
h.	Dye penetration test	IEC : 61109-2008
i.	Water diffusion test	IEC : 61109-2008

In the event of failure of the sample to satisfy the acceptance test(s) specified in 4.2 above, the retest procedure shall be as per IEC 61109.

### **1.5.2.3 Routine Tests**

#### **1.5.2.3.1 For Composite Long Rod Insulator Units**

a)	Visual Examination	As per IEC:61109-2008
b)	Mechanical routine test	As per IEC:61109 -2008

### **1.5.3 Guaranteed Technical Particulars**

#### **1.5.3.1 Electrical system Data**

<b>Sl.</b>	<b>Parameters</b>	<b>Unit</b>	<b>System Voltage</b>	
1.	Nominal Voltage	kV	<b>220</b>	<b>132</b>
2.	Maximum system voltage	kV	245	145
3.	BIL (Impulse)	kV (Peak)	±1050	±650
4.	Power frequency withstand voltage (Wet)	kV (rms)	460	275
5.	Switching surge withstand voltage (Wet)	kV (rms)	NA	NA
6.	Minimum Corona extinction voltage at 50 Hz AC system under dry condition	kV (rms) phase to earth	156	NA
7.	Radio interference voltage at one MHz for phase to earth voltage of 508 KV under dry condition.	Micro Volts	1000 (Max)	NA
8.	Minimum creepage distance .	mm	6125	3625
9.	Electromechanical strength of Insulator Unit.	kN	120	120

## **2.0 AAC / ACSR CONDUCTOR**

### **2.1 Details of AAC Conductor**

2.1.1 The contractor shall supply the conductor as per the standard guaranteed technical particulars enclosed in Annexure-B of the technical specification,

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Chapter 12 – Switchyard Erection and separate approval is not required during detailed engineering.

Owner has also standardised the guaranteed technical particulars for the conductors which are enclosed in Annexure-E of the technical specification, Chapter 12 – Switchyard Erection. The contractor shall supply the conductor as per the standard guaranteed technical particulars.

2.1.2 The details of the AAC Bull conductor are tabulated below:

Sl. No.	Description	Unit	AAC BULL
a)	Stranding and wire diameter	mm	61/4.25
b)	Number of Strands		
	1st Aluminium Layer	Nos.	1
	2nd Aluminium Layer	Nos.	6
	3rd Aluminium Layer	Nos.	12
	4th Aluminium Layer	Nos.	18
	5th Aluminium Layer	Nos.	24
c)	Total sectional area	Sq.mm	865.36
d)	Overall diameter	mm	38.25
e)	Approximate weight	kg/ km	2400
f)	Calculated d.c. resistance at 20oC	ohm/km	0.0334
g)	Minimum UTS	kN	139

2.1.3 The details of Aluminium strand are as follows:

Sl. No.	Description	Unit	AAC BULL
a)	Minimum breaking load of strand before stranding	KN	2.23
b)	Minimum breaking load of strand after stranding	KN	2.12
c)	Maximum D.C. resistance of strand at 20 deg. Centigrade	Ohm/KM	3.651

### 2.2 Details of ACSR Conductor

2.2.1 The details of the ACSR Moose conductors shall be as per the standard guaranteed technical particulars enclosed in Annexure-A are tabulated below:

#### **ACSR MOOSE CONDUCTOR:**

Sl. No.	Description	Unit	ACSR MOOSE
a)	Stranding and wire diameter	mm	54/3.53 (Al)+ 7/3.53 (Steel)
b)	Number of Strands		

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	Steel centre	Nos.	1
	1st Steel Layer	Nos.	6
	1st Aluminium Layer	Nos.	12
	2nd Aluminium Layer	Nos.	18
	3rd Aluminium Layer	Nos.	24
c)	Sectional area of Aluminium	Sq. mm	528.5
d)	Total sectional area	Sq. mm	597.00
e)	Overall diameter	mm	31.77
f)	Approximate weight	kg/km	2004
g)	Calculated d.c. resistance at 20oC	ohm/km	0.05552
h)	Minimum UTS	kN	161.2

2.2.2 The details of Aluminium strand are as follows:

### **ACSR MOOSE CONDUCTOR:**

Sl. No.	Description	Unit	ACSR MOOSE
a)	Minimum breaking load of strand before stranding	KN	1.57
b)	Minimum breaking load of strand after stranding	KN	1.49
c)	Maximum D.C. resistance of strand at 20 deg. Centigrade	Ohm /KM	2.921

2.2.3 The details of steel strand are as follows:

### **ACSR MOOSE CONDUCTOR:**

Sl. No.	Description	Unit	ACSR MOOSE
a)	Minimum breaking load of strand before stranding	KN	12.86
b)	Minimum breaking load of strand after stranding	KN	12.22
c)	Minimum number of twists to be withstood in torsion test when tested on a gauge length of 100 times diameter of wire	Nos.	18 (Before stranding) 16 (Before stranding)

## **2.3 Workmanship**

2.3.1 The finished conductor shall be smooth, compact, uniform and free from all imperfections including kinks (protusion of wires), wire cross over, over riding, looseness (wire being dislocated by finger/hand pressure and/or unusual bangle

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noise on tapping), material inclusions, white rust, powder formation or black spot (on account of reaction with trapped rain water etc.), dirt, grit etc.

2.3.2 All the Aluminium and steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, diemarks, scratches, abrasions, etc., after drawing.

2.3.3 The steel strands shall be hot dip galvanised and shall have a minimum zinc coating of 260 gms/sq.m. after stranding of the uncoated wire surface. The zinc coating shall be smooth, continuous and of uniform thickness, free from imperfections and shall withstand minimum three dips in standard Preece test. The finished strands and the individual wires shall be of uniform quality and have the same properties and characteristics as prescribed in ASTM designation : B 498-74.

2.3.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands in the event of cutting of composite core wire. Care shall be taken to avoid, damages to galvanisation during pre-forming and post-forming operation.

### **2.4 Joints in Wires**

#### **2.4.1 Aluminium Wires**

Joints in aluminium wires shall be as per relevant International standard.

#### **2.4.2 Steel Wires**

There shall be no joint of any kind in the finished wire entering into the manufacture of the strand. There shall also be no strand joints or strand splices in any length of the completed stranded steel core of the conductor.

### **2.5 Tolerances**

The manufacturing tolerances shall be as per relevant International standard.

#### **A. AAC Bull and AAC Tarantala conductor:**

a)	Diameter of Aluminium and Steel Strands						
		AAC BULL			AAC TARANTALA		
		Standard	Maximum	Minimum	Standard	Maximum	Minimum
	Aluminium	4.25 mm	4.29 mm	4.21 mm	5.23	5.28	5.18
b)	Lay ratio of Conductor						
			AAC BULL		AAC TARANTALA		
			Maximum	Minimum	Maximum	Minimum	
	Aluminium	6 wire layer	16	10	16	10	
		12 wire layer	16	10	16	10	
		18 wire layer	16	10	16	10	
		24 wire layer	14	10	-	-	

#### **B. ACSR Bersimis and ACSR Moose conductor:**

a)	Diameter of Aluminium and Steel Strands
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		ACSR BERSIMIS			ACSR MOOSE		
		Standard	Maximum	Minimum	Standard	Maximum	Minimum
	Aluminium	4.57 mm	4.61 mm	4.53 mm	3.53 mm	3.55 mm	3.51 mm
	Steel	2.54 mm	2.57 mm	2.51 mm	3.53 mm	3.60 mm	3.46 mm
b)	Lay ratio of Conductor						
			ACSR BERSIMIS		ACSR MOOSE		
			Maximum	Minimum			
	Steel	6 wire layer	18	13	18		16
	Aluminium	8/12 wire layer	17	10	14		12
		14/18 wire layer	16	10	13		11
		20/24 wire layer	14	10	12		10

### **2.6 Materials**

#### **2.6.1 Aluminium**

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity not less than 99.5% and a copper content not exceeding 0.04%.

#### **2.6.2 Steel**

The steel wire strands shall be drawn from high carbon steel wire rods and shall conform to the following chemical composition:

Element	% Composition
Carbon	0.50 to 0.85
Manganese	0.50 to 1.10
Phosphorous	Not more than 0.035
Sulphur	Not more than 0.045
Silicon	0.10 to 0.35

#### **2.6.3 Zinc**

The zinc used for galvanising shall be electrolytic High Grade Zinc of 99.95% purity.

### **2.7 Standard Length**

2.7.1 The conductor shall be supplied as required. No joint shall be allowed within a single span of stringing, jumpers and equipment interconnection.

### **2.8 Tests :**

2.8.1 The following type, acceptance & routine tests and tests during manufacturing shall be carried out on the conductor.

#### **2.8.2 Type Tests**

In accordance with the stipulation of specification, the following type tests reports of the conductor shall be submitted for approval as per clause 9.2 of Chapter 2 -GTR.

- a) UTS test on stranded conductor.

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- 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



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on each coil.

### **2.8.5 Tests During Manufacture**

- a) Chemical analysis of zinc used for galvanising
- b) Chemical analysis of aluminium used for making aluminium strands
- c) Chemical analysis of steel used for making steel strands

### **2.8.6 Sample Batch for Type Testing**

The Contractor shall offer material for selection of samples for type testing, only after getting quality assurance plans approved from Owner's Quality Assurance Department. The sample shall be manufactured strictly in accordance with the Quality Assurance Plan approved by Owner.

## **3.0 Galvanised Steel Earth wire**

### **3.1 Details of Earth wire**

3.1.1 The contractor shall supply the earthwire as per the standard guaranteed technical particulars enclosed in Annexure-E of the technical specification, Chapter 12 – Switchyard Erection and separate approval is not required during detailed engineering.

Owner has also standardised the guaranteed technical particulars for the earthwire which are enclosed in Annexure-E of the technical specification, Chapter 12 – Switchyard Erection. The contractor shall supply the earthwire as per the standard guaranteed technical particulars.

3.1.2 The basic details of the earth wire are tabulated below:

Sl.No.	Description	Unit	Value
1.	Stranding & Wire diameter	mm	7/3.66 (steel)
2.	Strands		
	a) Steel Core	No.	1 (one)
	b) Outer layer	No.	6 (six)
3.	Total sectional area	Sq. mm.	73.65

Other technical details are furnished in of Annexure -E of this Specification.

## **3.2 Workmanship**

3.2.1 All steel strands shall be smooth, uniform and free from all imperfections, such as

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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 galvanized (and shall have minimum Zinc coating of 275 gms/sq.m) after stranding of the uncoated wire surface. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections and shall withstand three and a half dips after stranding in standard Preece test. The steel wire rod shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands shall be of uniform quality and have the same properties and characteristics as prescribed in ASTM designation B498-74.
- 3.2.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands while cutting of composite earth wire. Care shall be taken to avoid damage to galvanisation during preforming and postforming operation.
- 3.2.5 To avoid susceptibility towards wet storage stains (white rust), the finished material shall be provided with a protective coating of boiled linseed oil.

### **3.3 Joints in Wires**

There shall be no joint of any kind in the finished steel wire strand entering into the manufacture of the earth wire. There shall be no strand joints or strand splices in any length of the completed stranded earth wire.

### **3.4 Tolerances**

The manufacturing tolerance to the extent of the following limits only shall be permitted in the diameter of the individual steel strands and lay length of the earth wire:

	Standard	Maximum	Minimum
Diameter	3.66 mm	3.75 mm	3.57 mm
Lay length	181 mm	198 mm	165 mm

### **3.5 Materials**

#### **3.5.1 Steel**

The steel wire strands shall be drawn from high carbon steel rods and shall conform to the following requirements as to the chemical composition.

Element	% Composition
Carbon	Not more than 0.55
Manganese	0.4 to 0.9
Phosphorous	Not more than 0.04
Sulphur	Not more than 0.04
Silicon	0.15 to 0.35

#### **3.5.2 Zinc**

The zinc used for galvanising shall be electrolytic High Grade Zinc of 99.95% purity. It shall conform to and satisfy all the requirements of IS: 209 -1979/ Equivlent BS standard.

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#### **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

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- b) Chemical analysis of steel

#### **3.8.6 SAMPLE BATCH FOR TYPE TESTING**

The Contractor shall offer material for sample selection for type testing, only after getting quality assurance programme approved by the Owner. The samples for type testing shall be manufactured strictly in accordance with the Quality Assurance Programme approved by the Owner.

#### **4.0 TUBULAR BUS CONDUCTORS**

##### **4.1 General**

The contractor shall supply the aluminium tubes as per the standard guaranteed technical particulars enclosed in Annexure- E of the technical specification, Chapter 12 – Switchyard Erection and separate approval is not required during detailed engineering.

Owner has also standardised the guaranteed technical particulars for the aluminium tube which are enclosed in Annexure- E of the technical specification, Chapter 12 – Switchyard Erection. The contractor shall supply the aluminium tube as per the standard guaranteed technical particulars.

##### **4.2 Constructional Features**

- 4.2.1 For outside diameter (OD) & thickness of the tube there shall be no minus tolerance, other requirements being as per relevant International standard.

- 4.2.2 The aluminium tube shall be supplied in suitable cut length to minimize wastage.

- 4.2.3 The welding of aluminium tube shall be done by the qualified welders duly approved by the owner.

##### **4.3 Tests**

In accordance with stipulations of the specification, Routine tests shall be conducted on tubular bus conductors. Also the wall thickness and ovality of the tube shall be measured. In addition to the above tests, 0.2% proof tests on both parent metal and Aluminium tube after welding shall be conducted.

##### **4.4 Technical Parameters**

<b>Sl. No.</b>	<b>Description</b>	<b>4" AL. TUBE</b>
1.	Size	4" IPS (EH Type)
2.	Outer diameter	114.2 mm
3.	Thickness	8.51 mm
4.	Cross-sectional area	2825.61 sq.mm
5.	Weight	7.7 kg/m

#### **5.0 EARTHING CONDUCTORS**

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#### **5.0 General**

The grounding grid shall consist of copper flat conductor cable or stranded copper wire of minimum size (cross sectional area) 160sq. mm. The ground electrodes shall be 16mm diameter and 3.0 meter long (min.) copper clad steel. The risers shall consist of copper conductor of adequate size (but not less than 160 sq. mm.)

#### **6.0 SPACERS**

##### **6.1 General**

The spacers are to be located at a suitable spacing to limit the short circuit forces as per IEC -60865. Wherever Employer's 220kV & 132kV standard gantry structures are being used, the spacer span(s) for different conductor / span configurations and corresponding short circuit forces shall be as per Annexure-D. For strung buses, flexible type spacers shall be used whereas for jumpers and other connections rigid type spacers shall be used.

Wherever Employer's 220kV & 132kV standard gantry structures are not being used, necessary spacer span calculation shall be provided by the contractor during detailed engineering for the approval of Employer.

##### **6.2 Constructional Features**

- 6.2.1 No magnetic material shall be used in the fabrication of spacers except for GI bolts and nuts.
- 6.2.2 Spacer design shall be made to take care of fixing and removing during installation and maintenance.
- 6.2.3 The design of the spacers shall be such that the conductor does not come in contact with any sharp edge.

##### **6.3 Tests**

Each type of spacers shall be subjected to the following type tests, acceptance tests and routine tests:

- 6.3.1 Type Tests: Following type test reports shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

- a) **Clamp slip tests**

The sample shall be installed on test span of twin conductor bundle string or quadruple conductor bundle string (as applicable) at a tension of 44.2 kN. One of the clamps of the sample when subjected to a longitudinal pull of 2.5 kN parallel to the axis of the conductor shall not slip on the conductor. The permanent displacement between the conductor and the clamp of sample measured after removal of the load shall not exceed 1.0 mm. Similar tests shall be performed on the other clamps of the same sample.

- b) Fault current test.

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- c) Corona Extinction Voltage Test (Dry).

This test shall be performed on 220 kV equipment as per procedure mentioned at Annexure - C, Minimum Corona Extinction voltage shall be 156 kV (rms) line to ground for 220 kV spacers.

- d) RIV Test (Dry)

This test shall be performed as per procedure mentioned at Annexure - C, Maximum RIV level at 156 kV (rms) line to ground for 220 kV spacers shall be 1000 micro volts, across 300 ohm resistor at 1 MHz

- e) Resilience test (if applicable)

- f) Tension Test

- g) Log decrement test (if applicable)

- h) Compression test

- i) Galvanising test

### **6.3.2**

#### **Acceptance Test**

- a) Visual examination

- b) Dimensional verification

- c) Movement test

- d) Clamp slip test

- e) Clamp bolt torque test (if applicable)

- f) Assembly torque test

- g) Compression test

- h) Tension test

- i) Galvanising test

- j) Hardness test for neoprene (if applicable)

The shore hardness of different points on the elastometer surface of cushion grip clamp shall be measured by shore hardness meter. It shall be between 65 to 80.

- k) Ultimate Tensile Strength Test

The UTS of the retaining rods shall be measured. It shall not be less than 35 kg/Sq. mm.

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#### **6.3.3 Routine test**

- a) Visual examination
- b) Dimensional verification

#### **7.0 BUS POST INSULATORS**

The post insulators shall conform in general to latest IEC-60168, IEC 60273 and IEC-60815.

#### **7.1 Constructional Features**

7.1.1 Post type insulators shall consist of a porcelain part permanently secured in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand any shocks to which they may be subjected to by the operation of the associated equipment. Only solid core insulators will be acceptable.

7.1.2 Porcelain used shall be homogeneous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

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

7.1.4 The insulator shall have alternate long and short sheds with aerodynamic profile, The shed profile shall also meet the requirements of IEC-60815 for the specified pollution level.

7.1.5 When operating at normal rated voltage there shall be no electric discharge between conductor and insulators which would cause corrosion or injury to conductors or insulators by the formation of substance produced by chemical action.

7.1.6 The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.

7.1.7 All ferrous parts shall be hot dip galvanised. The zinc used for galvanising shall be grade Zn 99.95. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux ash, rust stains, bulky white deposits and blisters. The metal parts shall not produce any noise generating corona under the operating conditions.

- 7.1.8
  - a) Every bolt shall be provided with a steel washer under the nut so that part of the threaded portion of the bolts is within the thickness of the parts bolted together.
  - b) Flat washer shall be circular of a diameter 2.5 times that of bolt and of suitable thickness. Where bolt heads/nuts bear upon the beveled surfaces they shall be provided with square tapered washers of suitable thickness to afford a seating square with the axis of the bolt.
  - c) All bolts and nuts shall be of steel with well formed hexagonal heads

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forged from the solid and shall be hot dip galvanised. The nuts shall be good fit on the bolts and two clear threads shall show through the nut when it has been finally tightened up.

7.1.9 Bidder shall make available data on all the essential features of design including the method of assembly of shells and metals parts, number of shells per insulator, the manner in which mechanical stresses are transmitted through shells to adjacent parts, provision for meeting expansion stresses, results of corona and thermal shock tests, recommended working strength and any special design or arrangement employed to increase life under service conditions.

#### **7.2 Tests**

In accordance with the stipulations of the specification, the post insulators shall be subject to type, acceptance, sample and routine tests as per IEC-60168.

7.2.1 In addition to acceptance/sample/routine tests as per IEC-60168, the following tests shall also be carried out.

- a) Ultrasonic test as an acceptance test
- b) Soundness test, metallurgical tests and magnetic test on MCI caps and pedestal tests as acceptance test.
- c) All hot dip galvanised components shall be subject to check for uniformity of thickness and weight of zinc coating on sample basis.
- d) The bending test shall be carried out at 50% minimum failing load in four directions as a routine test and at 100% minimum failing load in four directions as an acceptance test.
- e) Acceptance norms for visual defects allowed at site and also at works shall be agreed in the Quality plan.

7.2.2 In accordance with the stipulation of specification, the following type tests reports of the post insulators shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

- a) Power frequency withstand test (dry & wet)
- b) Lightning impulse test (dry)
- c) Measurement of R.I.V (Dry)
- d) Corona extinction voltage test (Dry)
- e) Test for deflection under load
- f) Test for mechanical strength.

#### **7.3 Technical Parameters of Bus Post Insulators.**

Sl. No.	Description	245 kV	145 kV
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a)	Type	Solid Core	Solid Core
b)	Voltage Class (kV)	245	145
c)	Dry and wet one minute power frequency withstand voltage(kV rms)	460	275
d)	Dry lightning impulse withstand Voltage (kVp)	± 1050	±650
e)	Wet switching surge withstand voltage (kVp)	---	---
f)	Max. radio interference voltage (in microvolts) at voltage of 508 kV (rms) , 305 kV (rms) and 156 (rms) for 765 kV, 400 kV & 220 kV respectively between phase to ground.	500	500
g)	Corona extinction voltage (kV rms) (min.)	156	105
h)	<b><i>Cantilever Strength</i></b>		
i)	Total minimum cantilever strength (Kg)	800	600
(ii)	<b><i>Total minimum breaking strength (Kg)</i></b>	<b>1000</b>	<b>720</b>
i)	Minimum torsional moment	As per IEC-273	As per IEC-273
j)	Total height of insulator (mm)	2300	
k)	P.C.D Top (mm)	127	<b>127</b>
	Bottom (mm)	254	<b>254</b>
l)	No. of bolts		
	Top	4	<b>4</b>
	Bottom	8	<b>8</b>
m)	Diameter of bolt/holes (mm)		
	Top	M16	<b>M16</b>
	Bottom dia	18	<b>18</b>
n)	Pollution level as per IEC-815	Heavy(III)	Heavy(III)
o)	Minimum total creepage distance for Heavy Pollution (mm)	6125	3165

### **7.3.1 33kV Bus Post Insulators.**

a)	Type	Solid Core
b)	Voltage class (kV)	36
c)	Dry and wet one minute power frequency withstand voltage(kV rms)	70
d)	Dry lightning impulse withstand Voltage (kVp)	±170
e)	Total minimum cantilever strength (Kg)	450
f)	Minimum torsional moment	As per IEC-273
g)	Total height of insulator (mm)	As per requirement
h)	Pollution level as per	Heavy(III)

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- i) Minimum creepage distance for Heavy Pollution (mm) 900

7.3.2 If corona extinction voltage is to be achieved with the help of corona ring or any other similar device, the same shall be deemed to be included in the scope of the Contractor. Material of Corona ring shall be aluminium/aluminium alloy of 63401W grade or equivalent.

## **8.0 GROUNDING SYSTEM**

### **8.1 GENERAL**

This specification covers the design, supply, delivery, installation and testing of the complete grounding system as described below.

The complete station grounding work shall be in accordance with the recommendation in the "Guide for Safety in Substation Grounding" IEEE No. 80 and the requirements of this section.

### **8.2 GROUNDING INSTALLATION FEATURES**

8.2.1 The installation shall be complete in all respects for efficient and trouble free service. All work shall be carried out in a first class neat workman like manner. Grounding conductors shall be handled carefully to avoid kinking and cutting of the conductors during laying and installation. All exposed ground conductors runs shall be taken in a neat manner, horizontal, vertical and parallel to building walls or columns and shall not be laid haphazardly.

8.2.2 For all connections made to equipment or to the structures, the grounding conductor, connectors and equipment enclosures shall have good clean contact surfaces. Grounding conductor connection to all electrical equipment, switchgear, transformers, motors, panels, conduit system, equipment enclosures, cable trays, distribution boards, equipment frames, bases, steel structure, etc. shall be by pressure type or bolting type connectors.

8.2.3 All lap, cross and tee connections between two grounding conductors shall be made by thermowelding process or compression type connector. The various joints shall have adequate mechanical strength as well as necessary electrical conductivity not less than that of the parent conductors of the joints. All accessories for grounding installation shall be of quality and design approved by the Employer. The earthing connection between earthing pad of equipment/structures shall be made by two earthing leads.

8.2.4 Ground conductors, when crossing underground trenches, directly laid underground pipe and equipment foundation, if any, shall be at least 300mm below the bottom elevation of such trenches/pipes.

8.2.5 The maximum size of each grid of grounding mat shall not exceed 4X4 meters. The terminals for connecting ground mat and equipment shall be terminated whenever necessary. The new grounding shall be bonded with existing grounding network at the existing Substations.

### **8.3 GROUNDING CONDUCTOR**

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- 8.3.1      **Main Ground Grid**  
The main ground system shall consist of a grounding grid buried minimum 0.6 meter below grade level. The grounding grid shall consist of copper flat conductor cable or stranded copper wire of minimum size (cross sectional area) 160sq. mm.
- 8.3.2      **Ground Electrodes**  
The ground electrodes shall be 16mm diameter and 3.0 meter long (min.) copper clad steel. These shall be driven into ground and connected to the main ground grid.
- 8.3.3      **Risers**  
The risers shall consist of copper conductor of adequate size (but not less than 160 sq. mm.) connected at one end to the main ground mat and at the other end to the equipment.
- 8.4        **DESIGN REQUIREMENTS**
- 8.4.1      The Contractor shall measure the soil resistivity in presence of the Employer. Based on the resistivity the contractor shall calculate the total length of buried ground conductor, number of grounding electrode and their depth and spacing to achieve a grounding system resistance of less than 1.0 (One) Ohm.
- 8.4.2      The Contractor shall calculate the cross-section considering the maximum fault level of 40 kA.
- 8.4.3      The Contractor shall submit the details of calculations of the grounding system for the Employer's approval. The earthing system shall be of single earthing system for the whole substation i.e. all earthings shall be connected to main earthing grid.
- 8.5        **TESTS**  
  
On completion of the installation, either wholly or in sections, it shall be tested in compliance with relevant Code by the Contractor in presence of the Employer. The cost of any test including labor, material and equipment charges shall be borne by the Contractor. If the ground grid resistance can not be obtained as per his design, then additional grounding conductors shall be buried in the earth, or if necessary, buried in treated soil to obtain the required low ground resistance without any additional cost.
- 8.6        **LIGHTNING PROTECTION**  
  
The outdoor equipment of the substation and the substation building shall be protected against lightning. The lightning protection shall be achieved by an overhead lightning shield system of galvanized steel wire of 7/3.35 mm, which shall be connected to the main grounding grid by steel conductor of 7/3.35 mm. Lighting mast with electrode length of 2.5mtr (maximum) may be used in sqitchyard area for lightning protection as per requirement. The above electrode may be connected to the main grounding grid by steel conductor of 7/3.35 mm . The design of the lightning protection system shall be subject to the approval of the Employer.
- 8.7        **DRAWINGS**

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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	$\geq 160$
3. Cross section of riser conductors	Sq mm	$\geq 160$
4. Ground electrodes		
-Material		Copper clad steel
-Diameter	mm	$\geq 16$
-Length	meter	3
5. Material of risers		Copper
6. Earthing system designed for	ohm	$\leq 1$

#### **9.0 Main Bus Bars (Applicable for Aluminium tube)**

The brief description of the bus switching scheme, bus bar layout and equipment connection to be adopted are indicated elsewhere in the specification. The bus bar arrangements are shown in drgs enclosed with the bid documents.

#### **9.1 The Contractor shall furnish supporting calculations where applicable for the bus bars/conductors to show adequacy of design parameters for:**

- a) Fibre-stress
- b) Cantilever strength of post insulators
- c) Aeolian vibrations
- d) Vertical deflection of bus bars
- e) Short circuit forces in bundle conductor and spacer location for each span of ACSR conductor stringing as per layout drawings.

#### **9.1.1 The welds in the aluminium tubes shall be kept to the minimum and there shall not be more than one weld per span. The procedure and details of welding shall be subject to Owner's approval. Material for welding sleeve shall be same as that of Aluminium tube. Welding sleeve shall be of 600mm length**

#### **9.1.2 Corona bells shall be provided wherever the bus extends beyond the clamps and on free ends, for sealing the ends of the tubular conductor against rain and moisture and to reduce the electrostatic discharge loss at the end points. There shall be a small drain hole in the corona bell. The material of Corona bell shall be Aluminium alloy similar to that of clamps & connectors.**

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- 9.1.3 To minimise the vibrations in the aluminium tubes, damping conductor shall be provided inside the aluminium tubes. For this purpose, the cut pieces of ACSR conductor which otherwise are considered wastages, shall be used as damping conductor.
- 9.1.4 Details of past experience of the persons proposed to be employed for Aluminium tube welding and the test reports of the welded pieces to prove the electrical and mechanical characteristics shall also be furnished along with the bid. Welding at site shall be done by adopting a qualified procedure and employing qualified welders as per ASME-Section IX.

#### **10.0 BAY EQUIPMENT**

- 10.1 The disposition of various bay equipments shall be as per single line diagrams and layout drawings.

#### **10.2 Bay Marshalling Kiosk:-**

One no. of bay marshalling kiosk shall be provided for each 220 kV and 132 kV bay under present scope. In addition to the requirements specified elsewhere in the specification, the bay marshalling kiosk shall have two distinct compartments for the following purpose:-

- (i) To receive two incoming 400V, 3 phase, 63Amps, AC supply with auto changeover and MCB unit and distribute minimum six outgoing 400V, 3 phase, 16 Amps AC supplies controlled by MCB.
- (ii) To distribute minimum ten outgoing 230V, 10 Amps single phase supplies to be controlled by MCB to be drawn from above 3 phase incomers.
- (iii) 200 nos. terminal blocks in vertical formation for interlocking facilities for substations without automation system.
- (iv) Necessary Terminal Blocks for terminating cables from ACDB and switchyard panel rooms.

#### **11.0 EQUIPMENT ERECTION DETAILS**

- 11.1 For equipment interconnection, the surfaces of equipment terminal pads, Aluminium tube, conductor & terminal clamps and connectors shall be properly cleaned. After cleaning, contact grease shall be applied on the contact surfaces of equipment terminal pad, Aluminium tube/conductor and terminal clamps to avoid any air gap in between. Subsequently bolts of the terminal pad/terminal connectors shall be tightened and the surfaces shall be cleaned properly after equipment interconnection.
- 11.2 Muslin or leather cloth shall be used for cleaning the inside and outside of hollow insulators.
- 11.3 All support insulators, circuit breaker interrupters and other fragile equipment shall preferably be handled with cranes having suitable booms and handling capacity.

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- 11.4 Bending of Aluminium tube and compressed air piping if any should be done by a bending machine and through cold bending only. Bending shall be such that inner diameter of pipe is not reduced.
- 11.5 Cutting of the pipes wherever required shall be such as to avoid flaring of the ends. Hence only a proper pipe cutting tool shall be used. Hack saw shall not be used.
- 11.6 Handling of equipment shall be done strictly as per manufacturer's/supplier's instructions/instruction manual.
- 11.7 Handling equipment, sling ropes etc. should be tested periodically before erection for strength.
- 11.8 The slings shall be of sufficient length to avoid any damage to insulator due to excessive swing, scratching by sling ropes etc.
- 12.0 **STORAGE**
- 12.1 The Contractor shall provide and construct adequate storage shed for proper storage of equipments, where sensitive equipments shall be stored indoors. All equipments during storage shall be protected against damage due to acts of nature or accidents. The storage instructions of the equipment manufacturer/Owner shall be strictly adhered to.
- 13.0 **CABLING MATERIAL**
- 13.1 **CABLE TAGS AND MARKERS**
- 13.1.1 Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.
- 13.1.2 The tag shall be of aluminium with the number punched on it and securely attached to the cable conduit by not less than two turns of 20 SWG GI wire. Cable tags shall be of rectangular shape for power cables and of circular shape for control cables.
- 13.1.3 Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanised iron plate.
- 13.1.4 Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable joints".
- 13.1.5 The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road and drain crossings.
- 13.1.6 Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry and at each end & turning point in cable tray/trench runs. Cable tags shall be provided inside the switchgear, motor control centres, control and relay panels etc., wherever required for cable identification, where a number of cables enter together through a gland plate.

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#### **13.2 Cable Supports and Cable Tray Mounting Arrangements**

- 13.2.1 The Contractor shall provide embedded steel inserts on concrete floors/walls to secure supports by welding to these inserts or available building steel structures.
- 13.2.2 The supports shall be fabricated from standard structural steel members.
- 13.2.3 Insert plates will be provided at an interval of 750 mm wherever cables are to be supported without the use of cable trays, such as in trenches, while at all other places these will be at an interval of 2000 mm.
- 13.2.4 Vertical run of cables on equipment support structure shall be supported on perforated cable trays of suitable width which shall be suitably bolted/clamped with the equipment support structure.

#### **13.3 Cable Termination and Connections**

- 13.3.1 The termination and connection of cables shall be done strictly in accordance with cable and termination kit manufacturer's instructions, drawing and/or as directed by the Owner.
- 13.3.2 The work shall include all clamping, fittings, fixing, plumbing, soldering, drilling, cutting, taping, heat shrinking (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job.
- 13.3.3 Supply of all consumable material shall be in the scope of Contractor.
- 13.3.4 The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The Contractor shall be responsible for drilling of gland plates, painting and touching up. Holes shall not be made by gas cutting.
- 13.3.5 Control cable cores entering control panel/switchgear/MCCB/MCC/miscellaneous panels shall be neatly bunched, clamped and tied with nylon strap or PVC perforated strap to keep them in position.
- 13.3.6 The Contractor shall tag/ferrule control cable cores at all terminations, as instructed by the Owner. In panels where a large number of cables are to be terminated and cable identification may be difficult, each core ferrule may include the complete cable number as well.
- 13.3.7 Spare cores shall be similarly tagged with cable numbers and coiled up.
- 13.3.8 All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively closed.
- 13.3.9 Double compression type nickel plated (coating thickness not less than 10 microns) brass cable glands shall be provided by the Contractor for all power and control cables to provide dust and weather proof terminations.
- 13.3.10 They shall comprise of heavy duty brass casting, machine finished and nickel plated, to avoid corrosion and oxidation. Rubber components used in cable glands shall be neoprene and of tested quality. Cable glands shall be of approved make.

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- 13.3.11 The cable glands shall also be suitable for dust proof and weather proof termination. The test procedure, if required, has to be discussed and agreed to between Owner and cable gland manufacturer.
- 13.3.12 If the cable-end box or terminal enclosure provided on the equipment is found unsuitable and requires modification, the same shall be carried out by the Contractor, as directed by the Owner.
- 13.3.13 Crimping tool used shall be of approved design and make.
- 13.3.14 Cable lugs shall be tinned copper solderless crimping type conforming to IS-8309 & 8394/ Equivalent International standard. Bimetallic lugs shall be used depending upon type of cables used.
- 13.3.15 Solderless crimping of terminals shall be done by using corrosion inhibitory compound. The cable lugs shall suit the type of terminals provided.
- 13.4 **STORAGE AND HANDLING OF CABLE DRUMS**
- 13.4.1 Cable drums shall be unloaded, handled and stored in an approved manner and rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum.
- 14.0 **DIRECTLY BURIED CABLES**
- 14.1 The Contractor shall construct the cable trenches required for directly buried cables. The scope of work shall include excavation, preparation of sand bedding, soil cover, supply and installation of brick or concrete protective covers, back filling and ramming, supply and installation of route markers and joint markers. The Bidder shall ascertain the soil conditions prevailing at site, before submitting the bid.
- 14.2 The cable (power and control) between LT station, control room, DG set location and fire lighting pump house shall be laid in the buried cable trenches. In addition to the above, for lighting purpose also, buried cable trench can be used in outdoor area.
- 14.3 Cable route and joint markers and RCC warning covers shall be provided wherever required. The voltage grade of cables shall be engraved on the marker.
- 15.0 **INSTALLATION OF CABLES**
- 15.1 Cabling in the control room shall be done on ladder type cable trays for vertical runs while cabling in switchyard area shall be done on angles in the trench.
- 15.2 All cables from bay cable trench to equipment's including and all interpole cables (both power and control) for all equipment, shall be laid in PVC pipes of minimum 50 mm nominal outside diameter which shall be buried in the ground at a depth of 250mm below finish formation level. Separate PVC pipes shall be laid for control and power cables. Cable pull boxes of adequate size shall be provided if required.



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- 15.3 Cables shall be generally located adjoining the electrical equipment through the pipe insert embedded in the floor. In the case of equipments located away from cable trench either pipe inserts shall be embedded in the floor connecting the cable trench and the equipment or in case the distance is small, notch/opening on the wall shall be provided. In all these cases necessary bending radius as recommended by the cable manufacturer shall be maintained.
- 15.4 Cable racks and supports shall be painted after installation with two coats of metal primer (comprising of red oxide and zinc chromate in a synthetic medium) followed by two finishing coats of aluminium paint.
- 15.5 Suitable arrangement should be used between fixed pipe / cable trays and equipment terminal boxes, where vibration is anticipated.
- 15.6 Power and control cables in the cable trench shall be laid in separate tiers. The order of laying of various cables shall be as follows, for cables other than directly buried.
- a) Power cables on top tiers.
  - b) Control instrumentation and other service cables in bottom tiers.
- 15.7 Single core cables in trefoil formation shall be laid with a distance of three times the diameter of cable between trefoil centre lines. All power cables shall be laid with a minimum centre to centre distance equal to twice the diameter of the cable of higher size of cables.
- 15.8 Trefoil clamps for single core cables shall be of pressure die cast aluminium (LM-6), Nylon -6 or fibre glass and shall include necessary fixing GI nuts, bolts, washer etc. These are required at every 2 metre of cable runs.
- 15.9 Power and control cables shall be securely fixed to the trays/supports with self locking type nylon ties with deinterlocking facility at every 5 metre interval for horizontal run. Vertical and inclined cable runs shall be secured with 25 mm wide and 2 mm thick aluminium strip clamps at every 2m.
- 15.10 Cables shall not be bent below the minimum permissible limit. The permissible limits are as follows:
- | Table of Cable and | Minimum bending radius |
|--------------------|------------------------|
| Power cable        | 12 D                   |
| Control cable      | 10 D                   |
- D is overall diameter of cable
- 15.11 Where cables cross roads, drains and rail tracks, these shall be laid in reinforced spun concrete or steel pipes buried at not less than one metre depth.
- 15.12 In each cable run some extra length shall be kept at a suitable point to enable one (for LT cables)/two (for H.T. cables) straight through joints to be made in case the cable develop fault at a later date.
- 15.13 Selection of cable drums for each run shall be so planned as to avoid using

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straight through joints. Cable splices will not be permitted except where called for by the drawings, unavoidable or where permitted by the Owner. If straight through joints are unavoidable, the Contractor shall use the straight through joints kit of reputed make.

- 15.14 Control cable terminations inside equipment enclosures shall have sufficient lengths so that changing of termination in terminal blocks can be done without requiring any splicing.
- 15.15 Metal screen and armour of the cable shall be bonded to the earthing system of the station, wherever required by the Owner.
- 15.16 Rollers shall be used at intervals of about two metres while pulling cables.
- 15.17 All due care shall be taken during unreeling, laying and termination of cable to avoid damage due to twist, kinks, sharp bends, etc.
- 15.18 Cable ends shall be kept sealed to prevent damage. In cable vault, fire resistant seal shall be provided underneath the panels.
- 15.19 Inspection on receipt, unloading and handling of cables shall generally be in accordance with relevant international standard.
- 15.20 Wherever cable pass through floor or through wall openings or other partitions, GI/PVC wall sleeves with bushes having a smooth curved internal surface so as not to damage the cable, shall be supplied, installed and properly sealed by the Contractor at no extra charges.
- 15.21 Contractor shall remove the RCC/Steel trench covers before taking up the work and shall replace all the trench covers after the erection-work in that particular area is completed or when further work is not likely to be taken up for some time.
- 15.22 Contractor shall furnish three copies of the report on work carried out in a particular week, indicating cable numbers, date on which laid, actual length and route, testing carried out, terminations carried out, along with the marked up copy of the cable schedule and interconnection drawing wherever any modifications are made.
- 15.23 Contractor shall paint the tray identification number on each run of trays at an interval of 10 m.
- 15.24 In case the outer sheath of a cable is damaged during handling/installation, the Contractor shall repair it at his own cost to the satisfaction of the Owner. In case any other part of a cable is damaged, the same shall be replaced by a healthy cable at no extra cost to the Owner, i.e. the Contractor shall not be paid for installation and removal of the damaged cable.
- 15.25 All cable terminations shall be appropriately tightened to ensure secure and reliable connections. The Contractor shall cover the exposed part of all cable lugs whether supplied by him or not with insulating tape, sleeve or paint.
- 15.26 **Cable trays**
  - i) The cable trays shall be of G.S.sheet and minimum thickness of sheet

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shall be 2mm.

- ii) The Contractor shall perform all tests and inspection to ensure that material and workmanship are according to the relevant standards.

A 2.5 metre straight section of 300mm, 600mm wide cable tray shall be simply supported at two ends. A uniform distributed load of 76 kg/m shall be applied along the length of the tray. The maximum deflection at the mid-span shall not exceed 7mm.

#### **15.27 Conduits, Pipes and Duct Installation**

- 15.27.1 Contractor shall supply and install all rigid conduits, mild steel pipes, flexible conduits, hume pipes etc. including all necessary sundry materials such as tees, elbows, check nuts, bushing, reducers, enlargers, coupling cap, nipples, gland sealing fittings, pull boxes etc as specified and to be shown in detailed drawing. The size of the conduit/pipe shall be selected on the basis of 40% fill criterion.
- 15.27.2 Contractor shall have his own facility for bending, cutting and threading the conduits at site. Cold bending should be used. All cuts & threaded ends shall be made smooth without leaving any sharp edges. Anticorrosive paint shall be applied at all field threaded portions.
- 15.27.3 All conduit/pipes shall be extended on both sides of wall/floor openings. The fabrication and installation of supports and the clamping shall be included in the scope of work by Contractor.
- 15.27.4 When two lengths of conduits are joined together through a coupling, running threads equal to twice the length of coupling shall be provided on each conduit to facilitate easy dismantling of two conduits.
- 15.27.5 Conduit installation shall be permanently connected to earth by means of special approved type of earthing clamps. GI pull wire of adequate size shall be laid in all conduits before installation.
- 15.27.6 Each conduit run shall be painted with its designation as indicated on the drawings such that it can be identified at each end.
- 15.27.7 Embedded conduits shall have a minimum concrete cover of 50 mm.
- 15.27.8 Conduit run sleeves shall be provided with the bushings at each end.
- 15.27.9 Metallic conduit runs at termination shall have two locknuts and a bushing for connection. Flexible conduits shall also be suitably clamped at each end with the help of bushings. Bushings shall have rounded edges so as not to damage the cables.
- 15.27.10 Where embedded conduits turn upwards from a slab or fill, the termination dimensions shown on the drawings, if any, shall be taken to represent the position of the straight extension of the conduit external to and immediately following the bend. At least one half of the arc length of the bend shall be embedded.
- 15.27.11 All conduits/pipes shall have their ends closed by caps until cables are pulled.

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After cables are pulled, the ends of conduits/pipes shall be sealed in an approved manner to prevent damage to threaded portions and entrance of moisture and foreign material.

- 15.27.12 For underground runs, Contractor shall excavate and back fill as necessary.
- 15.27.13 Contractor shall supply, unload, store and install conduits required for the lighting installation as specified. All accessories/fittings required for making the installation complete, including but not limited to pull out boxes, ordinary and inspection tees and elbow, checknuts, male and female bushings (brass or galvanised steel), caps, square headed male plugs, nipples, gland sealing fittings ,pull boxes, conduits terminal boxes, gaskets and box covers, saddle terminal boxes, and all steel supporting work shall be supplied by the Contractor. The conduit fittings shall be of the same material as conduits.
- 15.27.14 All unarmoured cables shall run within the conduits from lighting panels to lighting fixtures, receptacles etc.
- 15.27.15 Size of conduit for lighting shall be selected by the Contractor during detailed engineering.
- 15.27.16 Exposed conduits shall be run in straight lines parallel to building columns, beams and walls. Unnecessary bends and crossings shall be avoided to present a neat appearance.
- 15.27.17 Conduit supports shall be provided at an interval of 750mm for horizontal runs and 1000mm for vertical runs.
- 15.27.18 Conduit supports shall be clamped on the approved type spacer plates or brackets by saddles or U- bolts. The spacer plates or brackets in turn, shall be securely fixed to the building steel by welding and to concrete or brick work by grouting or by nylon rawl plugs. Wooden plug inserted in the masonry or concrete for conduit support is not acceptable.
- 15.27.19 Embedded conduits shall be securely fixed in position to preclude any movement. In fixing embedded conduit, if welding or brazing is used, extreme care should be taken to avoid any injury to the inner surface of the conduit.
- 15.27.20 Spacing of embedded conduits shall be such as to permit flow of concrete between them.
- 15.27.21 Where conduits are placed alongwith cable trays, they shall be clamped to supporting steel at an interval of 600mm.
- 15.27.22 For directly embedding in soil, the conduits shall be coated with an asphalt-base compound. Concrete pier or anchor shall be provided wherever necessary to support the conduit rigidly and to hold it in place.
- 15.27.23 Conduit shall be installed in such a way as to ensure against trouble from trapped condensation.
- 15.27.24 Conduits shall be kept, wherever possible, at least 300mm away from hot pipes, heating devices etc. when it is evident that such proximity may reduce the service life of cables.

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- 15.27.25 Slip joints shall be provided when conduits cross structural expansion joints or where long run of exposed conduits are installed, so that temperature change will cause no distortion due to expansion or contraction of conduit run.
- 15.27.26 For long conduit run, pull boxes shall be provided at suitable intervals to facilitate wiring.
- 15.27.27 Conduit shall be securely fastened to junction boxes or cabinets, each with a lock nut inside and outside the box.
- 15.27.28 Conduits joints and connections shall be made thoroughly water-tight and rust proof by application of a thread compound which insulates the joints. White lead is suitable for application on embedded conduit and red lead for exposed conduit.
- 15.27.29 Field bends shall have a minimum radius of four (4) times the conduit diameter. All bends shall be free of kinks, indentations of flattened surfaces. Heat shall not be applied in making any conduit bend. Separate bends may be used for this purpose.
- 15.27.30 The entire metallic conduit system, whether embedded or exposed, shall be electrically continuous and thoroughly grounded. Where slip joints are used, suitable bounding shall be provided around the joint to ensure a continuous ground circuit.
- 15.27.31 After installation, the conduits shall be thoroughly cleaned by compressed air before pulling in the wire.
- 15.27.32 Lighting fixtures shall not be suspended directly from the junction box in the main conduit run.

#### **16.0 JUNCTION BOX**

- a) The Contractor shall supply and install junction boxes complete with terminals as required. The brackets, bolts, nuts, screws etc required for erection are also included in the scope of the Contractor.
- b) Junction boxes having volume less than 1600 cubic centimeters may be installed without any support other than that resulting from connecting conduits where two or more rigid metallic conduits enter and accurately position the box. Boxes shall be installed so that they are level, plumb and properly aligned to present a pleasing appearance.
- c) Boxes with volumes equal to or greater than 1600 cubic cm, and smaller boxes terminating on less than two rigid metallic conduits or for other reasons not rigidly held, shall be adequately supported by auxiliary steel of standard steel shapes or plates to be fabricated and installed. The Contractor shall perform all drilling, cutting, welding, shimming and bolting required for attachment of supports.

#### **17.0 TESTING AND COMMISSIONING**

- 17.1 An indicative list of tests for testing and commissioning is given below. Contractor shall perform any additional test based on specialities of the items as

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per the field Q.P./instructions of the equipment Contractor or Owner without any extra cost to the Owner. The Contractor shall arrange all equipments instruments and auxiliaries required for testing and commissioning of equipments alongwith calibration certificates and shall furnish the list of instruments to the Owner for approval.

17.2

### **GENERAL CHECKS**

- (a) Check for physical damage.
- (b) Visual examination of zinc coating/plating.
- (c) Check from name plate that all items are as per order/specification.
- (d) Check tightness of all bolts, clamps and connecting terminals using torque wrenches.
- (e) For oil filled equipment, check for oil leakage, if any. Also check oil level and top up wherever necessary.
- (f) Check ground connections for quality of weld and application of zinc rich paint over weld joint of galvanised surfaces.
- (g) Check cleanliness of insulator and bushings.
- (h) All checks and tests specified by the manufacturers in their drawings and manuals as well as all tests specified in the relevant code of erection.
- (i) Check for surface finish of grading rings (Corona control ring).
- (j) Pressure test on all pneumatic lines at 18.5 times the rated pressure shall be conducted.

17.3

### **STATION EARTHING**

- a) Check soil resistivity
- b) Check continuity of grid wires
- c) Check earth resistance of the entire grid as well as various sections of the same.
- d) Check for weld joint and application of zinc rich paint on galvanised surfaces.
- e) Dip test on earth conductor prior to use.

17.4

### **AAC/ ACSR STRINGING WORK, TUBULAR BUS WORK AND POWER CONNECTORS**

- a) Physical check for finish
- b) Electrical clearance check

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- c) Testing of torque by torque wrenches on all bus bar power connectors and other accessories.
- d) Millivolt drop test on all power connectors.
- e) Sag and tension check on conductors.

#### **17.5 ALUMINIUM TUBE WELDING**

- a) Physical check
- b) Millivolt drop test on all joints.
- c) Dye penetration test & Radiography test on 10% sample basis on weld joints.
- c) Test check on 5% sample joints after cutting the weld piece to observe any voids etc.

#### **17.6 INSULATOR**

Visual examination for finish, damage, creepage distance etc.

- 17.7** All pre/commissioning activities and works work for substation equipment shall be carried out in accordance with owner's "Pre- Commissioning procedures and formats for substation bay equipments" by the contractor. This document shall be provided to the successful contractor during detailed engineering stage.

ANNEXURE – A

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### **A. SHORT CIRCUIT FORCES AND SPACER SPAN FOR 220 kV GANTRY STRUCTURE**

Sl. No.	Max. Span	Conductor Configuration	Ph-Ph Spacing	Normal Tension	SCF per Phase	Spacer span
I.	<b>For Fault Level of 40 kA for 1 sec.</b>					
1.	54 mtr	QUAD ACSR	4.5 mtr	4 T	5.00 T	2.5 mtr
2.	54 mtr	TWIN ACSR	4.5 mtr	2 T	3.50 T	2.5 mtr
3.	74 mtr	TWIN ACSR	4.5 mtr	4 T	5.00 T	2.5 mtr
4.	54 mtr	QUAD ACSR	4.0 mtr	4 T	5.70 T	2.5 mtr
5.	54 mtr	TWIN ACSR	4.0 mtr	2 T	3.50 T	2.5 mtr
6.	74 mtr	TWIN ACSR	4.0 mtr	4 T	5.70 T	2.5 mtr
7.	48 mtr	QUAD ACSR	4.0 mtr	4 T	5.30 T	2.5 mtr
8.	52 mtr	QUAD ACSR	4.0 mtr	4 T	5.35 T	2.5 mtr
9.	68 mtr	TWIN ACSR	4.0 mtr	4 T	5.20 T	2.5 mtr
10.	56 mtr	QUAD ACSR	4.0 mtr	4 T	5.50 T	2.5 mtr
11.	72 mtr	TWIN ACSR	4.0 mtr	4 T	5.27 T	2.5 mtr

NOTE: ACSR conductor as mentioned above indicates that it is suitable for ACSR MOOSE conductor.

### **B. SHORT CIRCUIT FORCES AND SPACER SPAN FOR 132 kV GANTRY STRUCTURE**

Sl. No.	Max. Span	Conductor Configuration	Ph-Ph Spacing	Normal Tension	SCF per Phase	Spacer span
I.	<b>For Fault Level of 31.5kA for 1 sec.</b>					
1.	36 mtr	Twin Moose/ Zebra ACSR	3 mtr	1 T	2.15 T	2.5 mtr
2.	31.5 mtr	Twin Moose/ Zebra ACSR	2.7mtr	1 T	2.15 T	2.5 mtr
3.	48 mtr	Single Moose/ Zebra ACSR	3 mtr	1 T	2.05 T	NA
4.	42 mtr	Single Moose/ Zebra ACSR	2.7 mtr	1 T	2.03 T	NA



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**SWITCHYARD ERECTION**

**ANNEXURE-B**

**STANDARD TECHNICAL DATA SHEETS FOR AAC/ACSR CONDUCTORS,  
GS EARTHWIRE AND ALUMINIUM TUBE**

**1.0 GENERAL**

Owner has standardised the guaranteed technical particulars for the following AAC/ACSR conductors, Galvanised steel earthwire and aluminum tube. The contractor shall supply the conductors as per the standard GTP mentioned below. Any deviation to the following GTP shall be clearly brought out by the bidder in their bid.

**1.1 Guaranteed Technical Particulars (GTP) for conductors:**

**A. GTP of ACSR MOOSE conductor:**

Sl.	Description	Unit	ACSR MOOSE
<b>1.0</b>	<b>Applicable Standard</b>	IEC-61089	
<b>2.0</b>	<b>Raw Materials</b>		
2.1	Aluminium		
a)	Minimum purity of Aluminium	%	99.50
b)	Maximum copper content	%	0.04
2.2	Steel wires/ rods		
a)	Carbon	%	0.50 to 0.85
b)	Manganese	%	0.50 to 1.10
c)	Phosphorous	%	Not more than 0.035
d)	Sulphur	%	Not more than 0.045
e)	Silicon	%	0.10 to 0.35 (Max.)
2.3	Zinc		
a)	Minimum purity of Zinc	%	99.95
<b>3.0</b>	<b>Aluminium strands after stranding</b>		
3.1	Diameter		
a)	Nominal	mm	3.53
b)	Maximum	mm	3.55
c)	Minimum	mm	3.51
3.2	Minimum Breaking load of strand		
a)	Before stranding	KN	1.57
b)	After stranding	KN	1.49
c)	Maximum D.C. resistance of strand at 20 deg. Centigrade	Ohm/ KM	2.921
3.3	Maximum resistance of 1 m length of strand at 20 deg. C	Ohm	0.002921

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Sl.	Description	Unit	ACSR MOOSE
<b>1.0</b>	<b>Applicable Standard</b>	IEC-61089	
<b>2.0</b>	<b>Raw Materials</b>		
2.1	Aluminium		
<b>4.0</b>	<b>Steel strand after stranding</b>		
4.1	Diameter		
a)	Nominal	mm	3.53
b)	Maximum	mm	3.60
c)	Minimum	mm	3.46
4.2	Minimum Breaking load of strand		
a)	Before stranding	KN	12.86
b)	After stranding	KN	12.22
4.3	Galvanising		
a)	Minimum weight of zinc coating per sq.m.	gm	260
b)	Minimum number of dips that the galvanised strand can withstand in the standard preece test	Nos.	2 dips of one minute & 1 dip of half minute
c)	Min. No. of twists in guage length equal 100 times the dia. of wire which the strand can withstand in the torsion test (after stranding)	Nos	16 (After stranding) 18 (Before stranding)
<b>5.0</b>	<b>ACSR Conductor</b>		
5.1.a)	Stranding		Al -54/3.53 mm+ Steel-7/3.53 mm
b)	Number of Strands		
i.	Steel centre	Nos.	1
ii.	1st Steel Layer	Nos.	6
iii.	1st Aluminium Layer	Nos.	12
iv.	2nd Aluminium Layer	Nos.	18
v.	3rd Aluminium Layer	Nos.	24
5.2	Sectional Area of aluminium	Sq. mm	528.50
5.3	Total sectional area	Sq. mm	597.00
5.4	Approximate Weight	Kg/m	2.004
5.5	Diameter of the conductor	mm	31.77
5.6	UTS of the conductor	kN	161.20 (Min.)
5.7	Lay ratio of the conductor	mm	Max                  Min
a)	Outer Steel layer	mm	18                  16

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**ANNEXURE-B**

Sl.	Description	Unit	ACSR MOOSE
<b>1.0</b>	<b>Applicable Standard</b>	IEC-61089	
<b>2.0</b>	<b>Raw Materials</b>		
2.1	Aluminium		
b)	8/12 wire Aluminium layer	mm	14      12
c)	14/ 18 wire Aluminium layer	mm	13      11
d)	20/24 wire Aluminium layer	mm	12      10
5.8	DC resistance of the conductor at 20°C	ohm/km	0.05552
5.9	Standard length of the conductor	m	1800
5.10	Tolerance on Standard length	%	(+/-) 5
5.11	Direction of lay of outer layer	-	Right Hand
5.12	Linear mass of the conductor		
a)	Standard	kg/km	2004
b)	Minimum	kg/km	1965
c)	Maximum	kg/km	2045
5.13	Modulus of Elasticity (Final State)	Kg/sq.mm	6860
5.14	Co-efficient of Linear Expansion	Per Deg. C	19.3x10 <sup>-6</sup>
5.15	Minimum Corona Extinction Voltage	KV (rms)	320
5.16	RIV at 1 Mhz under dry condition	Micro volts	Max. 1000 at 320 kV (rms)
<b>6.0</b>	<b>Drum Dimensions</b>		
a)	Flange Diameter	mm	1800
b)	Traverse width	mm	950
c)	Barrel Diameter	mm	650
d)	Flange thickness	mm	50x50

**1.2      Guaranteed technical particulars of Galvanised Steel Earthwire**

	Description	Unit	Standard Values
<b>1.0</b>	<b>Raw Materials</b>		
<b>1.1</b>	<b>Steel wires / rods</b>		
a)	Carbon	%	Not more than 0.55
b)	Manganese	%	0.40 to 0.90
c)	Phosphorous	%	Not more than 0.04
d)	Sulphur	%	Not more than 0.04

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e)	Silicon	%	0.15 to 0.35
<b>1.2</b>	<b>Zinc</b>		
a)	Minimum purity of Zinc	%	99.95
<b>2.0</b>	<b>Steel strands</b>		
<b>2.1</b>	<b>Diameter</b>		
a)	Nominal	mm	3.66
b)	Maximum	mm	3.74
c)	Minimum	mm	3.58
<b>2.2.</b>	<b>Minimum breaking load of strand</b>		
a)	After stranding	KN	10.58
<b>2.3</b>	<b>Galvanising</b>		
a)	Minimum weight of zinc coating per sq.m. after stranding	gms.	275
b)	Minimum number of dips that the galvanized strand can withstand in the standard preece test	Nos.	3 dips of 1 minute and one dip of ½ minute
c)	Minimum number of twists in a gauge length equal to 100 times diameter of wire which the strand can withstand in the torsion test, after stranding	Nos.	18
<b>3.0</b>	<b>Stranded Earth wire</b>		
<b>3.1</b>	<b>UTS of Earth wire</b>	KN	68.4 (min.)
<b>3.2</b>	<b>Lay length of outer steel layer</b>		
a)	Standard	mm	181
b)	Maximum	mm	198
c)	Minimum	mm	165
<b>3.3</b>	<b>Maximum DC resistance of earth wire at 20° C</b>	Ohm/km	3.375
<b>3.4</b>	<b>Standard length of earth wire</b>	M	2000 or actual quantity whichever is less.
<b>3.5</b>	<b>Tolerance on standard length</b>	%	±5
<b>3.6</b>	<b>Direction of lay for outside layer</b>		Right hand
<b>3.7</b>	<b>Linear mass</b>		
a)	Standard	Kg/km	583
b)	Maximum	Kg/km	552
c)	Minimum	Kg/km	600
<b>3.8</b>	<b>Overall diameter</b>	mm	10.98

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**1.3 Guaranteed Technical Parameters of Aluminum Tube**

**A. GTP for 3" IPS & 4" IPS AL. TUBE**

Sl. No.	Description	3" AL. TUBE	4" AL. TUBE
1.	Size	3" IPS (EH Type)	4" IPS (EH Type)
2.	Material	Aluminium Alloy 6101 T6 confirms to 63401 WP (range 2) of IS 5082 : 1998/Equivqlent BS standard	
3.	Chemical Composition		
i)	Cu	0.05 Max	
ii)	Mg	0.4 to 0.9	
iii)	Si	0.3 to 0.7	
iv)	Fe	0.5 Max	
v)	Mn	0.03 Max	
Vi)	Al	Remainder	
4.	Outer diameter	88.90 mm	114.2 mm
5.	Tolerance on outer diameter	+2.2 mm, - 0.0 mm	+2.2 mm, - 0.0 mm
6.	Thickness	7.62 mm	8.51 mm
7.	Tolerance on thickness	+2.2 mm, - 0.0 mm	+2.2 mm, - 0.0 mm
8.	Cross-sectional area	1945.76 sq.mm	2825.61 sq.mm
9.	Weight	5.25 kg/m	7.7 kg/m
10.	Moment of Inertia	1621589.99 mm <sup>4</sup>	3972577.97 mm <sup>4</sup>
11.	Section Modulus	36481.21 mm <sup>3</sup>	69572.29 mm <sup>3</sup>
12.	Minimum Ultimate Tensile Strength	20.5 Kg/sq.mm	
13.	Temperature co-efficient of resistance	0.00364 per Deg.C	
14.	Minimum Electrical Conductivity at 20 deg.C	55% of IACS	
15.	Linear Temperature Co-efficient of Expansion (20 Deg.C -200 Deg.C)	0.000023	
16.	Modulus of Elasticity	6700 Kg/sq.mm	
17.	Minimum Elongation on 50 mm	10%	
18.	Thermal Conductivity at 100 Deg.C	0.43 Calories/sec/sq.mm/cm/deg.C	
19.	Minimum 0.2% proof stress	17.34 Kg/sq.mm	
20.	Minimum Yield point	17.50 Kg/sq.mm	17.50 Kg/sq.mm
21.	Minimum Breaking Strength	20.42 Kg/sq.mm	20.42 Kg/sq.mm

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**ANNEXURE-C**

**CORONA AND RADIO INTERFERENCE VOLTAGE (RIV) TEST**

**1. General**

Unless otherwise stipulated, all 220kV & 132kV equipment together with its associated connectors, where applicable, shall be tested for external corona both by observing the voltage level for the extinction of visible corona under falling power frequency voltage and by measurement of radio interference voltage (RIV).

**2. Test Levels:**

The test voltage levels for measurement of external RIV and for corona extinction voltage are listed under the relevant clauses of the specification.

**3. Test Methods for RIV:**

3.1 RIV tests shall be made according to measuring circuit as per International Special-Committee on Radio Interference (CISPR) Publication 16-1(1993) Part - 1. The measuring circuit shall preferably be tuned to frequency with 10% of 0.5 Mhz but other frequencies in the range of 0.5 MHz to 2 MHz may be used, the measuring frequency being recorded. The results shall be in microvolts.

3.2 Alternatively, RIV tests shall be in accordance with NEMA standard Publication No. 107-1964, except otherwise noted herein.

3.3 In measurement of, RIV, temporary additional external corona shielding may be provided. In measurements of RIV only standard fittings of identical type supplied with the equipment and a simulation of the connections as used in the actual installation will be permitted in the vicinity within 3.5 meters of terminals.

3.4 Ambient noise shall be measured before and after each series of tests to ensure that there is no variation in ambient noise level. If variation is present, the lowest ambient noise level will form basis for the measurements. RIV levels shall be measured at increasing and decreasing voltages of 85%, 100% and 110% of the specified RIV test voltage for all equipment unless otherwise specified. The specified RIV test voltage for 220 KV is listed in the detailed specification together with maximum permissible RIV level in microvolts.

3.5 The metering instruments shall be as per CISPR recommendation or equivalent device so long as it has been used by other testing authorities.

3.6 The RIV measurement may be made with a noise meter. A calibration procedure of the frequency to which noise meter shall be tuned shall establish the ratio of voltage at the high voltage terminal to voltage read by noise meter.

**4. Test Methods for Visible Corona**

The purpose of this test is to determine the corona extinction voltage of apparatus, connectors etc. The test shall be carried out in the same manner as RIV test described above with the exception that RIV measurements are not required during test and a search technique shall be used near the onset and extinction voltage, when the test voltage is raised and lowered to determine their precise values. The test voltage shall be raised to 110% of RIV test voltage and maintained there for five minutes. In case corona inception does not take place at 110%, test shall be stopped, otherwise test shall be continued and the voltage will then be decreased slowly until all visible corona disappears. The procedure shall be repeated at least 4 times with corona inception and extinction voltage recorded each time. The corona extinction voltage for purposes of determining

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compliance with the specification shall be the lowest of the four values at which visible corona (negative or positive polarity) disappears. Photographs with laboratory in complete darkness shall be taken under test conditions, at all voltage steps i.e. 85%, 100%, and 110%. Additional photographs shall be taken at corona inception and extinction voltages. At least two views shall be photographed in each case using Panchromatic film with an ASA daylight rating of 400 with an exposure of two minutes at a lens aperture of f/5.6 or equivalent. The photographic process shall be such that prints are available for inspection and comparison with conditions as determined from direct observation. Photographs shall be taken from above and below the level of connector so as to show corona on bushing, insulators and all parts of energised connectors. The photographs shall be framed such that test object essentially, fills the frame with no cut-off.

In case corona inception does not take place at 110%, voltage shall not be increased further and corona extinction voltage shall be considered adequate.

- 4.1 The test shall be recorded on each photograph. Additional photograph shall be taken from each camera position with lights on to show the relative position of test object to facilitate precise corona location from the photographic evidence.
- 4.2 In addition to photographs of the test object preferably four photographs shall be taken of the complete test assembly showing relative positions of all the test equipment and test objects. These four photographs shall be taken from four points equally spaced around the test arrangement to show its features from all sides. Drawings of the laboratory and test set up locations shall be provided to indicate camera positions and angles. The precise location of camera shall be approved by Purchaser's inspector, after determining the best camera locations by trial energisation of test object at a voltage which results in corona.
- 4.3 The test to determine the visible corona extinction voltage need not be carried out simultaneously with test to determine RIV levels.
- 4.4 However, both test shall be carried out with the same test set up and as little time duration between tests as possible. No modification on treatment of the sample between tests will be allowed. Simultaneous RIV and visible corona extinction voltage testing may be permitted at the discretion of Purchaser's inspector if, in his opinion, it will not prejudice other test.

#### **5. Test Records:**

In addition to the information previously mentioned and the requirements specified as per CISPR or NEMA 107-1964 the following data shall be included in test report:

- a) Background noise before and after test.
- b) Detailed procedure of application of test voltage.
- c) Measurements of RIV levels expressed in micro volts at each level.
- d) Results and observations with regard to location and type of interference sources detected at each step.
- e) Test voltage shall be recorded when measured RIV passes through 100 microvolts in each direction.
- f) Onset and extinction of visual corona for each of the four tests required shall be recorded

## **CHAPTER 13: STRUCTURE**

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## 1.0 GENERAL

The scope of specification covers design, fabrication, trial assembly, supply and erection of galvanized steel structures for towers, girders, lightning masts and equipment support structures. Structures shall be lattice or Pipe type structure fabricated from structural steel conforming to relevant Indian Standard codes /British standard Codes (BS Codes)/ equivalent International Standards.

The line diagram of all structures of 220 kV & 132kV for new switch yards are already finalized and are attached as tender documents, shall be used to prepare fabrication drawing. Some of the drawings may be available in Category II/III for correction. Contractor has to redraw all the Line diagrams a fresh, giving fresh Title by referring old reference drawing number for approval during detailed Engineering. In case a few towers redesign is needed during detailed Engineering, the same shall be in the scope of Successful bidder. The fabrication drawing/line diagram of structures for extension of existing switch yards shall be furnished by NEA/Consultant to the successful bidder progressively during detailed engineering stage. The bidder shall mention in their bid for the type of proposed structure i.e. Pipe or lattice type structure. The fabrication drawings, proto corrected drawings along with Bill of Material (BOM) for all the structures (Both Gantry and Equipment support structures) shall be prepared by the contractor during detailed engineering for submission to NEA/Consultant for their approval. Support structure for circuit breaker shall also be designed by the Manufacturer/Contractor.

It is the intent of the NEA/Consultant to provide structures which allow interchangeability of equipments at a later stage. Accordingly, Contractor is expected to design the equipment support structures with the provision of stool. Stools shall be provided by the Contractor between the equipment and its support structure to match the bus bar height. The top of stool shall be connected to the equipment and the bottom of the stool shall be connected to the Base support structure.

The scope shall include supply and erection of all types of structures including bolts, nuts, washers, step bolts, inserts in concrete, gusset plates, equipment mounting bolts, structure earthing bolts, foundation bolts, spring washers, fixing plates, ground mounted marshalling boxes (AC/DC Marshalling box & equipment control cabinets), structure mounted marshalling boxes and any other items as required to complete the job.

The connection of all structures to their foundations shall be with base plates and embedded anchor/foundation bolts. All steel structures and anchor/foundation bolts, fasteners (Nuts, bolts, washers ) shall be fully galvanized as per relevant British standard Codes (BS Codes) / equivalent International Standards. The weight of the zinc coating shall be at least 610 grams /sq. m for anchor bolts/foundation bolts and for structural members. One additional nut shall be provided below the base plate which may be used for the purpose of leveling.

Contractor shall provide suitable arrangement on the equipment support structures wherever required to suit fixation of accessories such as marshalling boxes, MOM

boxes, Control Cabinets, Junction box, surge counter, etc. in the equipment structure fabrication drawings.

## 2.0 DESIGN REQUIREMENTS FOR STRUCTURES

- 2.1 For design of steel structures loads such as dead loads, live loads, wind loads etc. shall be based on relevant Indian Standard (IS Codes)/British standard Codes (BS Codes) / equivalent International Standards.
- 2.2 For materials and permissible stresses, relevant British standard Codes (BS Codes) / equivalent International Standards. Shall be followed in general. However, additional requirements given in following paragraphs shall be also considered.
- 2.3 Minimum thickness of galvanized lattice structure member shall be as follows:

Members Min Thickness	(mm)
Leg members, Ground wire	5
Peak members/Main members	5
Other members	4
Redundant members	4

- 2.4 Maximum slenderness ratios for leg members, other stressed members and redundant members for compression force shall be as per relevant British standard Codes (BS Codes) / equivalent International Standards.
- 2.5 Minimum distance from hole center to edge shall be  $1.5 \times$  bolt diameter. Minimum distance between center to center of holes shall be  $2.5 \times$  bolt diameter.
- 2.6 All bolts shall be M16 or higher as per design requirement.

### 2.7 Step Bolts

In order to facilitate inspection and maintenance, the tower structures shall be provided with climbing devices. Each tower shall be provided with M16 step bolts 175mm long spaced not more than 450mm apart, staggered on faces on diagonally opposite legs extending from about 0.5 meters above plinth level to the top of the tower. The step bolt shall conform to relevant British standard Codes (BS Codes) / equivalent International Standards. Ladders along with safety guard shall be provided for the Lightning Mast Tower.

### 2.8 Design Criteria

- a) All gantry structures shall be designed for the worst combination of dead loads, live loads, wind loads and Seismic forces as per relevant British standard Codes (BS Codes) / equivalent International Standards. (latest), loads due to deviation of conductor, load due to unbalanced tension in conductor, torsional load due to unbalanced vertical and horizontal forces, erection loads, short circuit forces including “snatch” in the case of bundled conductors etc. Short circuit forces shall be calculated considering a fault level of 40.0 kA for 220kV, 31.5KA for 132kV and 25KA for 33kV or as applicable. Relevant British standard Codes (BS Codes) / equivalent International Standards. May be followed for evaluation of short circuit forces.

- b) Switchyard gantry structures shall be designed for the two conditions i.e. normal condition and short circuit condition. In both conditions the design of all structures shall be based on the assumption that stringing is done only on one side i.e. all the three (phase) conductors broken on the other side.  
Factor of safety of 2.0 under normal conditions and 1.5 under short circuit condition shall be considered on all external loads for the design of switchyard structures.
- c) Vertical load of half the span of conductors/string and the earth wires on either side of the beam shall be taken into account for the purpose of design. Weight of man with tools shall be considered as 150 kgs. for the design of structures.
- d) Terminal/line take off gantries shall be designed for a minimum conductor tension of 2 metric tonnes per phase for 220 kv, 1 Metric tonne per phase for 132 kV and 0.50 Metric Tonne for 33 kV or as per requirements whichever is higher. The distance between terminal gantry and dead end tower shall be taken as 200 meters for 220kV, 150m for 132kV and 80 m for 33 kV switch yard. The design of these terminal gantries shall also be checked considering +/- 30 deg deviation of conductor in both vertical and horizontal planes. For other gantries the structural layout requirements shall be adopted in design.
- e) The girders / beams shall be connected with lattice/Tower columns by bolted joints.
- f). All equipment support structures shall be designed for the worst combination of dead loads, erection load. Wind load/seismic forces, short circuit forces and operating forces acting on the equipment and associated bus bars as per relevant British standard Codes (BS Codes) / equivalent International Standards.
- g) If luminaries are proposed to be fixed on gantries/towers, then the proper loading for the same shall be considered while designing. Also holes for fixing the brackets for luminaries should be provided wherever required.
- h) Foundation bolts shall be designed for the loads for which the structures are designed.
- i) The height of Lightning Mast shall be as per approved structural layout and designed for diagonal wind condition. . The lightning mast shall be provided with platform for mounting of lighting fixtures and a structural steel ladder within its base up to the level of platform. The ladder shall be provided with protection rings The platforms shall also have protection railing. The details of lighting fixtures would be as per approved drawings of electrical fixtures.

### **3.0 DESIGN, DRAWINGS, BILL OF MATERIALS AND DOCUMENTS**

- 3.1 The Contractor shall submit line diagram of each structure based on already finalized Single Line Diagram of Towers for approval of NEA/Consultant. Fabrication drawing based on approved line diagram shall be prepared by the contractor for approval of NEA/Consultant. The BOM (Bill Of Material) shall be prepared by the contractor based on approved fabrication drawing. The Line diagram should indicate not only profile, but section, numbers and sizes of bolts and details of typical joints. In case NEA/Consultant feels that any design or drawings are to be modified even after its approval, Contractor shall modify the designs & drawings and resubmit the same for approval.

- 3.2 The fabrication drawings shall indicate complete details of fabrication and erection including all erection splicing details and typical fabrication splicing details, lacing details, weld sizes and lengths. Bolt details and all customary details in accordance with standard structural engineering practice. The fabrication drawing and bill of material based on design/line diagram shall be submitted to NEA/Consultant for approval. Approved bill of materials prepared on the basis of fabrication drawing shall be the basis for payment.
- 3.3 Such approvals shall, however, not relieve the contractor of his responsibility for safety and durability of the structure and good connection and any loss occurring due to defective fabrication, design or workmanship shall be borne by the contractor.
- 3.4 **The contractor shall submit editable soft copy of all designs preferably in STAAD / excel form and drawings in AutoCAD to NEA/Consultant.** The list of British standard codes relevant to steel structures have been given in Chapter-14-Civil section of technical specification This list is illustrative but not exhaustive. The contractor shall submit the copy of relevant portion of BS codes/equivalent International standard referred to NEA/Consultant for reference if necessary during detailed engineering stage.

#### **4.0 FABRICATION AND ERECTION**

- 4.1 The fabrication and erection works shall be carried out generally in accordance with relevant Indian Standard Code(IS) /British standard Codes (BS Codes) / equivalent International Standards. All materials shall be completely shop fabricated and finished with proper connection material and erection marks for ready assembly in the field.
- 4.2 The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged and shall be so prepared that the specified camber, if any, is provided. In order to minimize distortion in member the component parts shall be positioned by using the clamps, clips, dogs, jigs and other suitable means and fasteners (bolts and welds) shall be placed in a balanced pattern. If the individual components are to be bolted, paralleled and tapered drifts shall be used to align the part so that the bolts can be accurately positioned.
- 4.3 Sample towers, beams and lightning masts and equipment support structures may be trial assembled in the fabrication shop to ensure fitment of various members and to avoid problems during erection.
- 4.4 For all structures, BOM along with fabrication drawings in hard and editable soft copies shall be submitted to NEA/Consultant as document for information. The responsibility of correctness of such fabrication drawing and BOM shall be fully with the contractor.

- 4.5 Approval of fabrication drawings and BOM shall, however, not relieve the Contractor of his responsibility for the safety and durability of the structure and good connections and any loss or damage occurring due to defective fabrication, design or workmanship shall be borne by the Contractor.
- 4.6 The Contractor should arrange on his own all plant and equipment, welding set, tools and tackles, scaffolding, trestles equipments and all other accessories and ancillaries required for carrying out erection without causing any stresses in the members which may cause deformation and permanent damage. Minor modification if any, required during erection shall be done at site with the approval of NEA/Consultant.

## **5.0 BOLTING**

- i) Every bolt shall be provided with a washer under the nut so that no part of the threaded portion of the bolt is within the thickness of the parts bolted together.
- ii) In case of fasteners, the galvanizing shall conform to relevant Indian Standard Code/British standard Codes (BS Codes)/ equivalent International Standards. The spring washer shall be electro galvanized as per relevant Indian/British standard Codes (BS Codes) / equivalent International Standards.

## **6.0 WELDING**

The work shall be done as per approved fabrication drawings which shall clearly indicate various details of joints to be welded, type of weld, length and size of weld, Symbols for welding on erection and shop drawings shall be according to relevant Indian standard Codes/British standard Codes (BS Codes) / equivalent International Standards. Welding shall be carried out in accordance to relevant Indian Standard Codes/British standard Codes (BS Codes) / equivalent International Standards.

## **7.0 FOUNDATION BOLTS**

- 7.1 Foundation bolts for the towers and equipment supporting structures and elsewhere shall be embedded in first stage concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate.
- 7.2 The Contractor shall be responsible for the correct alignment and leveling of all steel work on site to ensure that the towers/structures are plumb.
- 7.3 All foundation bolts for lattice structure, pipe structure are to be supplied by the Contractor.
- 7.4 All foundation bolts shall be fully galvanized so as to achieve minimum 610 grams Per Sq.m. of Zinc Coating as per relevant British standard Codes

(BS Codes) / equivalent International Standards.

- 7.5 All foundation bolts and its material shall conform to relevant Indian Standard Code (I.S. Code) / British standard Codes (BS Codes) / equivalent International Standards. All foundation bolts shall be provided with two number standard nuts, one check nut, one plain washer and MS plate at the bottom of foundation bolt.

## **8.0 STABILITY OF STRUCTURE**

The Supplier shall be responsible for the stability of the structure at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations.

## **9.0 GROUTING**

The method of grouting the column bases shall be subject to approval of NEA/Consultant and shall be such as to ensure a complete uniformity of contact over the whole area of the steel base. No additional payment for grouting shall be admissible.

## **10.0 GALVANISING**

- 10.1 All structural steel works (Gantry structures, Equipment support structures) and foundation bolts shall be galvanized after fabrication. The galvanization shall be done as per requirement relevant Indian Standard Code/British standard Codes (BS Codes) / equivalent International Standards.
- 10.2 Zinc required for galvanizing shall have to be arranged by the Contractor/manufacturer. Purity of zinc to be used shall be 99.95% as per relevant Indian Standard (IS)/British standard Codes (BS Codes) / equivalent International Standards.
- 10.3 The Contractor shall be required to make arrangement for frequent inspection by the owner as well as continuous inspection by a resident representative of the owner, if so desired for fabrication work.

## **11.0 TOUCH-UP PAINTING**

Minor defects in hot dip galvanized members shall be repaired by applying zinc rich primer and two coats of enamel paint to the satisfaction of NEA/Consultant before erection.

## **12.0 INSPECTION BEFORE DISPATCH**

Each part of the fabricated steel work shall be inspected as per approved quality plans and certified by NEA/Consultant or his authorized representative as satisfactory before it is dispatched to the erection site. Such certification shall not relieve the Contractor of his responsibility regarding adequacy and completeness of fabrication.

## **13.0 TEST CERTIFICATE**

Copies of all test certificates relating to material procured by the Contractor for the works shall be submitted to NEA/Consultant.

## **14.0 MODE OF MEASUREMENT**

The measurement of the structure, fasteners (Nuts, Bolts, and Washers) and foundation bolts including its nuts washers and MS Plate at bottom shall be done as per Bid price schedule (BPS). The weight of all structural members and foundation bolts (Bolt, Nuts, washer and MS steel plates welded at bottom of bolt) shall be measured under one head in Metric Tonne. The weight of fasteners and step bolts (Nuts, bolts and washers) used to erect/complete structures shall be measured under another head in Metric tons.

## **15.0 SAFETY PRECAUTIONS**

The Contractor shall strictly follow all precautions at all stages of fabrication, transportation and erection of steel structures. The stipulations contained in relevant

British standard Codes (BS Codes) / equivalent International Standards for Safety during erection of structural steel work shall also be adhered to.

## **16.0 MANUFACTURING QUALITY PLAN**

The material specification shall also be as per relevant British standard Codes (BS Codes) / equivalent International Standards.

The Contractor shall prepare the manufacturing quality plan to accept/check the material, galvanization and welding as per relevant international standards/Indian Standard (IS)/BS codes within 1 month after award of work and submit the same to NEA/ Consultant for approval.

## **CHAPTER 14: CIVIL WORKS**

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## **1.0 GENERAL**

The intent of specification covers the following:

Design, engineering, drawing and construction of all civil works at sub-station. All civil works shall also satisfy the general technical requirements specified in other Sections of Specification and as detailed below. They shall be designed to the required service conditions/loads as specified elsewhere in this Specification or implied as per relevant Indian Standard Codes (I.S.Codes)/British standard codes (B S Codes)/ equivalent International Standards.

All civil works shall be carried out as per applicable Standards and Codes. All materials shall be of best quality conforming to relevant International Standards and Codes. In case of any conflict between Standards/ Code and Technical Specification, the provisions of Technical Specification shall prevail.

The Contractor shall furnish all design, drawings, labour, tools, equipment, materials, temporary works, constructional plant and machinery, fuel supply, transportation and all other incidental items not shown or specified but as may be required for complete performance of the Works in accordance with approved drawings, specifications and direction of NEA/Consultant.

The work shall be carried out according to the design/drawings to be developed by the Contractor and approved by the NEA/Consultant. For all buildings, structures, foundations etc. necessary layout and details shall be developed by the Contractor keeping in view the functional requirement of the substation facilities and providing enough space and access for operation, use and maintenance. Certain minimum requirements are indicated in this specification for guidance purposes only. However, the Contractor shall quote according to the complete requirements.

## **2.0 GEOTECHNICAL INVESTIGATION (ALREADY CARRIED OUT)**

- 2.1 The Contractor shall perform a detailed soil investigation to arrive at sufficiently accurate, general as well as specific information about the soil profile and the necessary soil parameters of the Site in order that the foundation of the various structures can be designed and constructed safely and rationally.
- A detailed soil report including field data duly certified by site engineers of NEA/Consultant will be submitted by the Contractor for specific approval of NEA/Consultant. The report shall contain all soil parameters

along with recommendation of soil consultant for type of foundation i.e. pile or open type, soil treatment if any etc to be used for the design of civil foundations.

- 2.2 The Contractor may visit the site to ascertain the soil parameters. Any variation in soil data shall not constitute a valid reason for any additional cost & shall not affect the terms & conditions of the contract. Field tests must be conducted covering entire substation area including all the critical locations i.e. Control Room and GIS Building, township buildings, Lightning Mast. Towers, transformer/Reactor etc.

### 2.3 **SCOPE OF WORK**

This specification covers all the work required for detailed soil investigation and preparation of a detailed report. The work shall include mobilisation of necessary equipment, providing necessary engineering supervision and technical personnel, skilled and unskilled labour etc. as required to carry out field investigation as well as, laboratory investigation, analysis and interpretation of data and results, preparation of detailed Geo-technical report including specific recommendations for the type of foundations and the allowable safe bearing capacity for different sizes of foundations at different founding strata for the various structures of the substation. The Contractor shall make his own arrangement for locating the co-ordinates and various test positions in field as per the information supplied to him and also for determining the reduced level of these locations with respect to the benchmark indicated by the NEA/Consultant. The soil investigation for substation extension in existing switch yard has not been envisaged. Soil data of existing substation shall be referred for the design of foundations in switch yard extension under present scope of work.

All the work shall be carried out as per latest edition of the corresponding relevant British standard codes (B S Codes)/ equivalent International Standards. The Agency carrying out the soil investigation work must have the experience of carrying out soil investigation successfully in the relevant field. NEA shall assess the capability of the agency for soil investigation work for which technical inputs may be furnished by consultant to NEA.

#### 2.3.1 **Bore Holes (ALREADY CARRIED OUT)**

Bore holes of Minimum 150 mm diameter in accordance with the provisions of relevant international standards/British standards(BS) at the rate of minimum one number bore hole per hectare up to 25meter depth(Minimum) or to refusal which ever occur earlier shall be drilled for

new areas (220 kV Yards and 220/132/33 kV yards wherever applicable). In any case number of boreholes shall not be less than five. By refusal it shall mean that a standard penetration blow count (N) of 100 is recorded for 30 cm penetration. Number of boreholes may be increased in case soil strata are varying from borehole to borehole in order to have fair idea of soil profile. In case of deep pile foundations soil investigation is to be carried out up to 30 m depth from ground level or refusal whichever is earlier. In case rock is encountered, coring in all the boreholes shall be carried out up to 3 meter in rock.

Performing Standard Penetration Tests at approximately 1.5 m interval in the borehole starting from 1.5 m below ground level onwards and at every change of stratum. The disturbed samples from the standard penetrometer shall also be collected for necessary tests. Standard Penetration Test shall be performed as per relevant British standard codes (B S Codes)/ equivalent International Standards.

Undisturbed samples shall be collected in accordance with the recommendation of relevant British standard codes (B S Codes)/ equivalent International Standards. Or an alternative recognize method as agreed by NEA/Consultant. Undisturbed samples shall be taken in cohesive material or weak cemented granular material where ever possible at 1.0 m interval or at each change in stratum.

The depth of Water Table, if encountered, shall be recorded in each borehole. In case the soil investigation is carried out in winter/summer, the water table for rainy season shall be collected from reliable sources and recorded in the report.

All samples, both disturbed and undisturbed, shall be identified properly with the borehole number and depth from which they have been taken.

The sample shall be sealed at both ends of the sampling tubes with wax immediately after the sampling and shall be packed properly and transported to the Contractor's laboratory without any damage or loss.

The logging of the boreholes shall be compiled immediately after the boring is completed and a copy of the bore log shall be handed over to the Engineer-in-charge.

### **2.3.2 Trial Pits (AREADY CARRIED OUT)**

The Contractor shall excavate two number trial pits per substation (New) as and where directed by NEA/Consultant, of Plan area 10 sq.m. and not exceeding 4 m depth. Undisturbed samples shall be taken from the trial

pits as per the direction of the NEA/Consultant. All Trial Pits shall be re-filled with approved material after the tests are complete and shall be compacted in layers of not more than 500mm.

#### **2.3.3 Electrical Resistivity Test (AREADY CARRIED OUT)**

This test shall be conducted to determine the Electrical resistivity of soil required for designing safety-grounding system for the entire station area. The specifications for the equipments and other accessories required for performing electrical resistivity test, the test procedure, and reporting of field observations shall confirm to relevant British standard codes (B S Codes)/ equivalent International Standards. The test shall be conducted using Wagner's four electrode method as specified in relevant British standard codes (B S Codes)/ equivalent International Standards.. Unless otherwise specified at each test location, the test shall be conducted along two perpendicular lines parallel to the coordinate axis. On each line a minimum of 8 to 10 readings shall be taken by changing the spacing of the electrodes from an initial small value of 0.2 m upto a distance of 50.0 m.

#### **2.3.4 Plate load test (AREADY CARRIED OUT)**

Two number of Plate load tests shall be conducted each at the location of control room/ GIS building and township area as applicable only to determine the bearing capacity, modulus of sub grade reaction and load/settlement characteristics of soil at shallow depths by loading a plane and level steel plate kept at the desired depth and measuring the settlement under different loads, until a desired settlement takes place or failure occurs. The specification for the equipment and accessories required for conducting the test, the test procedure, field observations and reporting of results shall conform to relevant BS standard. Plate load test shall be performed at the proposed foundation depth below finished ground level for bearing capacity.

Undisturbed tube samples shall also be collected from the pit at 1.0 m depth and bottom of pit from natural ground level for carrying out laboratory tests.

The size of the pit in plate load test shall not be less than five times the plate size and shall be taken up to the specified depth. All provisions regarding excavation and visual examination of pit shall apply here.

Unless otherwise specified the reaction method of loading shall be adopted. Settlement shall be recorded from dial gauges placed at four diametrically opposite ends of the test plate.

The load shall be increased in stages. Under each loading stage, record of Time vs. Settlement shall be kept as specified in relevant British standard codes (B S Codes)/ equivalent International Standards.

Backfilling of the pit shall be carried out as per the directions of the NEA/Consultant. Unless otherwise specified the excavated soil shall be used for this purpose. In cases of gravel-boulder or rocky strata, respective relevant codes shall be followed for tests.

#### **2.3.5 Water Sample (AREADY CARRIED OUT)**

Representative samples of ground water shall be taken when ground water is first encountered before the addition of water to aid drilling of boreholes. The samples shall be of sufficient quantity for chemical analysis to be carried out and shall be stored in air-tight containers.

#### **2.3.6 Back Filling of Bore Holes (AREADY CARRIED OUT)**

On completion of each hole, the Contractor shall backfill all bore holes as directed by the NEA/Consultant. The backfill material can be the excavated material.

#### **2.3.7 Laboratory Test (AREADY CARRIED OUT)**

1. The laboratory tests shall be carried out progressively during the field work after sufficient number of samples has reached the laboratory in order that the test results of the initial bore holes can be made use of in planning the later stages of the field investigation and quantum of laboratory tests.
2. All samples brought from field, whether disturbed or undisturbed shall be extracted/prepared and examined by competent technical personnel, and the test shall be carried out as per the procedures laid out in the relevant British standard codes (B S Codes)/ equivalent International Standards.

The following laboratory tests shall be carried out

- a) Visual and Engineering Classification
- b) Atterberg limits Tests.
- c) Natural moisture content, bulk density and specific gravity.
- d) Grain size distribution analysis.

- e) Swell pressure and free swell index determination.
- f) California bearing ratio.
- g) Consolidated drained test with pore pressure measurement.
- h) Chemical tests on soil and water to determine the carbonates, sulphates, nitrates, chlorides, Ph value, and organic matter and any other chemical harmful to the concrete foundation.
- i) In case rock is encountered, the soil test required for rock as per relevant British standard codes (B S Codes)/ equivalent International Standards including following tests shall also be conducted.
  - (i) UCC test.
  - (ii) Point load index test.

#### **2.3.8 Test Results and Reports (AREADY CARRIED OUT & REPORT SHALL BE PROVIDED TO SUCCESSFUL BIDDER)**

The Contractor shall submit the detailed report in two (2) copies wherein information regarding the geological detail of the site, summarised observations and test data, bore logs, and conclusions and recommendations on the type of foundations with supporting calculations for the recommendations. The contractor shall also submit the bearing capacity calculation in editable soft copy to NEA/consultant. Initially the contractor shall submit draft report and after the draft report is approved, the final report in four (4) copies shall be submitted. The field and laboratory test data shall bear the signatures of the Investigation Agency, Contractor and also site representative of NEA/Consultant.

The report shall include, but not limited to the following:-

- a) A plan showing the locations of the exploration work i.e. bore holes, trial pits. Plate load test, electrical resistivity test, CBR sample location etc.
- b) Bore Logs: Bore logs of each bore holes clearly identifying the stratification and the type of soil stratum with depth. The values of Standard Penetration Test (SPT) at the depths where the tests were conducted on the samples collected at various depths shall be clearly shown against that particular stratum.

Test results of field and laboratory tests shall be summarised strata wise as well in combined tabular form. All relevant graphs,

charts tables, diagrams and photographs, if any, shall be submitted along with report. Sample illustrative reference calculations for settlement, bearing capacity, pile capacity shall be enclosed.

**Recommendations:** The report should contain specific recommendations for the type of foundation for the various structures envisaged at site. The Contractor shall acquaint himself about the type of structures and their functions from the NEA/Consultant. The observations and recommendations shall include but not limited to the following:

- a) Geological formation of the area, past observations or historical data, if available, for the area and for the structures in the nearby area, fluctuations of water table etc.
- b) Recommended type of foundations for various structures. If piles are recommended the type, size and capacity of pile and groups of piles shall be given after comparing different types and sizes of piles and pile groups.
- c) Allowable bearing pressure on the soil at various depths for different sizes of the foundations based on shear strength and settlement characteristics of soil with supporting calculations. Minimum factor of safety for calculating net safe bearing capacity shall be taken as 3.0 (three). Recommendation of liquefaction characteristics of soil if applicable shall be provided.
- d) Recommendations regarding slope of excavations and dewatering schemes, if required.
- e) Comments on the Chemical nature of soil and ground water with due regard to deleterious effects of the same on concrete and steel and recommendations for protective measures.
- f) If expansive soil is met with, recommendations on removal or retainment of the same under the structure, road, drains, etc. and thickness of treatment shall be given. In the latter case detailed specification of any special treatment required including specification or materials to be used, construction method, equipments to be deployed etc. shall be furnished. Illustrative diagram of a symbolic foundation showing details shall be furnished.
- g) Recommendations for additional investigations beyond the scope of the present work, if considered such investigation as necessary.

- f) In case of foundation in rocky strata, type of foundation and recommendation regarding rock anchoring etc. should also be given.

### **3.0 CONTOUR SURVEY, SITE LEVELLING**

#### **3.1 CONTOUR SURVEY & SITE LEVELLING:**

Basic work of Contour survey has been executed and Finished Ground Level (FGL) has already been finalised but site levelling work has not been fully completed. Therefore to execute balance work of site levelling, the contractor shall carry out re-survey work (To be verified by NEA Representative) by taking spot level at 05 m x 05 m grid interval with respect to temporary bench mark already available at site. 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. At some of the places of site, loose earth heaps are available from tower pit excavation and are kept there for back filling of tower/transformer foundation pits. Hence while recording the initial spot levels, loose earth heaps are to be left from cutting scope for site levelling. The land for construction of substation will be handed over to the successful bidder as on where basis progressively after award of work.

The contractor will arrange balance levelling as per already finalised Finished Ground Level conveniently with the approval of Nepal Electricity Authority (NEA).

The layout and levels of all structure etc shall be made by the Contractor at his own cost from the general grids of the plot and benchmarks set by the Contractor and approved by NEA/Consultant. The Contractor shall provide all assistance in instruments, materials and personnel to NEA/Consultant for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

#### **3.2 SCOPE**

This clause covers clearance of site, contour survey, site levelling, maintaining finished ground level by cutting/filling in all types of soil and soft/ disintegrated rock, supplying and compaction of fill material if required. Cutting/felling of trees and their disposal has not been envisaged under the present scope.



### 3.3 GENERAL

Site shall be cleared, surveyed and levelled/sloped by the contractor as per approved general arrangement drawing or levelling area decided during detailed engineering after award of work.

Work covered under this clause comprises the site clearance, survey work/setting out and making profiles (preparation of plot plan, setting up Bench Mark and taking spot levels at 05m x 05 m interval, preparation of contour plan with contour interval of 0.50 m), Earth work in Excavation(Wherever required)& filling in specified area (Wherever required)with all lifts and leads and earth work in filling with borrowed earth with all leads and lifts (Borrow areas including payment of royalty for borrowed earth shall be arranged by the contractor at his own cost). During detailed engineering stage, the contractor will prepare the levelling proposal for optimum levelling and submit to NEA/Consultant for approval. Contractor shall submit the hard copy and editable soft copy of levelling proposal (levelling quantity calculation in Excel form and levelling drawing in Auto CAD) to NEA/Consultant for approval.

- 3.4 Filling material shall conform to relevant Indian Standard (IS)/British standard codes (BS Codes)/equivalent International Standards. Unsuitable filling material if any shall be removed and replaced by suitable fill material. The filling shall be compacted in layers to achieve 95% of standard Proctor's density at Optimum moisture contents (OMC). Cohesion less material shall be compacted to 70% relative density (minimum). Levelling/Filling shall be carried out as per relevant British standard codes (B S Codes)/ equivalent International Standards.
- 3.5 All materials involved in excavation shall be classified by NEA/ Consultant in the following groups:
  - 3.5.1 **All kinds of soils and soft/disintegrated rocks (Not requiring blasting):** The material which can be 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.
  - 3.5.2 **Hard Rocks:** All kinds of rocks which can only be excavated by machines and requires blasting, chiselling in edging or in another agreed method and will also include reinforcement cement concrete.
- 3.6 The quantity of excavation in all types of soils and soft/disintegrated rock shall be worked out by using initial and final level and no void deduction shall be made to calculate net quantity of earth work with 95% compaction.
- 3.7 The volume of hard rock shall be computed on the basis of stack of excavated rubble after making 50 % deduction for voids.
- 3.8 The surface of excavation or filling shall be neatly dressed to the required

formation level with tolerance of ( $\pm$ ) 100 mm.

#### **4.0 SITE PREPERATION, EXCAVATION, BACKFILL&DISPOSAL OF SURPLUS EARTH.**

##### **4.1 SITE PREPERATION**

The layout and levels of all structure etc shall be made by the Contractor at his own cost from the general grids of the plot and benchmarks set by the Contractor and approved by the NEA/Consultant. The Contractor shall give all help in instruments, materials and personnel to the NEA/Consultant for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

##### **4.2 SCOPE**

This clause covers clearing of the site, maintaining the finished ground level with available surplus excavated suitable back fill material generated from foundation works etc.

##### **4.3 GENERAL**

- 1) The Contractor shall develop the site area to meet the requirement of the intended purpose. The site preparation shall conform to the requirements of relevant sections of this specification or as per stipulations of relevant British standard codes (B S Codes)/ equivalent International Standards.
- 2) The fill material shall be suitable for the above requirement. The fill shall be with such a material that the site so designed shall not be affected by erosion from wind and water from its final compacted position or the in-situ position of undisturbed soil.
- 3) Material unsuitable for founding of foundations shall be removed and replaced by suitable fill material to be approved by the NEA/Consultant.
- 4) Backfill material around foundations or other works shall be suitable for the purpose for which it is used and compacted to the density described under Compaction. Excavated material not suitable or not required for backfill shall be disposed off in areas as directed by purchaser up to a maximum lead of 2 km.

#### 4.4 EXCAVATION AND BACKFILL

##### SCOPE

This clause covers excavation for foundation works of Towers, Equipment support structures, Transformer/Reactor foundations, External Lighting poles, Cable trenches, Buildings, Car parking shed, Fire Wall, DG set, Water tanks, etc, backfilling of Foundations Works.

1. Excavation and backfill for foundations shall be in accordance with the relevant British standard codes (B S Codes)/ equivalent International Standards.
2. For Already Excavated Tower/Transformer foundation pits, back filling shall be arranged by contractor as per the scope of BPS item.
2. Whenever water table is met during the excavation, it shall be dewatered and water table shall be maintained below the bottom of the excavation level during excavation, concreting and backfilling.
3. When embankments are to be constructed on slopes of 15% or greater, benches or steps with horizontal and vertical faces shall be cut in the original slope prior to placement of embankment material. Vertical faces shall measure not more than 1 m in height.
4. Embankments adjacent to abutments, culverts, retaining walls and similar structures shall be constructed by compacting the material in successive uniform horizontal layers not exceeding 15 cm in thickness. (Of loose material before compaction). Each layer shall be compacted as required by means of mechanical tampers approved by the Purchaser. Rocks larger than 10 cm in any direction shall not be placed in embankment adjacent to structures.
5. Earth embankments of roadways and site areas adjacent to buildings shall be placed in successive uniform horizontal layers not exceeding 20 cm in thickness in loose stage measurement and compacted to the full width specified. The upper surface of the embankment shall be shaped so as to provide complete drainage of surface water at all times.

#### **4.5 COMPACTION**

- i. The density to which fill materials shall be compacted shall be as per relevant BS and as per direction of NEA/Consultant. All compacted sand filling shall be confined as far as practicable. Backfilled earth shall be compacted to minimum 95% of the Standard Proctor's density at OMC. The sub grade for the roads and embankment filling shall be compacted to minimum 95% of the Standard Proctor's density at OMC. Cohesion less material sub grade shall be compacted to 70% relative density (minimum).
- 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/Consultant.

#### **4.7 DISPOSAL OF SURPLUS EARTH**

The surplus earth generated from foundation work shall be disposed away from levelling area boundary at low lying areas within 2Km lead. The surplus earth if disposed within substation main boundary, the same shall be spread in uniform layers and compacted with suitable compacting equipment to achieve 95% compaction at O.M.C.

## **5.0 ANTIWEED TREATMENT & STONE SPREADING**

### **5.1 SCOPE OF WORK**

The Contractor shall furnish all labour, equipment and materials required for complete performance of the work in accordance with the drawings, specification.

Stone spreading along with cement concrete layer shall be done in the areas of the switchyard under present scope of work within fenced area. However the stone spreading along with cement concrete layer in future areas within fenced area shall also be provided in case step potential without stone layer is not well within safe limits.

### **5.2 GENERAL REQUIREMENT**

The material required for site surfacing/stone filling shall be free from all types of organic materials and shall be of standard quality, and as approved by the Purchaser.

The material to be used for stone filling/site surfacing shall be uncrushed/crushed/broken stone of 40mm nominal size (ungraded single size) conforming to relevant BS. Hardness, flakiness shall be as required for wearing courses shall be as are per relevant BS.

- (a) Hardness  
Abrasion value as per relevant BS.  
Impact value as per relevant BS.
- (b) Flakiness Index  
One test shall be conducted as per relevant British standard codes (B S Codes)/ equivalent International Standards.

After all the structures/equipments are erected, anti weed treatment shall be applied in the switchyard where ever stone spreading along with cement concrete is to be done and the area shall be thoroughly de-weeded including removal of roots. The recommendation of local agriculture or horticulture department may be sought where ever feasible while choosing the type of chemical to be used. The anti weed chemical shall be procured from reputed manufacturers. The doses and application of chemical shall be strictly done as per manufacturer's recommendation. Nevertheless the effectiveness of the chemical shall be demonstrated by the contractor in a test area of 10MX10M (appx.) and

shall be sprinkled with water at least once in the afternoon every day after forty eight hours of application of chemical. The treated area shall be monitored over a period of two to three weeks for any growth of weeds by the NEA/Consultant. The final approval shall be given by NEA/Consultant based on the results.

NEA/Consultant shall decide final formation level so as to ensure that the site appears uniform devoid of undulations. The final formation level shall however be very close to the formation level indicated in the approved drawing.

After anti weed treatment is complete, the surface of the switchyard area shall be maintained, rolled/compacted to the lines and grades as decided by NEA/Consultant. The sub grade shall be consolidated by using half ton roller with suitable water sprinkling arrangement to form a smooth and compact surface. The roller shall run over the sub grade till the soil is evenly and densely consolidated and behaves as an elastic mass.

In areas that are considered by the NEA/Consultant to be too congested with foundations and structures for proper rolling of the site surfacing material by normal rolling equipments, the material shall be compacted by hand, if necessary. Due care shall be exercised so as not to damage any foundation structures or equipment during rolling compaction.

The sub grade shall be in moist condition at the time the cement concrete is placed. If necessary, it should be saturated with water for not less than 6 hours but not exceeding 20 hours before placing of cement concrete. If it becomes dry prior to the actual placing of cement concrete, it shall be sprinkled with water and it shall be ensured that no pools of water or soft patches are formed on the surface.

Over the prepared sub grade, 75mm thick base layer of cement concrete in 1:5:10 (1 cement :5 sand : 10 Stone aggregates) shall be provided in the area excluding roads, drains, cable trenches as per detailed engineering drawing. For easy drainage of water, the slope of 1:1000 is to be provided from the ridge to the nearest drain. The ridge shall be suitably located at the centre of the area between the nearest drains. The above slope shall be provided at the top of base layer of cement concrete in 1:5:10. A layer of cement slurry of mix 1:6 (1 cement: 6 sand) shall be laid uniformly over cement concrete layer. The cement consumption for cement slurry shall not be less than 150 kg. Per 100 sq.m.

A final layer of 100mm thickness of uncrushed/crushed/broken stone of 40mm nominal size (ungraded size) shall be spread uniformly over

cement concrete layer after curing is complete.

## **6.0 SITE DRAINAGE**

Preparation of overall drainage layout, design, drawing and providing rain water drainage system within the substation boundary under the present scope including connection at one or more points to the outfall point located outside the substation boundary wall is in the scope of contractor. Invert level of drainage system at outfall point shall be decided in such a way that the water can easily be discharged outside the substation boundary wall. In case outfall point is more than 50M away from boundary wall, only 50 metre drain outside the boundary wall is in the scope of contractor. Outfall point shall be got approved from NEA/Consultant before commencement of construction. While designing the drainage system following points shall taken care of:

- (a) The surface of the switchyard shall be sloped to prevent accumulation of water.
- (b) Drain shall be constructed at suitable locations in such a way that substation is not flooded and roads are not affected with ponding of surface water. In the switchyard maximum spacing between two drains shall not be more than 100 meter. It will be ensured that no area is left un-drained.
- (c) Open surface drains having 300mm bottom width and 300mm depth at starting point of drain shall be provided. The depth of drain shall be measured with respect to finished ground level of switch yard i.e. from bottom of switch yard stone filling.
- (d) Longitudinal slope shall not be less than 1 in 1000.
- (e) Open surface drains shall be constructed with brick masonry or concrete blocks. As per design of contractor. PCC (1:2:4) shall be laid over 40mm thick layer of PCC 1:4:8 (1 cement: 4coarse sand: 8 stone aggregate 20mm nominal size.)
- (f) The side wall of the drains shall be 25 mm above the gravel level to prevent falling of gravel into drain. Groove of 125 mm width shall be provided at 2000 mm spacing with suitable mild steel grating.
- (g) The maximum velocity for pipe drains and open drains shall be limited to 2.4m/sec and 1.8m/sec respectively. However, minimum non-silting velocity of 0.6m/sec shall be ensured.
- (h) Pipe drains shall be provided in areas of switchyard where movement of crane will be necessary in operating phase of the substation.
- (i) For pipe drains, concrete pipe of class NP2 shall be used. However, for road crossings etc. higher strength pipe of class NP3 shall be provided. For rail crossings, RCC pipes of class NP4 shall

be provided. For design of RCC pipes for drains and culverts, relevant British standard codes (B S Codes)/ equivalent International Standards. Shall be followed.

- (j) Two Nos. of portable pumps of 5 hp capacity for drainage of water shall be provided by the Contractor.
- (k) Pipe drains shall be connected through manholes at an interval of max. 30m.
- (l) If the invert level of outfall point is above the last drain point in the substation boundary, sump of suitable size has to be constructed within the substation boundary.
- (m) The drainage scheme and associated drawings shall be got approved from NEA/Consultant before commencement of construction.

#### **6.1 RAINWATER HARVESTING:**

In addition to drainage of rainwater in accordance with above clause 6.0, the contractor shall design, prepare drawings and provide rainwater harvesting system also. Rainwater harvesting shall not be done if the depth of underground water table is within 8.0m from finished ground level or as per provision of relevant British standard codes (B S Codes)/ equivalent International Standards. While designing the rain water harvesting system, following points may be taken care of:

Rainwater harvesting shall be done by providing two numbers recharge structures with bore wells. The recharge structures shall be suitably located within the sub-station. Branch drains from the main drain carrying rainwater from entire switchyard, constructed in accordance with clause 5.0, shall be connected to the recharge structures.

The internal diameter of recharge shafts shall be 4.5 meter with 230mm thick lining of brick work up to a depth of 2.0 meter from ground level and 345mm thick brickwork below 2.0 meter depth. The brick/concrete block work shall be constructed with cement mortar 1:6 (1 cement: 6 coarse sand). The overall depth of shaft shall be 5.0 meter below invert level of drain. The shaft shall be covered with RCC slab for a live load of 300 kg. Persq.m. Two openings of size 0.7 x 0.7 meter shall be provided in the RCC cover slab as shown in the drawing. An iron cover made of 5mm thick chequered plate with hinges shall be provided on the openings. Galvanized M.S. rungs of 20mm diameter at spacing of 300 mm shall be provided in the wall of shaft below the opening in the RCC slab to facilitate cleaning of shaft.

A 300 mm diameter bore well shall be drilled in the centre of the shaft.



The depth of bore well shall be 5.0 meter more than the depth of sub soil water.

A 100 mm dia medium duty MS pipe conforming to relevant BS shall be lowered in the bore well keeping bail plug towards bottom of bore well. The pipe shall have 1.58mm holes for 4.0 meter length starting from 1.0 meter from bottom of bore well. Holes of 3.0mm dia shall be provided for a length of 2.0 meter starting from the bottom level of coarse sand and down wards. The overall length of pipe shall be equal to total depth of bore well plus depth of shaft.

Gravel of size 3mm to 6mm shall be filled around 100 dia MS pipe in the borewell. The shaft shall be filled with 500 mm thick layers each from the bottom of shaft with boulders of size 50mm to 150mm, gravel of size 5mm to 10mm, coarse sand having particle size 1.5mm to 2.0mm and boulders of size not less than 200mm respectively.

## **7.0 ROADS**

- a). All the roads as shown in the General Arrangement drawing for the substation issued along with the tender documents are in the present scope. Adequate turning space for vehicles shall be provided and bend radii shall be set accordingly. Road to the Transformer /Reactor shall be as short and straight as possible.
- b) All concrete roads within substation boundary wall shall be with 3.75 m RCC concrete pavement of suitable thickness and 1.3 m wide earthen shoulder on either side of the road. Below RCC concrete pavement, water bound macadam of adequate thickness as per design (WBM) shall be laid.
- c) All black top (Bituminous/Asphalt) roads within substation boundary wall if any shall be with 3.75 m asphaltic pavement of suitable thickness and 1.3 m wide earthen shoulder on either side of the road. Below black top pavement, water bound macadam of adequate thickness as per design (WBM) shall be laid.
- d) Strengthening of existing roads as applicable (as shown in General Arrangement Drawing) shall be carried out with 2.5 cm thick premix carpet and 100 mm thick compacted layer of WBM (Water Bound Macadam) after filling the pot holes of existing roads with WBM material.

- e) All roads shall be designed as per relevant British standard codes (B S Codes)/ equivalent International Standards. All drawings of road and culverts shall be prepared by the contractor.
- f) All the culverts and allied structures (required for road/rail, drain, trench crossings etc.) shall be designed as per relevant British standard codes (B S Codes)/ equivalent International Standards.

## **8.0 TRANSFORMERS/REACTOR FOUNDATION, RAIL TRACK/ RAIL CUM ROAD TRACK**

The Contractor shall design, prepare drawing and provide a RCC Rail cum road system integrated with the Transformer/Reactor foundation to enable installation and the replacement of any failed unit. The transfer track system shall be suitable to permit the movement of any failed unit fully assembled (including OLTC, bushings) with oil. This system shall enable the removal of any failed unit from its foundation to the nearest road. If trench/drain crossings are required then suitable R.C.C. culverts shall be provided in accordance with relevant BS.

The Contractor shall provide a pylon support system for supporting the fire fighting system.

Each Transformer /Reactor including oil conservator tank and cooler banks etc. shall be placed in a self-sufficient pit surrounded by retaining walls (Pit walls). The clear distance of the retaining wall of the pit from the Transformer/Reactor shall be 20% of the Transformer /Reactor height or 0.8m whichever is more. The oil collection pit thus formed shall have a void volume equal to 200% volume for 220 kV & above and 130% for 132 kV & below of total oil in the Transformer /Reactor. The minimum height of the retaining walls shall be 15 cm above the finished level of the ground to avoid outside water pouring inside the pit. The bottom of the pit shall have an uniform slope towards the sump pit. While designing the oil collection pit, the movement of the Transformer must be taken into account.

The grating shall be made of MS flat of size 40mmx 5mm placed at 30mm center to center and 25mmx5mm MS flat at spacing of 150mm at right angle to each other. Maximum length of grating shall be 2000mm and width shall not be more than 500mm. The gratings, supported on ISMB 150mm, shall be placed at the formation level and will be covered with 100mm thick layer of broken/crushed/non-crushed stone having size 40mm to 60mm which acts as an extinguisher for flaming oil. All steel works used for grating and support in transformer foundation shall be painted with Zinc phosphate primer (two packs) conforming to relevant British standard codes (B S Codes)/ equivalent International Standards.

Each oil collection pit shall be drained towards a sump pit within the collection pit

whose role is to drain water and oil due to leakage within the collection pit so that collection pit remains dry.

## **8.1 MATERIALS**

Complete foundation shall be made of reinforced cement concrete and shall be designed as per guidelines for design of foundations given in clause 10.0 in the specification.

## **8.2 DRAINAGE**

One 0.5 H.P pump for each pit shall be supplied and installed by the Contractor to evacuate the fire fighting& rain water from the sump pit in to the nearest drain.

## **9.0 FIRE PROTECTION WALLS**

### **9.1 GENERAL**

Fire protection walls shall be provided, if required, in accordance with Local Advisory Committee (LAC) recommendations. The scope of works covers design, preparation of drawing and construction of RCC fire protection walls. While designing the wall, following points may be taken care of:

#### **9.1.1 FIRE RESISTANCE**

The firewall shall have a minimum fire resistance of 3 hours. The partitions, which are made to reduce the noise level, shall have the same fire resistance. The walls of the building, which are used as firewalls, shall also have a minimum fire resistance of 3 hours.

The firewall shall be designed to protect against the effect of radiant heat and flying debris from an adjacent fire.

#### **9.1.2 DIMENSIONS**

The firewall shall extend 600 mm on each side of the Transformer /Reactors and 600 mm above the conservator tank or safety vent.

These dimensions might be reduced in special cases, as per the approval of owner where there is lack of space. A minimum of 2.0meter clearance shall be provided between the equipments e.g. Transformer /Reactors and firewalls.

The building walls, which act as firewalls, shall extend at least 1 m above the roof in order to protect it.

### 9.1.3 MATERIALS

The firewall will be made of reinforced cement concrete as per the relevant British standard codes (B S Codes)/ equivalent International Standards.

## 10.0 CABLE TRENCHES AND CABLE TRENCH CROSSINGS

The work covered under this clause comprises of design, drawing and construction of cable trenches and cable trench crossings. While designing, following points may be taken care of:

- a). The cable trenches and pre-cast removable RCC cover (with lifting arrangement) shall be constructed using RCC of M25 (Minimum) grade as per relevant British standard codes (B S Codes)/ equivalent International Standards.
- b). The cable trench walls shall be designed for the following loads.
  - (i) Dead load of 155 kg/m length of cable support + 75 Kg on one tier at the outer edge of tier.
  - (ii) Earth pressure + uniform surcharge pressure of 2T/m<sup>2</sup>.
- c). Cable trench covers shall be designed for self-weight of top slab + concentrated load of 150 kg at centre of span on each panel.
- d). Necessary sumps shall be provided and each sump shall be provided with pumps of 5 HP capacity shall be supplied for pumping out water collected in cable trench. Cable trenches shall not be used as storm water drains.
- e). The top of trenches shall be kept at least 100 mm above the finished ground level. The top of cable trench shall be such that the surface rainwater do not enter the trench.
- f). All metal parts inside the trench shall be connected to the earthing system.
- g). Trench wall shall not foul with the foundation. Suitable clear gap shall be provided.
- h). The trench bed shall have a slope of 1/500 along the run & 1/250 perpendicular to the run.
- i). Cable trenches shall be blocked at the ends if required with brick masonry in cement sand mortar 1:6 and plaster with 12mm thick 1:6

cement sand mortar.

- J) Cable trench crossings shall be designed for critical load likely to be passed over the crossing. The cable trench crossing may be of either RCC box culvert type or RCC hume pipes embedded in plain concrete as per design of contractor.

## **11.0 FOUNDATION / RCC CONSTRUCTION**

### **11.1 GENERAL**

1. Work covered under this Clause of the Specification comprises the design ,drawing and construction of foundations and other RCC constructions for switchyard tower structures, bus supports, equipment supports, cable trenches, Transformer /Reactors, jacking pad, pulling blocks, fire protection walls, control cubicles, marshalling kiosks, auxiliary equipments, Control Room Cum Administrative building, GIS hall, Fire fighting Pump house, fire fighting water tanks, Auxiliary Building, Panel room, ,township buildings, Parking shed ,RCC retaining wall, or for any other equipment or service and any other foundation required to complete the work. This clause is as well applicable to the other RCC constructions.
2. Concrete shall conform to the requirements mentioned in relevant Indian Standard Codes (IS Codes)/ British standard codes (B S Codes)/ equivalent International Standards. And all the tests shall be conducted as per relevant British standard codes (B S Codes)/ equivalent International Standards. However, a minimum grade of M25 (design Mix) concrete shall be used for all foundations and structural/load bearing members as per relevant British standard codes (B S Codes)/ equivalent International Standards.
3. If the site is sloppy, the foundation height will be adjusted to maintain the exact level of the top of structures to compensate such slopes.
4. The switchyard foundation's plinths and building plinths shall be minimum 300mm and 500 mm above finished ground level respectively.
5. Minimum 75mm thick lean concrete (1:4:8) shall be provided below all underground structures, foundations, trenches etc. to provide a base for construction.
6. Concrete made with Portland slag cement shall be carefully cured and special importance shall be given during the placing of concrete and removal of shuttering.

7. The design and detailing of foundations shall be done based on the approved soil data and sub-soil conditions as well as for all possible critical loads and the combinations thereof. The Spread footings foundation or pile foundation as may be required based on soil/sub-soil conditions and superimposed loads shall be provided.
8. If pile foundations are adopted, the same shall be cast-in-situ driven/bored or pre-cast or under reamed type as per relevant parts of relevant British standard codes (B S Codes)/ equivalent International Standards. Only RCC piles shall be provided. Suitability of the adopted pile foundations shall be justified by way of full design calculations. Detailed design calculations shall be submitted by the contractor showing complete details of piles/pile groups proposed to be used. Necessary initial load test shall also be carried out by the bidder at their cost to establish the piles design capacity. Only after the design capacity of piles has been established, the Contractor shall take up the job of piling. Routine tests for the piles shall also be conducted. All the work (design & testing) shall be planned in such a way that these shall not cause any delay in project completion.

## 11.2 DESIGN

While designing foundations, following may be taken care of:

- 11.2.1. All foundations except for external lighting poles shall be of reinforced cement concrete. The external lighting pole shall be embedded in plain cement concrete (1:2:4) foundation. The design and construction of RCC structures shall be carried out as per relevant BS and minimum grade of concrete shall be M-25 (design Mix). Higher grade of concrete than specified above may be used at the discretion of Contractor without any additional financial implication to the NEA/Consultant.
- 11.2.2. Limit state method or any other method as per relevant Indian Standard (I.S.Codes) British standard codes (B S Codes)/ equivalent International Standards of design shall be adopted unless specified otherwise in the specification.
- 11.2.3. For detailing of reinforcement relevant Indian Standard (I.S.Codes)/BS followed. Cold twisted deformed bars conforming to relevant British standard codes (B S Codes)/ equivalent International Standards. Two layers of reinforcement (on inner and outer face) shall be provided for wall & slab sections having thickness of 150 mm and above. Clear cover to reinforcement shall be as per relevant British standard codes (B S

Codes)/ equivalent International Standards.

- 11.2.4. RCC water retaining structures like storage tanks, etc. shall be designed as uncracked section in accordance with relevant British standard codes (B S Codes)/ equivalent International Standards. However, water channels shall be designed as cracked section with limited steel stresses as per relevant BS.
- 11.2.5. The procedure used for the design of the foundations shall be the most critical loading combination of the steel structure and or equipment and/or superstructure and other conditions which produces the maximum stresses in the foundation or the foundation component and as per the relevant British standard codes (B S Codes)/ equivalent International Standards of foundation design. Detailed design calculations shall be submitted by the bidder showing complete details of piles/pile groups proposed to be used.
- 11.2.6. Design shall consider any sub-soil water pressure that may be encountered following relevant standard strictly.
- 11.2.7. Necessary protection to the foundation work, if required shall be provided to take care of any special requirements for aggressive alkaline soil, black cotton soil or any other type of soil which is detrimental/harmful to the concrete foundations.
- 11.2.8. RCC columns shall be provided with rigid connection at the base.
- 11.2.9. All sub-structures shall be checked for sliding and overturning stability during both construction and operating conditions for various combinations of loads. Factors of safety for these cases shall be taken as mentioned in relevant British standard codes (B S Codes)/ equivalent International Standards or as stipulated elsewhere in the Specifications. For checking against overturning, weight of soil vertically above footing shall be taken and inverted frustum of pyramid of earth on the foundation should not be considered.
- 11.2.10. Earth pressure for all underground structures shall be calculated using co-efficient of earth pressure at rest, co-efficient of active or passive earth pressure (whichever is applicable). However, for the design of substructures of any underground enclosures, earth pressure at rest shall be considered.
- 11.2.11. In addition to earth pressure and ground water pressure etc., a surcharge load of 2T/Sq.m shall also be considered for the design of all underground structures including channels, sumps, tanks, trenches,

substructure of any underground hollow enclosure etc., for the vehicular traffic in the vicinity of the structure.

- 11.2.12. Following conditions shall be considered for the design of water tank in pumps house, channels, sumps, trenches and other underground structures:
- a) Full water pressure from inside and no earth pressure & ground water pressure & surcharge pressure from outside (application only to structures which are liable to be filled up with water or any other liquid).
  - b) Full earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.
  - c) Design shall also be checked against buoyancy due to the ground water during construction and maintenance stages. Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the superimposed loadings.
- 11.2.13. Base slab of any underground enclosure shall also be designed for empty condition during construction and maintenance stages with maximum ground water table (GWT). Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the super-imposed loadings.
- 11.2.14. Base slab of any underground enclosure like water storage tank shall also be designed for the condition of different combination of pump sumps being empty during maintenance stages with maximum GWT. Intermediate dividing piers of such enclosures shall be designed considering water in one pump sump only and the other pumps sump being empty for maintenance.
- 11.2.15. The foundations shall be proportioned so that the estimated total and differential movements of the foundations are not greater than the movements that the structure or equipment is designed to accommodate.
- 11.2.16. The foundations of transformer/reactor and circuit breaker shall be of lock type foundation. Minimum reinforcement shall be governed by relevant British standard codes (B S Codes)/ equivalent International Standards.
- 11.2.17. The tower and equipment foundations shall be checked for a factor of safety as per relevant British standard codes (B S Codes)/ equivalent International Standards for two conditions i.e. Normal condition and



short circuit condition against sliding, overturning and pullout. The same factors shall be used as partial safety factor over loads in limit state design also.

### **11.3 ADMIXTURES & ADDITIVES**

- 11.3.1. Only approved admixtures shall be used in the concrete for the Works. When more than one admixture is to be used, each admixture shall be batched in its own batch and added to the mixing water separately before discharging into the mixer. Admixtures shall be delivered in suitably labelled containers to enable identification.
- 11.3.2. Admixtures in concrete shall conform to relevant Indian Standard (I.S.Codes)/British standard codes (B S Codes)/ equivalent International Standards. The water proofing cement additives shall conform to relevant BS. Concrete Admixtures/ Additives shall be approved by NEA/Consultant.
- 11.3.3. The Contractor may propose and the NEA/Consultant may approve the use of a water-reducing set-retarding admixture in some of the concrete. The use of such an admixture will not be approved to overcome problems associated with inadequate concrete plant capacity or improperly planned placing operations and shall only be approved as an aid to overcoming unusual circumstances and placing conditions.
- 11.3.4. The water-reducing setting-retarding admixture shall be an approved brand as per relevant British standard codes (B S Codes)/ equivalent International Standards.  
The water proofing cement additives shall be used as required/advised by NEA/Consultant.

### **12.0 CHAINLINK FENCING AND GATE**

#### **12.1 General**

Work covered under this clause comprises of design, drawing, supply, fabrication, erection, painting or galvanisation as specified etc of switch yard Fencing and gate, construction of foundation of steel posts and toe wall .While providing switch yard fencing and gate, Following points may be taken care of:

#### **12.2 Areas requiring Fencing**

- 12.2.1 Fencing shall be provided for complete switchyard as per drawing. Separate gate shall be provided for men and equipment.

- 12.2.2 Internal fence surrounding the various equipments (if) mounted on ground or a height lower than 2.5m. Necessary gates shall be provided for each area so surrounded.

**12.3 Product materials**

The minimum requirements are as follows:

Chain link fence fabric (galvanization) in accordance to relevant British standard codes (B S Codes)/ equivalent International Standards.

**12.4 Posts**

The posts shall be of medium M.S. tubes of 50mm diameter conforming to grade as per relevant international /BS standard. The tubes shall also conform relevant British standard codes (B S Codes)/ equivalent International Standards. The length of tubular post shall be 2600 mm.

An M.S. base plate of size 160 X 160 X 6mm thick shall be welded with the tubular post. The post shall be provided on the top with M S plate.

The tubular post shall be welded with 8 number of M S flat of size 50 x 6mm – 75mm long at suitable locations. Two number of 13.5 mm diameter holes on each cleats shall be provided to bolt the fence fabric panel. The cleats shall be welded at equal spacing in such a way that 4 numbers of cleats are on one side and remaining 4 cleats are on the opposite side of the post. The cleats on the corner posts shall be welded in such a way that it suits the site requirement.

The whole assembly of tubular post shall be hot dip galvanized. The zinc coating shall be minimum 610 gram per sq. meter. The purity of zinc shall be 99.95% as per relevant BS.

**12.5 Fence Fabric & Fence Panel**

Chain link fencing shall be made of 3.15 mm diameter wire with 75 X 75 mm mesh size. Fence fabric shall be electro-galvanised. Chain link fencing shall be fabricated in the form of panel 1300 X 2928 mm. An M.S. flat of at least 50x6 mm size shall be welded all-round fence fabric to form a panel. Four pairs of 13.5mm diameter holes on the vertical M S flat matching the spacing of holes in cleats fixed with pipe shall be provided to fix the fence panel with the tubular posts. A washer shall also be provided below each nut. The contractor, for fixing the panels, shall supply the 12mm diameter bolts including nuts and washers. All nuts, bolts and washers shall be hot dip galvanized.

The fence panel shall be provided with two or more coats of approved

standard Zinc paint over approved standard steel primer.

#### **12.6 Installation**

1. Fence shall be installed along the switchyard line as shown in the approved drawings.
2. Post holes shall be excavated by approved method.
3. All posts shall be 3.0m apart measured parallel to ground surface.
4. Posts shall be set in 1:2:4 Plain Cement Concrete block of minimum 0.40x0.40x1.2m depth. 75mm thick plain cement concrete 1:4:8 shall be provided below concrete blocks. Posts shall be braced and held in plumb position and true alignment and elevation until concrete has set.
5. Fence fabric shall not be installed until concrete has cured a minimum of 7 days.
6. Fence fabric panel shall be fixed to the post at 4 nos. MS flat each of 50x6, 75 long through 2 nos. of bolts (12mm diameter) on each flat.

#### **12.7 Gate**

1. The gate shall be made of medium duty M.S. pipe conforming to relevant I.S. with welded joints. The main frame (outer frame) of the gate shall be made of 40mm dia pipe and vertical pipes of 15mm dia @ 125mm spacing (maximum) shall be welded with the main frame. Two number of 1.25 mm thick and 125 mm wide MS plates (Horizontal) @ 500 mm centre to centre distance shall be welded on each gate leaf. Gate leaves shall be fixed with a vertical post of 2700 mm long two steel channels-150 welded together. A 8 mm thick 200X 200 mm size MS plate shall be welded at the bottom of channel frame.
2. The gates shall be fabricated with welded joints to achieve rigid connections. The gate frames shall be painted with one coat of approved steel primer and two coats of synthetic enamel paint.
3. The gates shall be provided with suitable locking arrangement welded on 4 mm thick MS plate on the gate leaf.
4. The main gate shall be 5.0m wide and shall be of double leaf type (as shown in the drawing). Next to the main gate, a men gate (1.25m wide single leaf) shall also be provided.
5. Steel roller shall be provided with the gate.
6. Gate shall be installed in location as shown in approved G.A. drawing.
7. The vertical post of gate shall be embedded in PCC foundation of 500 X500X1250 mm deep size.

## **13.0 BUILDINGS**

### **13.1 GENERAL**

The scope includes the design, drawing, engineering and construction including anti-termite treatment, plinth protection, DPC of Building including sanitary, water supply, electrification, false ceiling etc as applicable ,complete of control room building,fire fighting building, Auxiliary building and panel room. Electrification and air conditioning of building shall be provided as detailed in other sections of electrical portion.

### **13.2 CONTROL ROOM CUM ADMINISTRATIVE BUILDING**

#### **GENERAL**

Design of control room building has already been finalised. Architectural drawings are attached along with Tender drawing however structural drawing shall be provided to contractor after award of work. The scope includes construction, including anti-termite treatment, plinth protection, DPC, peripheral drains, water supply, plumbing, sanitation, fire-fighting, electrification etc. of Control Room Building.

The Control Room Building shall be of size 20 m X 25 m approximately. It will be a double storeyed RCC Framed structure if constructed separately away from GIS hall. It shall be so designed that most of the area of switchyard is visible from the Control Room.

The building auxiliary services like air conditioning systems, fire protection and detection systems and all other miscellaneous services shall be designed in accordance with the requirements as specified in relevant section or elsewhere in this Specification. The building shall be constructed as per the design and drawings to be developed by the contractor. Tentative carpet area requirement for different rooms of control room cum administrative building is given as below for guidance to the contractor:

#### **AREA REQUIREMENTS**

- |                    |                                 |
|--------------------|---------------------------------|
| • Control Room     | 37 sq.m.                        |
| • ACDB & DCDB Room | 145 Sq.M or As per requirement. |
| • Battery Room     | 48 Sq. M or As per requirement. |
| • Electrical Lab   | 23 sq.m.                        |

• Conference Room with attached Toilet	33 sq.m.
• Telecom Room	As per requirement
• S/S-In-charge office with attached Toilet	27 sq.m.
• Room for executives	55 sq.m.
• Room for non-executives	40 sq.m.
• Lobby -Reception	25 sq.m.
• Corridor width	Minimum width of corridor shall be 1800 mm.
• Portico	25 sq.m. (approx.).
• Common Toilet-Men	07 sq.m.
• Toilet for Women	4 sq.m.
• Janitor Room	3 sq.m.
• Pantry	7 sq.m.
• Provision of shaft for electrical, sanitary, water supply facilities shall also be kept.	

### 13.3 DESIGN CRITERIA

The Building shall be designed:

- i. To the requirements of the International standards/British Standards for the specified climatic and loading conditions.
- ii. 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.
- iii. with a functional and economical space arrangement.
- iv. To be aesthetically pleasing. Different buildings shall show a uniformity and consistency in architectural design, as far as possible.
- v. To allow for easy access to the equipments as well as maintenance of the equipments.
- vi. Wherever access to the roof is required, RCC stair case shall be provided.
- vii. 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.
- viii. Suitable Expansion joints, wherever required, shall be provided as per Codal Provisions.
- ix. With the FFL, Building shall be 750 mm above finished ground level or as

mentioned in the tender drawings.

x. All the members of the buildings frame shall be designed for the worst combination of loads as per relevant British standard codes (B S Codes)/ equivalent International Standards.

xi. Permissible stresses for different load combinations shall be taken as per relevant Indian Standard Codes (IS Codes)/British standard codes (B S Codes)/ 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 Indian Standard Codes (IS Codes)/British standard codes (B S Codes)/ equivalent International Standards.

xiii. All the structures and its component must be designed and detailed as per latest BIS Standard/Indian Standard Codes incorporating ductile detailing. List of reference codes e.g. IS 456-2000 (latest), IS:875 all parts, IS 1893 all parts, IS 4326. IS13920, SP34 etc.

xiv. RCC columns shall be provided with rigid connection at the base.

xv. The design of Steel Structure for Pre-Engineered Building shall be done in accordance with IS:800-2007 with Limit state method or elsewhere mentioned in Section Project.

xvi. Limit State method of concrete design shall be adopted unless specified otherwise in the specification.

xvii. Clear cover to reinforcement shall be as per IS:456 (Latest).

xviii. Expansion joint wherever necessary with the provision of twin columns shall be as per the provisions of relevant IS or international codes.

xix. Any sub soil water encountered at founding level, same shall be considered in the design.

xx. For maintaining adequate air pressure inside GIS Halls, following measures needs to be adopted:-

- (a) Elastomeric sealant to be provided at door/windows junction with walls, duct entry points, roof joints, etc to check any air leakages.
- (b) Cable sealing system shall be provided at the cable entry points.
- (c) Mats to be provided at cable trenches to reduce air leakage.
- (d) External doors shall be inward opening.

(e) Providing of air lock lobby for separating the inside area of GIS hall.

#### 13.4 DESIGN LOADS

1. Building structure shall be designed for the most critical combinations of dead loads, super-imposed loads, equipment loads, erection loads, wind loads, seismic loads etc. Any other incidental load, if anticipated, shall be duly accounted for in the design, and shall be clearly mentioned by the bidder.
2. Dead loads shall include the weight of structures complete with finishes, fixtures and partitions, and shall be taken as per relevant British standard codes (B S Codes)/ equivalent International Standards.
3. Super-imposed loads in different areas shall include live loads, minor equipment loads, cable trays, small pipe racks/hangers and erection, operation and maintenance loads, wherever these loads are expected. Equipment loads shall constitute, if applicable, all load of equipments to be supported on the building frame.

AREA	Load
1. For Offices.	5.0 kN/m <sup>2</sup>
If higher than 5.0 kN/m <sup>2</sup> .	As per actual Requirement.
2. For Equipment Floors.	10.0 kN/m <sup>2</sup>
If higher than 10 kN/m <sup>2</sup> (Based on Equipment weight and layout plans).	As per actual Requirement.
3. Staircases & Balconies.	5.0 kN/m <sup>2</sup>
4. Toilets.	2.0 kN/m <sup>2</sup>
5. Chequered Plate.	4.0 kN/m <sup>2</sup>
6. Cooridoors/Walkways.	3.0 kN/m <sup>2</sup>
7. Accessible Roofs.	1.5 kN/m <sup>2</sup>
8. Non-accessible Roofs.	0.75 kN/m <sup>2</sup>

4. Wind loads shall be calculated as per relevant British standard codes (B S Codes)/ equivalent International Standards. The Factors affecting the wind speed shall be taken based on the site conditions.
5. Earthquake loads shall be calculated as per relevant British standard codes (B S Codes)/ equivalent International Standards.

6. Wind forces and Seismic forces shall not be considered to act simultaneously.
7. All the load combinations to create worst combinations of loads shall be as per relevant International standards/British Standards.
8. Floors/ Slabs shall be designed to carry loads imposed by equipments, cables, piping, movement of maintenance trucks (if required) and any other load associated with the building. In general, floors shall be designed for live loads as per relevant British standard codes (B S Codes)/ equivalent International Standards. Cable and piping loads shall also be considered in addition to the live loads for floors where these loads are expected.

### **13.5 FLOORS, WALLS & ROOFS**

1. Exterior of CRB and Switch Yard Panel Room shall have brick work as per traditional Nepali/Newari Architecture of small Dachi Appa (Special Nepali traditional brick) including duracell silicon base thinner paint and anchoring with inside wall (if required) and shall have traditionally decorated Tundal (4' to 6' long) and Kassimo (Cornice Brick). Type of jointing materials such as Lime Surkhi-Sand or Cement-Sand mortar shall be approved before construction of wall and also design and material of pointing works shall be approved.

Exterior walls of Township quarters, Fire fighting pump house and Fire fighting water tank shall have machine made brick work with approved design and material of pointing works including duracell silicon base thinner paint on exterior surface.

2. All walls shall be non-load bearing in filled panel walls, in brickwork as per the specification. Minimum thickness of external walls shall be 230 mm (one brick) with 1:6 cement sand mortar. Partition walls if any shall be of 115 mm thick brick masonry in cement sand mortar (1:4). Horizontal bands at plinth, lintel, sill, roof, gable etc. of walls are as per NBC 202:1994.

3. All Floor/Roof slabs shall be regular beam slab construction. However, sunken RCC slab shall be provided in toilet areas as per the requirement.

4. False ceiling as per requirement shall be provided as detailed in Table-1 (Detailed Finish Schedule).

5. Minimum height of skirting above finished floor level shall be 150 mm. The skirting material shall match with the floor finish.

6. Minimum height of the parapet walls shall be 750 mm.

7. Ground floor finish shall be laid over 20 mm thick cement sand mortar, 100 mm thick plain cement concrete (PCC) 1:4:8 (1 cement: 4 sand : 8 stone aggregates), 100 mm thick local sand filling. The earth below ground floor shall be well rammed before laying sand filling.

8. First floor details shall comprise of finish as per schedule, 20 mm cement sand mortar and 50 mm thick PCC(1:4:8) over RCC slab.

### **13.6 DETAILS OF ROOF**

Roof of the Building shall consist of Cast-in-situ RCC slab treated with a water proofing system which shall be an integral cement based treatment conforming



to relevant British standard codes (B S Codes)/ equivalent International Standards. The water proofing treatment shall be of following operations:

(a) Applying and grouting a slurry coat of neat cement using 2.75 kg/m<sup>2</sup> of cement admixed with proprietary water proofing compounds conforming to relevant British standard codes (B S Codes)/ equivalent International Standards. Over the RCC slab including cleaning the surface before treatment.

(b) Laying cement concrete using broken stone of size from 25mm to 100mm size with 50% of cement mortar 1:5 (1 cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to relevant British standard codes (B S Codes)/ equivalent International Standards over 20mm thick layer of cement mortar of min 1:5 (Cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to relevant British standard codes (B S Codes)/ equivalent International Standards to required slope and treating similarly the adjoining walls up to 300mm height including rounding of junctions of walls and slabs.

(c) After two days of proper curing applying a second coat of cement slurry admixed with proprietary water proofing compound conforming relevant British standard codes (B S Codes)/ equivalent International Standards.

(d) Finishing the surface with 20mm thick joint less cement mortar of mix 1:4 (1 cement: 4 coarse sand) admixed with proprietary water proofing compound conforming to relevant British standard codes (B S Codes)/ equivalent International Standards and finally finishing the surface with trowel with neat cement slurry and making of 300 x 300 mm square.

(e) The whole terrace so finished shall be flooded with water for a minimum period of two weeks for curing and for final test. All above operations to be done in order and as directed and specified by the Engineer-in-charge.

(f) Average thickness of water proofing shall be 120 mm and minimum thickness at khurra shall be 65 mm.

### **13.7 PARTITIONS**

Partitions wherever provided, shall be made of powder coated aluminum frame provided with 5.5 mm thick clear glass or pre-laminated board depending upon the location of partition.

### **13.8 PLASTERING**

Outer walls of Control Room Building shall not require plastering due to provision of Modular Bricks as per Nepal Outlook.

Inside wall surfaces shall have 12/15 mm thick 1:6 cement sand plaster. Rough surfaces shall have 15mm and smooth surface shall have 12 mm thick cement sand plaster.

All RCC ceilings shall be provided with 6 mm thick cement sand (fine) plaster (1:3) except for areas with false ceiling.

### **13.9 EXTERNAL PAINTING**

External surfaces of the Control Room Building shall be made as per requirement

of Nepal Outlook.

#### **13.10 DOORS, WINDOWS AND VENTILATORS**

The schedule of doors, windows and ventilators of the Control Room Building shall be as per the detailed finish schedule given in Table-1 (Detailed Finish Schedule), and shall conform to the relevant British standard codes (B S Codes)/ equivalent International Standards. Rolling Steel shutters shall be provided as per the layout and requirements of the building. Main entrance door to control room building shall be made of powder coated aluminium frame with 5.5 mm thick glazing.

#### **13.11 CABLE TRENCH INSIDE CONTROL ROOM BUILDING**

All cable trenches inside the Control Room Building shall be covered with minimum 6mm thick steel chequered plate with suitable stiffeners.

#### **13.12 PLINTH PROTECTION**

750 mm wide and 50 mm thick plain cement concrete 1:2:4 (1 cement:2 sand:4 graded 20 mm nominal size stone aggregate ) shall be laid over 75 mm thick dry stone aggregates well rammed and consolidated with interstices filled with local sand including smooth finishing top.

#### **13.13 PLUMBING & SANITATION**

1. All plumbing and sanitation works shall be executed to comply with the requirements of the appropriate bye-laws, rules and regulations of the Local Authority having jurisdiction over such matters. The Contractor shall arrange for all necessary formalities to be met with regards to the inspection, testing, obtaining approval and giving notices etc.

2. 'SINTEX' or an equivalent make PVC Roof water tank(s) of adequate capacity depending on the number of users for 24 hours storage shall be provided. However, a minimum of 2 nos. 1500 liter capacity shall be provided.

3. Chlorinated Polyvinyl chloride (CPVC) pipes having thermal stability for hot and cold water supply including all CPVC plain and brass threading conforming to relevant British standard codes (B S Codes)/ equivalent International Standards shall be used for internal piping works for water supply.

4. Sand C.I. pipes with lead joints conforming to relevant British standard codes (B S Codes)/ equivalent International Standards shall be used for sanitary works above ground level and RCC pipes shall be used for sanitary works below ground.

5. Each toilet shall have the following minimum fittings:

(i) WC (Western type) 390 mm high along with toilet paper roll holder and all other fittings, in toilets attached to conference room and S/S In-charge office; and WC (Indian Type) Orissa Pattern (580 x 440 mm) with all fittings shall be provided in common toilets.

(ii) Urinal (430 x 260 x 350 mm size) with all fittings and built-in-sensor for automatic flush after use.

- (iii) Wash basin (550 x 400 mm) with all fittings.
- (iv) Bathroom mirror (600 x 450 x 6 mm thick) with hard board backing.
- (v) CP brass towel rail (600 x 20 mm) with CP brass brackets.
- (vi) Soap holder and liquid soap dispenser.
- (vii) Automatic Hand Dryer.

6. Water cooler for drinking water with adequate water storage facility shall be provided which shall preferably be located near pantry and away from the toilet block.

7. One no. stainless steel kitchen sink with Drain board (510 x 1040 x 178 mm bowl depth) for pantry shall be provided.

8. All fittings, fasteners, gratings shall be chromium plated.

9. All sanitary fixtures and fittings shall be of approved quality and type, manufactured by reputed manufacturers. All items brought to site must bear identification marks of the Manufacturer.

10. Contractor shall provide necessary nos. of septic tank and soak pit of adequate capacity to treat the sewage/sullage from the buildings.

11. Contractor shall undertake all other activities required to complete and commission the building.

#### **13.14 BUILDING STORM WATER DRAINAGE**

1. The building design shall provide for the collection of storm water from the roof. This water shall be drained to the main drainage system of the Sub-station.

2. Cast Iron Rainwater down comer pipes conforming to relevant International standards/British Standards with water tight lead joints or medium class galvanized mild steel pipes conforms to relevant British standard codes (B S Codes)/ equivalent International Standards shall be provided to drain off the rain water from the roofs. These pipes shall be suitably concealed with masonry work or cement concrete or cladding material. The number and size of down comer pipes shall be governed by relevant British standard codes (B S Codes)/ equivalent International Standards.

3. All drains inside the buildings shall have minimum 40 mm thick grating covers; and in areas where heavy equipment loads are envisaged, Pre-Cast RCC covers shall be provided in place of steel grating.

4. Suitable arrangements for draining out water collected from equipment blow downs, leakages, floor washings, fire fighting etc. shall be provided for each floor.

#### **13.15 DETAILED FINISH SCHEDULE**

The detailed finish schedule for Control Room Building Cum Administrative building is given below:

**Table- 1: DETAILED FINISH SCHEDULE**

Sl. No.	LOCATION	FLOORING & SKIRTING 150 MM HIGH	WALL(INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
1.	Control Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of 10mm thick toughened glass by using suitable patch fittings/spider fittings. The glass shall extend horizontally from column to column and vertically from sill level of 0.75 m to bottom of lintel/roof beam. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
2.	Conference Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing
3.	S/S In-charge Room.	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
4	Office Rooms	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
5.	Electrical/Electronic Test Lab./Telecom Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
6.	ACDB & DCDB Room	62mm thick cement concrete flooring with metallic hardener topping. Skirting shall be of cement sand plaster.	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool. Windows/ventilator shall be of powder coated aluminium with 4mm glazing.
7.	Battery Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with	White wash above False Ceiling*	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool.

Sl. No.	LOCATION	FLOORING & SKIRTING 150 MM HIGH	WALL(INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
			plaster of paris (2 mm thick)		Windows/ventilator shall be of powder coated aluminium with 4mm glazing.
8.	Reception/Lobby	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
9.	Corridor	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminum doors with 5.5.mm thk. Glazing.
10.	Portico	Cast-in-situ 52mm thk. Cement concrete with metallic hardener .	Granite cladding	Oil bound washable distemper on smooth surface applied with plaster of paris putty	All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
11.	Toilet	Ceramic tiles	DADO glazed tile 2100mm high, oil bound washable distemper above DADO	Oil bound washable distemper	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters made of pre-laminated particle board with powder coated aluminium frame.
12.	Janitor room	Ceramic tiles with white cement	Vitrified tiles 8mm thick size 600 x 600mm	Oil bound washable distemper	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters made of pre-laminated particle board with powder coated aluminium frame.
13	Main Door of Control Room Building (CRB)				Main door of the Control building shall be of wood carved(local look) with designed with necessary fittings.

\*Providing and fixing 15mm thick approximately 600 X 600mm Mineral fiber board panel false ceiling and making cut-outs for electrical fixtures, AC diffusers,

openable access etc complete with silhouette profile system with 15mm wide flange incorporating 6mm central recess white / black main runners at 1200mm centre-centre and not greater than 600mm from the adjacent wall. The cross tees shall be provided to make a module of approximately 600mm X 600mm by fitting 600 mm long cross tees centrally placed between 1200 mm long cross tees .Cross tees also have 15mm wide flange incorporating 6mm central recess white/black. The module formed above shall be anchored to the slab with channels or angles, suspenders as per manufacturer's specifications.

#### **13.16 SUBMISSIONS**

The following information/documents/drawings shall be submitted for review and approval:

1. Structural design calculations already finalized which shall be provided to contractor after award of work. However contractor shall reproduce/arrange fresh submission of all the drawings with contract details and fresh Title for record purpose, both in hard and soft copies, for all reinforced concrete, structural steel structures, other Civil works.
2. Fully dimensioned and detailed floor plans, cross-sections, longitudinal sections and elevations identifying the major building components.
3. Product information of building components and materials, including walls, partitions, flooring, ceilings, roofing, doors, wall paneling and windows and building finishes along with BOQ.
5. A detailed schedule of building finishes including colors schemes along with item description.
6. A door & window schedule showing door & window types and locations, lock sets and latch sets and other door hardware along with item details.

Approval of the above information shall be obtained before ordering materials or starting construction/fabrication, as applicable.

#### **13.17 FALSE CEILING**

Providing and fixing seamless ceiling with Gypsum board of 12mm thick fixed to the underside of GI frame work. The GI is fixed to the roof Slab with metal expansion fastener. The joint shall be finished with joint paper tape by using jointing Compound recommended by manufacturer with the approval of NEA/Consultant. The rate includes for all necessary cutting of ceiling for the fixing of complete fixtures.

#### **13.18 Under deck Insulation**

The method of fixing shall consist of slotted M.S. angles of appropriate size (minimum 65x50x2mm) fixed to soffit of RCC roof slab at 600mm centres in both directions by Rawl plugs of adequate strength. The slots shall have 14g G.I. tie

wire drawn through them.

50mm thick insulation mat Fibreglass Crown - 100 or equivalent shall, be made out of fibre-glass or approved equivalent conforming to IS: 8183, backed with 34g aluminium foil and 22g x 12mm mesh wire netting. The net shall be stretched tightly across the slotted angles or slotted plates holding it in place by means of wires. The joints of the wire netting shall be butted and tightly laced down with 14g G.I. wire. The system shall be got approved from NEA/Consultant.

### **13.19 ELECTRIFICATION**

All electrification shall be executed as per details specified elsewhere in the technical specification. All details shall be as per relevant British standard codes (B S Codes)/ equivalent International Standards.

## **14.0 FIRE FIGHTING PUMP HOUSE BUILDING**

### **GENERAL**

Design of Fire Fighting Pump House building has already been finalised. Architectural drawings are attached along with Tender drawing however structural drawing shall be provided to contractor after award of work. The scope includes and construction, including anti-termite treatment, plinth protection, DPC, peripheral drains, fire-fighting, electrification etc. of fire fighting pump house building. Minor structure like Pump Foundation and inside cable trenches etc shall be designed by contractor.

The fire fighting pump house building shall be essentially single storied reinforced cement concrete (RCC) framed Building. The building auxiliary services like internal electrification, fire protection systems shall be designed in accordance with the requirements as specified in relevant section of technical Specification. The design and layout of foundation of various pumps and cable trenches inside building shall be prepared by the contractor as per requirement of proposed fire fighting system.

### **AREA REQUIREMENTS**

Dimensions of the Building already available in finalized Architectural Drawing. Contractor shall check for accommodating the Pumps, Pipes and accessories along with operating panels in the building.

### **DESIGN CRITERIA**

Design criterion considered for FFPH Design are produced below:

The Building shall be designed:

1. To the requirements of the relevant/British standards/ equivalent International standards quoted therein, and as specified in this specification.
2. for the specified climatic and loading conditions.

3. To adequately suit the requirements of the pumps and fire fighting system contained in the buildings and in all respects to be compatible with the intended use and occupancy.
4. with a functional and economical space arrangement.
5. To be aesthetically pleasing. Different buildings shall show a uniformity and consistency in architectural design, as far as possible.
6. To allow for easy access to the equipment's as well as maintenance of the equipments.
7. G.I. ladder with cage shall be provided for access to the roof.
8. With, wherever required, fire retarding materials for walls, ceilings doors etc., which would prevent supporting or spreading of fire and shall be decided by the bidder.
9. Suitable Expansion joints, wherever required, shall be provided as per Codal Provisions.
10. All the members of the buildings frame shall be designed for the worst combination of Loads as per relevant International standards/British Standards.
11. Permissible stresses for different load combinations shall be taken as per relevant International standards/British Standards.
12. Seismic analysis of the building for Earthquake forces shall be carried out as per relevant International standards/British Standards.

#### **DESIGN LOADS**

1. Building structure shall be designed for the most critical combinations of dead loads, super-imposed loads, equipment loads, wind loads, seismic loads etc. Any other incidental load, if anticipated, shall be duly accounted for in the design, and shall be clearly mentioned by the bidder.
2. Dead loads shall include the weight of structures complete with finishes, fixtures and partitions, and shall be taken as per relevant International standards/British Standards.
3. Super-imposed loads in different areas shall include live loads, cable trays, and small pipe racks/hangers, piping system and erection, operation and maintenance loads wherever these loads are expected.
- 1) Non-accessible Roof – 0.75 kN/m<sup>2</sup>.
- 2) Accessible Roof – 150 kN/m<sup>2</sup>
4. Wind loads shall be calculated as per relevant International standards/British Standards. The Factors affecting the wind speed shall be taken based on the site conditions.
5. Earthquake loads shall be calculated as per relevant International standards/British Standards.



6. Wind forces and Seismic forces shall not be considered to act simultaneously.
7. All the load combinations to create worst combinations of loads shall be as per relevant International standards/British Standards.
7. Floors shall be designed to carry loads imposed by Pumps, cables, piping, movement of maintenance trucks (if required) and any other load associated with the building. In general, floors shall be designed for live loads as per relevant International standards/British Standards. Cable and piping loads shall also be considered in addition to the live loads for floors where these loads are expected.

## **WALLS & FLOORS**

External brick layer shall be of machine made brick with use of cement-sand mortar with with approved design and material of pointing work including duracell silicon base thinner paint on exterior surface of approved quality and and free from grit and other impurities such as lime, iron and other deleterious salts, conforming NS 1 2035/ IS code (latest revision). These shall be well-burnt, sound, and hard with sharp edges and shall emit ringing sound when struck with a mallet. These shall be of uniform size. The size of the bricks shall be 24.0cm x 11.2cm x 5.7cm unless otherwise specified, with a tolerance of  $\pm 3$ mm in each direction. The compressive strength should be more than  $3.5\text{N/mm}^2$ .

The floor shall be constructed with 52 mm thick cement concrete finished with metallic hardener topping. 150 mm thick base plain cement concrete layer, 100 mm thick compacted local sand filling and 200 mm thick hard core of stone ballast with interstices filled with local sand shall be laid below cement concrete flooring top. The earth filling below floor shall be well rammed.

## **PLASTERING**

Outer walls of Control Room Building shall not require plastering due to provision of Modular Bricks as per Nepal Outlook.

Inside wall surfaces shall have 12/15 mm thick 1:6 cement sand plaster. Rough surfaces shall have 15mm and smooth surface shall have 12 mm thick cement sand plaster.

All RCC ceilings shall be provided with 6 mm thick cement sand (fine) plaster (1:3) except for areas with false ceiling.

## **EXTERNAL PAINTING**

External surfaces of the FFPH Building shall be made as per requirement of Nepal Outlook .

### **EXTERNAL PAINTING**

External surfaces of the Building shall be painted with acrylic exterior flat paint as per manufacturer's specification and approval of NEA/Consultant.

### **DOORS, WINDOWS AND VENTILATORS**

The schedule of doors, roller shutter, windows and ventilators of the Building shall be of steel as per relevant International standards/British Standards. Rolling Steel shutters shall be provided as per the layout and requirements of the building. Main entrance door to the Building shall be MS door frame with M.S. sheet double shutter. Windows and ventilators shall be of steel made of hot rolled sections windows and ventilators shall be provided with 5.5 mm thick glazing.

### **CABLE TRENCH INSIDE FIRE FIGHTING PUMP HOUSE BUILDING**

All cable trenches inside the building shall be covered with minimum 6 mm thick steel chequered plate with suitable stiffeners. The structural steel used for cable tray support, earthing cleat, chequered plates for internal cable trenches of fire fighting pump house building shall be measured and paid under miscellaneous steel item of BPS

### **PLINTH PROTECTION**

750 mm wide plinth protection all-around the building shall be provided. Plinth protection shall comprise of 50 mm thick PCC (1:2:4) laid over 75 mm thick well compacted stone aggregates with interstices filled with local sand including smooth finishing top.

### **PARAPET**

230 mm thick and 500 mm high brick parapet shall be provided. The parapet shall be plastered with cement sand plaster (1:6).

### **BUILDING STORM WATER DRAINAGE**

1. The building design shall provide for the collection of storm water from the roof. This water shall be drained to the main drainage system of the Sub-station.
2. Cast Iron Rainwater down comer pipes conforming to relevant International standards/British Standards with water tight lead joints or medium class galvanized mild steel pipes conforms to relevant International standards/British Standards shall be provided to drain off the rain water from the roofs. These pipes shall be suitably concealed with masonry work or cement concrete or cladding material.
3. Suitable arrangements for draining out water collected from equipment blow downs, leakages, floor washings, fire fighting etc. shall be provided, if found necessary.

### **DETAILS OF ROOF**

Roof of the Building shall consist of Cast-in-situ RCC slab treated with a water proofing system which shall be an integral cement based treatment conforming

to relevant International standards/British Standards. The water proofing treatment shall be of following operations:

(a) Applying and grouting a slurry coat of neat cement using 2.75 kg/m<sup>2</sup> of cement admixed with proprietary water proofing compounds conforming to relevant International standards/British Standards over the RCC slab including cleaning the surface before treatment.

(b) Laying cement concrete using broken stones 25mm to 100mm size with 50% of cement mortar 1:5 (1 cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to relevant International standards/British Standards over 20mm thick layer of cement mortar of min 1:5 (Cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to relevant International standards/British Standards to required slope and treating similarly the adjoining walls up to 300mm height including rounding of junctions of walls and slabs.

(c) After two days of proper curing applying a second coat of cement slurry admixed with proprietary water proofing compound conforming to relevant British standard codes (B S Codes)/ equivalent International Standards. (d)

Finishing the surface with 20mm thick joint less cement mortar of mix 1:4 (1 cement: 4 coarse sand) admixed with proprietary water proofing compound conforming to relevant International standards/British Standards and finally finishing the surface with trowel with neat cement slurry and making of 300 x 300 mm square.

(e) The whole terrace so finished shall be flooded with water for a minimum period of two weeks for curing and for final test. All above operations to be done in order and as directed and specified by the Engineer-in-charge.

(f) Average thickness of water proofing shall be 120 mm and minimum thickness at khurra shall be 65 mm.

#### **DETAILED FINISH SCHEDULE**

The detailed finish schedule for Fire Fighting Pump House Building is given below:

**Table- 2 : DETAILED FINISH SCHEDULE**

S.N	LOCATION	FLOORING & SKIRTING 150 MM HIGH	WALL(INTER NA L)	CEILING	ROLLER SHUTTER,DOOR, WINDOWS & VENTILATOR
1.	Fire Fighting Pump House	62mm thick cement concrete flooring with metallic hardener topping .skirting shall be of cement sand plaster.	Oil bound washable distemper on masonry portion.	As per Manufactu rer details.	Windows/ ventilator shall be hot rolled steel section with 5.5mm thick glazing. Entry door shall be of M.S. Sheet double shtter and rolling shutter shall be of steel.

## **ELECTRIFICATION**

All electrification shall be executed as per details specified elsewhere in the technical specification. All details shall be as per relevant British standard codes (B S Codes)/ equivalent International Standards.

### **15.0 AUXILLIARY BUILDING**

Auxiliary building shall be single storeyed reinforced cement concrete framed structure building. The size of building shall be about 15 m X 20 m approximately. However, bidder may suggest suitable size as per his requirement. The building shall house 11 kV indoor switchgear.

The details like floor details, door, windows, ventilator, internal finish details etc shall match with respective room of RCC control room building. External finish shall also match with control room building.

1. Contractor shall develop the layout in such a way that its aesthetic look is pleasant. The design of Auxiliary building shall be carried out as per relevant International standard/British Standards.
2. The internal cable trenches, panel etc shall be designed by the contractor as per requirement. Layout of these cable trenches, panel layout shall also be prepared by the contractor as per requirement.

#### **CABLE TRENCH INSIDE AUXILLIARY BUILDING**

All cable trenches inside the building shall be covered with minimum 6 mm thick steel chequered plate with suitable stiffeners. The structural steel used for cable tray support, earthing cleat, chequered plates for internal cable trenches shall be measured and paid under miscellaneous steel item of BPS.

## **ELECTRIFICATION**

All electrification shall be executed as per details specified elsewhere in the technical specification. All details shall be as per relevant British standard codes (B S Codes)/ equivalent International Standards.

### **16.0 FIRE FIGHTING WATER TANK**

1. Reinforced cement concrete water tank with two compartments each of size 9.31 m X 9.31 m and capacity of 317 Cubic Meter shall be constructed. A sump of size 2.5 m X 2.5 m x 0.5 m deep shall be provided at one corner in each compartment. Finished floor level of water tank shall be about 200 mm above finished ground level of switch yard. Base slab of water tank shall rest on 75 mm thick plain cement concrete (1:3:6) laid over 800 mm thick well compacted stone packing (Stone Size from 25 mm to 150 mm ) with interstices filled with local sand.
2. The roof of Water tank shall be of Asbestos Corrugated sheet. The sheet shall be supported on suitable steel purlins etc. Suitable gutter shall be provided to drain off rain water.

3. A steel door of size 900 mm X 1850 mm with single shutter made of hot rolled steel section and MS steel door frame shall be provided at about (+) 4.5 m level for access inside water tank.
4. Suitable MS rungs of 20 mm diameter rod @ 300 mm centre to centre staggered on both faces (External and internal) of wall at suitable location shall be provided to act as ladder.
5. Integral water proofing compound of reputed brand shall be added to the concrete and plaster of water tank. Quantity of compound shall be as per manufacturer's recommendation.
6. All inserts, nozzles, pipe sleeves etc shall be provided during concreting at suitable locations as per fire fighting system. The size is to be decided by the contractor to meet the requirement.
7. Inside surfaces of water tank shall be plastered with cement sand plaster (1 Cement: 6 sand).
8. The outer surface of water tank shall be painted with the paint matching with Fire fighting pump house building.
9. P.V.C. water stopper shall be provided at all construction joints of water tank.
10. The design of water tank shall be carried out as per relevant British standard codes (B S Codes)/ equivalent International Standards.

## **17.0 SWITCH YARD PANEL ROOM**

Design of Switchyard Panel Room building has already been finalised. Architectural drawings are attached along with Tender drawing however structural drawing shall be provided to contractor after award of work. The scope includes and construction, including anti-termite treatment, plinth protection, DPC, peripheral drains, fire-fighting, electrification etc. of Switchyard Panel Room. Minor structure like inside cable trenches, Air Conditioner Foundation etc shall be designed by contractor.

RCC switchyard panel room with the size as per attached Architectural Drawing shall be constructed. RCC sloped roof shall be provided. The sloped roof shall be covered with suitable tiles to enhance aesthetic look. The floor details (sand, PCC, cement mortar) shall match with that of other buildings. The floor finish shall be provided with vitrified tiles. Plinth protection as per other buildings. The finish details like painting, plaster shall match with other buildings. Doors shall be aluminium glazed.

Switchyard Panel Room Building shall have brick work as per Nepali/Newari Architecture. Accordingly for exterior walls, Brick work shall be comprising of two layer, inner side brick work shall be of normal brick and exterior brick layer shall be of Nepali Traditional Brick (small DachiAppa). Type of jointing materials such as Lime Surkhi-Sand or Cement-Sand mortar shall be approved before construction of wall and also design and material of pointing works shall be approved including duracell silicon base thinner paint on exterior surface. All

walls, floor and roof shall be provided with suitable chicken wire mesh which shall be connected with earthing system through 75 x 12 mm MS flat. Air conditioning and internal electrification of panel room shall be done as mentioned in respective technical specification and BPS in Electrical portion. The size and layout of internal cable trenches of panel room shall be decided by the contractor as per requirement. All cable trenches inside the panel room shall be covered with minimum 6 mm thick steel chequered plate with suitable stiffeners. The structural steel used for cable tray support, earthing cleat, chequered plates for internal cable trenches shall be measured and paid under miscellaneous steel item of BPS

### **PLASTERING**

Outer walls of Control Room Building shall not require plastering due to provision of Modular Bricks as per Nepal Outlook.

All RCC ceilings shall be provided with 6 mm thick cement sand (fine) plaster (1:3) except for areas with false ceiling.

### **UNDER GROUND WATER TANK**

Underground RCC water tank of specified capacity and quantity is to be constructed as per standard approved design and quality including pumping, supply and distribution facilities. Integral water proofing compound of reputed brand shall be added to the concrete and plaster of water tank. Quantity of compound shall be as per manufacturer's recommendation. When the construction of the reservoir is completed, and before the filling of any earthen embankment unless otherwise specified, it shall be tested for water tightness as directed by the Engineer.

### **EXTERNAL PAINTING**

External surfaces of all the building structures shall be made shining with appropriate material keeping Nepali cultural outlooks.

### **18.0 CAR PARKING SHED**

Aesthetically pleasant RCC car parking shed as per design and drawings as developed by the contractor and suitable to park 10 cars shall be constructed at suitable location to be decided during detailed engineering stage

### **19.0 WATER SUPPLY**

- (i) Water shall be made available by NEA/consultant at any feasible point within substation boundary at single point to the contractor. Contractor shall state the total water requirement both in terms of quantity and head to NEA/Consultant.
- (ii) The contractor shall carry out all the plumbing/erection works required for supply of water in control room cum administrative building beyond the single point as at (i) above.

- (iii) The contractor shall carry out all the plumbing/erection works required for supply of water to Fire Fighting pump house beyond the single point as at (i) above.
- (iv) The details of tanks, pipes, fittings, fixtures etc for water supply are given elsewhere in the specification under respective sections.
- (v) A scheme shall be prepared by the contractor indicating the layout and details of water supply which shall be got approved by NEA/Consultant before actual start of work including all other incidental items not shown or specified but as may be required for complete performance of the works. All drawings shall be prepared by the contractor for approval of NEA/Consultant.
- (vi) Bore wells and pumps for water supply is not in the scope of contractor.

## **20.0 SEWERAGE SYSTEM**

- (i) Sewerage system shall be provided for all buildings wherever applicable.
- (ii) The Contractor shall construct septic tank and soak pit suitable for 50 users each for control room building, transit camp and township buildings is constructed. If septic and soak pit system is not acceptable by local Nepal Authority, contractor will have to install suitable sewerage system as per local statutory requirement.
- (iii) The system shall be designed as per relevant British standard codes (B S Codes)/ equivalent International Standards. All drawings shall be prepared by the contractor for approval of NEA/Consultant.

## **21.0 GIS HALL CUM CONTROL ROOM BUILDING(PRE ENGINEERED BUILDING)**

### **21.1Control Room and GIS Hall**

The GIS building shall be of pre-engineered steel structure. Control room building, if attached to GIS hall, shall be of pre-engineered steel structure similar to GIS hall and shall be RCC framed structure, if it is not connected with GIS hall. In case of steel control room building all walls shall be of brick masonry and roof of ground floor shall be of RCC. Internal access to the GIS hall from control room building shall be provided.

Material specification and other details for construction of Pre-engineered steel building shall be as described in subsequent paragraphs. The base plate of steel columns shall be mounted on the RCC foundation by means of hot dip galvanised foundation bolts (Galvanisation of 610 gms/Sq. M). In order to facilitate inspection and maintenance, the structures shall be provided with climbing devices. Separate fire escape doors shall also be provided in the GIS Building.

Panels shall be kept in an air-conditioned enclosure. A glazed partition made of aluminium frame and 5.5mm thick glass shall be provided between GIS hall and panel room. The glazing shall be kept at a sill level of 0.9 m above floor level. The height of glazing shall be minimum 2.1 m above sill level.

Walkway of width not less than 1.0m shall be provided at gantry girder level on the two longer side of GIS hall along with climbing arrangement to facilitate maintenance of crane.

All the material required for Pre-engineered (steel) building shall be procured from reputed manufacturer for which prior approval shall be obtained. Manufacturing of various parts of the building shall start only after approval of "Manufacturing Quality Plan to be prepared by the bidder during detailed engineering stage". Complete material shall be offered for inspection by QA&I department of Consultant/NEA before dispatch. Inspection shall be carried out based on assembly (fabrication) drawings approved by consultant/NEA and "BILL OF MATERIAL" & Shop drawing prepared by the Manufacturer and certified by the Contractor for its correctness. Approval of BOM and shop drawing from employer is not required.

## **21.2 Material Specification**

- 21.2.1 Primary members fabricated from plates and sections with minimum yield strength of 345Mpa or to suit design by continuous welding.
- 21.2.2 Secondary members for Purlin and Girts shall conform to the physical specification of ASTM A570 (Grade 50) or equivalent BS/equivalent international standards having a minimum yield strength of 345MPa. The minimum thickness of secondary members shall be 2.5mm.
- 21.2.3 Rod/ ANGLE/pipe bracing shall conform to the physical specification of relevant BS/equivalent international standards of minimum 245Mpa Yield Strength



21.2.4 All hot rolled sections shall conform to the physical specifications of BS/equivalent international standards .All other miscellaneous secondary members shall have minimum yield strength of 250MPa.

21.3 **DESCRIPTION**

21.3.1 **PRIMARY MEMBERS:**

Primary structural framing shall include the transverse rigid frames, columns, corner columns, end wall wind columns and crane gantry girders and Frames at Door openings.

21.3.2 **SECONDARY MEMBERS:**

Secondary structural framing shall include the purlins, girts, eavestruts, wind bracing, flange bracing, base angles, clips, flashings and other miscellaneous structural parts. Suitable wind bracings sag rods to be reckoned while designing the structure.

21.3.3 **PURLINS, GIRTS, CLIPS:**

Purlins, girts and clips should be of PreGalvanised steel of 345Mpa having a coating thickness of 275gms/sq. M inclusive of both sides.

**21.3.4 ROOFSHEETING**

Factory assembled 50mm thick puff (density 40kg/cu.m. +2 Kg/cu m as per BS/equivalent International Standards) sandwiched panels shall be provided. These panels shall be made of puff insulation sandwiched between two high tensile steel sheets each of 0.5 mm thickness. The material of sheets shall confirm to ASTM 792 M Grade 345B with minimum yield strength of 345 Mpa .The steel sheets shall be provided with hot dip coating of Zinc aluminium alloy ( approximately 55% Al , 43.5% Zn and 1.5 % silicon ) .Total mass of zinc aluminium alloy coating shall be minimum 200 gm/Sq. m inclusive of both sides. The tolerance of base metal thickness (BMT) of steel sheet shall be as per BS/equivalent International Standards . After hot dip coating of Zinc aluminium alloy ,the sheet shall be provided with steel primer and silicon modified polyester (SMP) paint.The total thickness of primer and paint shall be 40 microns inclusive of both sides (TCT) comprising of 20 microns of SMP paint on top surface and 10 microns of backer coat ( polyester coat) on back surface over 5 microns thick primer each on both surfaces with inorganic pigments coated free from heavy metals. Painting shall conform to BS/equivalent International Standards . In case SMP paint is

not available, Super Durable Polyester paint (SDP) can also be used by the bidder without cost implication to POWERGRID.

#### **21.3.5 Wall Panels**

Wall panel material specifications shall be same as roof panels.

#### **21.3.6 SHEETINGFASTENERS:**

Standard fasteners shall be self tapping zinc plated metal screws with EPDM bonded zinc plated washers. All screws shall be colour coated to match roof and wall sheeting.

#### **21.3.7 SEALER:**

This is to be applied at all side lap and end laps of roof panels and around self-flashing windows. Sealer shall be pressure sensitive elastomeric Butyl tapes. The sealer shall be non-asphaltic, non-shrinking and nontoxic and shall be superior adhesive to metals, plastics and painted at temperatures from 51°C to +104°C.

#### **21.3.8 CLOSURES:**

Solid or closed cell closures matching the profiles of the panel shall be installed along the eaves, rake and other locations specified on drawings.

#### **21.3.9 FLASHINGANDTRIM:**

Flashing and/or trim shall be furnished at the rake, corners, eaves, and framed openings and wherever necessary to provide weather tightness and finished appearance. Colour shall be matching with the colour of wall. Material shall be 26 gauge thick conforming to the physical specifications of sheeting.

#### **21.3.10 WALL LIGHTS:**

For day lighting purpose of GIS hall, minimum 2 mm thick approved translucent polycarbonate sheet shall be provided for wall lighting in addition to windows for at least 10% of wall area on upper portion of both long walls. The polycarbonate sheet shall be fixed with necessary EPDM, rubber gasket, Silicon Sealant, cold forged fastener, aluminium profile etc. including MS supporting structural steel (conforming to relevant BS/equivalent International Standards) frame to ensure water tight arrangement.

#### **21.3.11 GUTTERS AND DOWNSPOUTS:**

Gutters and down spouts shall be adequately designed to ensure proper roof drainage system. Material shall be same as that of sheeting with matching colour.

#### **21.3.12 PAINTING OF BUILT UP STEEL FRAMES, CRANE GANTRY GIRDERS, FRAMES AT DOOR OPENINGS, WALK WAY STEEL AND LADDER:**

The built up frame ,Crane gantry girders, frames for door openings and steel for walk way shall be applied with a priming coat of standard steel primer followed by one coat coating of epoxy paint and final coating of PU (Minimum 100 Micron) . The steel work for aforesaid members shall be provided with suitable treatment of shot blasting before application of steel primer. The steel material of ladder shall be galvanized.

#### **21.3.13 COLOUR SCHEME:**

Colour Scheme matching with local aesthetic and best industry practices shall be submitted by vendors for approval of POWERGRID. Three alternatives of coloured isometric views with colour codes shall be submitted for approval. The monotony of external colour of sheet shall be avoided by providing vertical bands of different coloured sheet. The colour of roof sheet shall be light coloured to minimize heat absorption. External and internal masonry walls shall be painted with suitable colour matching with colour of steel sheet.

#### **21.4 CONNECTIONS:**

##### **21.4.1 SITECONNECTIONS**

- a) All primary bolted connections shall be provided with galvanized high strength bolts, washers, nuts conforming to specifications of relevant standard.
- b) All secondary bolted connections shall be furnished with bolts, nuts, washers conforming to the specifications of grade 4.6 of relevant standard or ASTM-A307.

##### **21.4.2 SHOPCONNECTIONS**

All shop connections shall be welded with appropriate arc welding process and welding shall be in accordance with relevant standard, AWS D1.1. as appropriate. The Webs should be welded on to

the flanges at both the faces at top and bottom for columns, beams and crane girders. Weld material should have strength more than the parent metal.

#### **21.4.3 ROOF&WALLBRACINGS**

Roof and wall bracings shall have minimum yield strength of 250Mpa and shall conform to the specifications of relevant standard.

#### **21.5 INTERNAL FINISH SCHEDULE**

The finishing schedule is given in subsequent clauses and table-1. Areas not specified in finish schedule shall be provided with vitrified tile flooring, and Premium Acrylic emulsion paint oil bound washable distemper over two mm thick putty. Paints used in the work shall be of best quality specified in relevant standard.

##### **21.5.1 FLOORING**

Flooring in various rooms of control room building and GIS hall shall be as per detailed schedule given in Table -1.

##### **21.5.2 WALLS**

All walls of control room building shall be non-load bearing walls. Min. thickness of walls shall be 230 mm (one brick) with 1:6 cement sand mortar. Partition walls (115mm thick) in toilets and pantry can be half brick walls with 1:4 cement sand mortar and two nos. 6mm dia MS bars at every third course.

In GIS building and the attached relay room 230mm thick brick wall shall be provided up to roof level of relay room attached to GIS hall. 50mm thick puff sandwiched panels as described above shall be provided above brick wall.

##### **21.5.3 ROOF**

###### **(A) GIS Building and Control Room (if steel structure)**

**Roofing Panel:** 50mm thick puff (density 40kg/cu.m.) sandwiched panels shall be provided as described in previous clauses.

##### **21.6 CABLE TRENCH IN GIS HALL**

All cable trenches in GIS hall shall be covered with minimum 6mm thick steel chequered plate with suitable stiffeners. Chequered plate shall be painted with two or more coats of Epoxy paint as per relevant standards.

##### **21.7 EXTERNAL PLASTER AND PAINTING**

External plaster 18mm thick shall be of 1:6 cement sand plaster in two

layers. External surface of the control room building and GIS building (brick wall portion) shall be painted with Premium acrylic smooth exterior paint with silicon additives over and including priming coat of exterior primer as per relevant standards.

## 21.8 INTERNAL FINISH SCHEDULE

Internal finish Schedule for control room building and GIS hall is given in Table - 1 below:

**Table -1**

S.No.	LOCATION	FLOORING & SKIRTING 150MM HIGH	WALL (INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
1.	Control Room	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of 10mm thick toughened glass by using suitable patch fittings/spider fittings. The glass shall extend horizontally from column to column and vertically from sill level of 0.75 m to bottom of lintel/roof beam. All doors shall be glazed powder coated aluminium doors with 5.5mm Thk. Glazing.
2.	Conference	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5mm thk. Glazing.
3.	In-charge Room	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5mm thk. Glazing.
4	Other Office Rooms	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5mm thk. Glazing.
5.	Electronics Test Lab.	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth	False ceiling and White wash above False	Windows shall be of powder coated aluminium with 5.5mm thick glazing.

S.No.	LOCATION	FLOORING & SKIRTING 150MM HIGH	WALL (INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
			surface applied with plaster of paris (2 mm thick)	Ceiling	All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
6.	ACDB & DCDB Room	62mm thick cement concrete flooring with metallic hardener topping	Oil bound washable distemper on smooth surface applied with plaster of paris putty as per relevant standards	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool. Windows/ventilator shall be of powder coated aluminium with 4mm glazing.
7.	Battery room	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool. Windows/ventilator shall be of powder coated aluminium with 4mm glazing.
8.	Lobby	18mm thick granite flooring	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
9.	Corridor	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
10.	Portico	18mm thick granite flooring	Granite cladding	Acrylic emulsion paint over a coat of cement primer on smooth surface applied with readymade putty 1 mm thick as per relevant standards	All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
11.	Toilet	Ceramic tiles	DADO glazed tile 2100mm high, oil bound	Acrylic emulsion paint over a coat of cement	Windows/ ventilator shall be of powder coated aluminium with 5.5mm

S.No.	LOCATION	FLOORING & SKIRTING 150MM HIGH	WALL (INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
			washable distemper above DADO	primer on smooth surface applied with readymade putty 1 mm thick as per relevant standards	thick glazing. All doors shall be flush door shutters made of pre-laminated particle board (with powder coated aluminium frame).
12.	Janitor room	Ceramic tiles	DADO glazed tile 2100mm high, oil bound washable distemper above DADO	Acrylic emulsion paint over a coat of cement primer on smooth surface applied with readymade putty 1 mm thick as per relevant standards	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters made of pre-laminated particle board with powder coated aluminium frame.
13.	GIS Hall	62mm thick cement concrete flooring with metallic hardener topping (DSR item code 11.5). Two coats of PU coating over the metallic hardener shall be provided. The final coat of PU shall be applied after Installation of equipments. Total thickness of PU coats shall be minimum 300 microns.	Premium Acrylic emulsion paint having Volatile Organic Compound (VOC) content less than 50 gms per liter of approved brand and manufacturer on smooth surface applied with plaster of paris (2 mm thick) over approved primer coat .	In case of RCC roof, ceiling shall be finished with Premium Acrylic emulsion paint having Volatile Organic Compound (VOC) content less than 50 gms per liter of approved brand and manufacturer over approved primer coat	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters with powder coated aluminium frame.
14.	Panel/Relay Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5mm thk. Glazing.
15.	AHU Room	62mm thick cement concrete flooring with metallic hardener topping	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	Acrylic emulsion paint over a coat of cement primer on smooth surface applied with readymade putty 1 mm thick as per relevant	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters with powder coated aluminium frame.

S.No.	LOCATION	FLOORING & SKIRTING 150MM HIGH	WALL (INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
				standards	

**21.9** Staircase shall be provided with stainless steel railing and 18mm thick granite slab in risers and treads.

#### **21.10 DOORS AND WINDOWS**

The details of doors and windows of the control room building shall be as per finish schedule Table-1 conforming to relevant BS/equivalent International Standards. Rolling steel shutters shall be provided as per layout and requirement of buildings. Main entrance door to control room building shall be made of powder coated aluminium frame with 5.5 mm thick glazing.

#### **21.11 PARTITION**

Partitions, if required, shall be made of powder coated aluminium frame provided with 5.5 mm thick clear glass or pre- laminated board depending upon the location of partition.

#### **21.12 FALSE CEILING**

Fifteen millimeter thick densified tegular edged ecofriendly light weight calcium silicate false ceiling as per relevant standards shall be provided in the areas specified in Finish Schedule.

#### **21.13 PLUMBING & SANITATION**

- (i) All plumbing and sanitation shall be executed to comply with the requirements of the appropriate bye-laws, rules and regulations of the Local Authority having jurisdiction over such matters. The Contractor shall arrange for all necessary formalities to be met in regard to inspection, testing, obtaining approval and giving notices etc.
- (ii) PVC "SYNTEX" or equivalent make Roof water tank of adequate capacity depending on the number of users for 24 hours storage shall be provided. Minimum 2 Nos 1500 liter capacity shall be provided.
- (iii) Galvanized MS pipe of medium class conforming to relevant standards shall be used for internal & external piping work for potable water supply.
- (iv) Sand CI pipes with lead joints conforming to relevant standards shall be used for sanitary works above ground level and RCC pipe shall be used for works below ground.



- (v) Each toilet shall have the following minimum fittings.
  - (a) WC (Western type) 390 mm high with toilet paper roll holder and all fittings in toilets attached to conference and sub-station in charge office.
  - and
  - WC (Indian Type) Orissa Pattern (580 x 440 mm) with all fittings shall be provided in common toilets.
  - (b) Urinal (430 x 260 x 350 mm size) with all fittings.
  - (c) Wash basin (550 x 400 mm) with all fittings.
  - (d) Bathroom mirror (600 x 450 x 6 mm thick) hard board backing
  - (e) CP brass towel rail (600 x 20 mm) with C.P. brass brackets
  - (f) CP Soap holder and CP liquid soap dispenser.
  - (g) All urinals and washbasins shall be provided with built in sensors.
- (vi) Water cooler for drinking water with adequate water storage facility shall be provided and located near control room and not near toilet block.
- (viii) 1 no. stainless steel kitchen sink with Drain board (510 x 1040 x 178 mm bowl depth) for pantry shall be provided.
- (ix) All fittings, fastener, grating shall be chromium plated.
- (x) All sanitary fixtures and fittings shall be of approved quality and type manufactured by well-known manufacturers. All items brought to site must bear identification marks of the type of the Manufacturer.
- (xi) Stoneware pipes may be used for soil, waste and drain pipes in the areas not subjected to heavy loads otherwise Heavy duty cast iron pipes may be used.
- (xii) Contractor shall provide septic tank and soak pit of adequate capacity to treat the sewage / sullage from the building.
- (xiii) Contractor shall implement all other jobs required to complete and commission the building.

## **22.00 RESIDENTIAL AND NON RESIDENTIAL BUILDINGS**

All buildings shall be constructed as RCC Framed buildings. The architectural features shall match with local architecture. For preparation of architectural drawings of these buildings, the contractor shall depute

local Architect of repute who must be well aware of local bye laws and statutory clearances required for residential and guest house/field hostel/Transit camp building from Nepal Electricity Authority. The buildings shall be designed for loads as applicable in accordance to relevant standards. The plumbing and sanitary works including overhead water tanks placed on terrace and for each building shall also be deemed to be included in the civil works of building. Construction of man holes/chambers, connection of internal plumbing and sanitary system with external sewerage and water supply system shall be considered as a part of civil works of buildings. These works will not be measured and paid separately.

The details and approximate size of various buildings are as below:

- (a) Transit Camp: One number of size 15 m X 14 m (Double Storeyed with each floor of 15 m X 14 m).
- (b) D-Type Quarter: One Number with size 15 m x 14 m-Single Storeyed.
- (c) C-Type Quarters: Four Numbers: One Block of four quarters having two quarters on ground floor and two quarters on first floor. Block will have an area of about 12 m X 25 m on each floor.
- (d) B-Type Quarters: Four Numbers: One Block of four quarters having two quarters on ground floor and two quarters on first floor. Block will have an area of about 10 m X 25 m on each floor.

The area for above buildings has been indicated as tentative. The Contractor shall adopt the suitable size to accommodate various rooms and services for each type of building. The size of various rooms shall be in accordance to local laws.

The finish schedule has been tabulated as below:

Schedule of Finishes for Quarters					
Floor	Room Name	Flooring	Walls	Ceiling	Remarks
Typical Flat	Living	Polished Vitrified Tiles	Plastered & Painted OBD Over 2mm POP Finish	Plastered & Painted with Wash Over 2MM POP	
	Living Balcony	Antiskid Vitrified Tiles	Plastered & Painted with Exterior Paint	DO	For Qrts. As applicable
	Kitchen	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M IS 15622	Plastered & Painted OBD Over 2mm POP Finish	DO	Ceramic Tiles UP to 0.6M Above Kitchen Platform
	Toilet	Do	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Above 2.1M Plaster & Painted OBD over 2MM POP Finish

	Bed Room	Vitrified Tiles	Plastered & Painted OBD Over 2mm POP Finish	DO	
	Bed Room Balcony	Antiskid Vitrified Tiles	Plastered & Painted with Exterior Paint	DO	
	Attached Toilet/ Bed Room Toilet	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M IS 15622	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Above 2.1M Plaster & Painted OBD over 2MM POP Finish
	Passage	Vitrified Tiles With Light Shade	Plastered & Painted OBD Over 2mm POP Finish	DO	
	Cupboard	1:2:4 Concrete with neat cement finish	Plastered & Painted OBD	DO	
	Staircase	Marble Stone Treads & Landings	Plastered & Painted OBD Over 2mm POP Finish	DO	Enamel Paint for M.S. Railing
	Car Parking	80mm Flexi Paver Blocks	Plastered & Painted with Exterior Paint	Plastered & Painted OBD over 2mm POP Finish	For D Type Qtrs. Only
<b>Schedule of Finishes for Transit Camp</b>					
Floor	Room Name	Flooring	Walls	Ceiling	Remarks
	Porch	60mm thk. Flexi Paver Blocks	Plastered & Painted with Exterior Paint	Plastered & Painted with OBD Over 2mm POP Finish	
	Drawing & Dining	Polished Vitrified Tiles 0.6x0.6M	Plastered & Painted Plastic Emulsion Paint over 2mm POP Finish	MineraFibre False Ceiling POP Cornice & Moulding Painted with Plastic Emulsion Paint	Vitrified Tiles Skirting of 150mm high to be Provided
	Lobby	DO	DO	Plastered & Painted OBD Over 2mm POP Finish	DO
	Kitchen	DO	DO	DO	Ceramic Tiles from Floor Level to 0.6M Above Kitchen Platform

	VIP Room & Lounge	DO	DO	DO	POP Cornice & Moulding shall be Provided for Ceiling
	Attached Toilet of VIP Room	Vitrified Tiles (Antiskid) 0.6x0.6M	Ceramic Tiles 0.3x0.45M (Minimum size) up to Ceiling	DO	
	Dormitory	22mm Thk. Terrazzo Tiles Light shade	Plastered & Painted OBD Over 2mm POP Finish	DO	
	Dormitory Toilet/Bath	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Area Above 2.1M Plaster & Painted OBD over 2MM POP Finish
	Staircase	18mm Thk. Udaipur Green Marble Stone	Plastered & Painted OBD Over 2mm POP Finish	DO	SS Hand Railing as per Drawing
	Bed Rooms	Polished Vitrified Tiles 0.6mx0.6m	Plastered & Painted with Plastic Emulsion Paint Over 2mm POP Finish	DO	
	Attached Toilets	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Area Above 2.1M Plaster & Painted OBD over 2MM Thk. POP Finish
	Care Taker Room	Vitrified Tiles With Light Shade	Plastered & Painted OBD Over 2mm POP Finish	DO	
	Common Toilet	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Area Above 2.1M Plaster & Painted OBD over 2MM Thk. POP Finish
	Store	Vitrified Tiles With Light Shade	Plastered & Painted OBD	DO	
	Balconies	Antiskid Vitrified Tiles Light Shade	Plastered & Painted with Exterior Paint	DO	
	Terrace	Brick Bat Coba Water Proofing	Plastered & Painted with Exterior Paint		

## **23.0 Boundary wall, Main Gate, Security Room and septic tank and soak pit**

### **23.1 Boundary Wall :**

RCC framed with brick masonry/concrete block/stone masonry in fill between columns shall be provided along periphery of substation. The brief description of boundary wall is given below:

- (a) Height of boundary wall (Masonry portion) above ground = 2.5 m
- (b) 0.5 m Height of Y shaped angle supports (50x50x6 mm) above each column with about 0.5 m deep grouted in column shall be provided as grill on the boundary wall
- (c) C/c distance of RCC Column (230 X 230 mm size) = 2.5 m
- (d) 8 rows of galvanised barbed wire with concertina coil a top of boundary wall shall be provided. 4 rows of barbed wire on each arm of Y-shaped angle is to be provided.
- (e) Grade of Concrete for RCC works = M25
- (f) Mix of masonry works = 1 Cement: 6 Sand
- (g) 12 mm thick Cement sand plaster (1 cement: 6 Sand) over exposed portion of boundary wall along with 50mm thk CC(1:2:4) coping on the top of wall.
- (h) Two coats of oil bound distemper with one coat of cement primer of approved make shall be applied over exposed portion of boundary wall.
- (i) A RCC plinth beam (230 X 300 mm deep) shall be provided at ground level. A lintel beam of 230 X 230 mm shall be provided over gratings.
- (j) Suitable steel grating made of 20 mm square bars shall be provided at suitable locations preferably @ 100 m to allow the flow of surface water.
- (k) Suitable foundation of about 1.5 depth shall be provided for each RCC column. 75 mm thick PCC (1:4:8) layer shall be provided below all RCC works.
- (l) All steel works shall be provided with two coats of synthetic enamel paint over a coat of steel primer of approved make.
- (m) Twin columns with 25 mm expansion gap at every 45 meter length shall be provided.
- (n) Suitable design of boundary wall shall be developed by the contractor.

The boundary wall shall be measured and paid on running meter length basis.

### **23.2 Main Gate**

A steel gate of 2.1 m high and 6 m wide along with 1.5 m wide man gate shall be provided at entry location of substation. The gate shall be supported on steel columns. The steel support columns shall be encased with suitable RCC foundations. Suitable wheel mounting arrangement shall be provided at the bottom of gate for smooth opening of gate. All steel works shall be provided with two coats of synthetic enamel paint over a coat of steel primer of approved make.

The item shall be measured and paid on Lump sum basis.

### **23.3 Security Room:**

A RCC framed room of size 3 m X 3m and 3 m high with 1.5 m wide veranda shall be provided near gate. An attached toilet of 1.5 m x 1.5 m size shall be provided. Suitable septic tank and soak pit for 10 users with cleaning interval of 3 years shall

also be provided. A RCC platform (600 mm wide) at window sill level along with wardrobe shall be provided. All sanitary works and a PVC water tank of 1000litre capacity shall also be provided. All finish details shall match with other buildings mentioned elsewhere in the technical specification.

The item shall be measured and paid on square meter area basis.

## **24.0 MODE OF MEASUREMENT**

### **24.1 Geotechnical investigation**

This shall include carrying out field tests, laboratory tests, compilation of results and preparation of soil report with recommendations for type of foundations shallow or pile type, suitability of soil for construction of substation etc. The geotechnical investigation work shall be measured on lump sum basis.

### **24.2 Contour survey and site leveling.**

The Contour survey work shall not be measured and paid separately and shall be deemed to be included in the item of site leveling work.

Measurement of Earth work in all kind of soil including soft/disintegrated rock in the item of cutting and filling and item of earth work in the filling with borrowed earth shall be made in Cubic meters. No void deduction for 95% compaction.

### **24.3 Earthwork**

This shall include excavation in all kinds of soil including rock, all leads and lifts including back filling with suitable earth, compacting, dewatering (if required) and disposal of surplus earth or rock to a suitable location within a lead up to 2 km. The surplus earth if disposed within substation boundary shall be spread in uniform layers each compacted with two passes of suitable compacting equipment. The quantity of excavation for foundations of towers, equipment support structures, all transformers/Reactors, DG Set, firewall, cable trenches, fire fighting water tank, buildings and underground water tanks, covered car parking, External lighting poles, control cubicles, marshalling box shall only be measured. The quantity of excavation for roads, rail cum road, drains, culverts, rainwater harvesting, septic tank, soak pit, external water supply system, site surfacing, chain link fencing (including gate) shall not be measured separately and shall be deemed to be included in the composite rates quoted by the bidder for the respective works. All other excavation required for the completion of the work including plinth protection, flooring, sewerage system, manholes, pipes, earth mat etc. shall also not be paid for. The measurement of excavation of all concrete works shall be made considering dimension of the pit leaving 150mm

gap around the base pad (lean concrete) or actually excavated pit, whichever is less. The quantity shall be measured in cubic metres.

#### **24.4 PCC**

Providing and laying Plain Cement Concrete of all types and at all locations including all leads and lifts. The quantity shall be measured in cubic meters as per lines and levels indicated in the drawings.

24.4.1 PCC 1:2:4 (1 cement : 2 sand : 4 coarse aggregate 20 mm nominal size) shall be measured in flooring of buildings, plinth protection, fencing, transformer/reactor foundation, rail track, drain, culverts, septic tank, chain link fencing, fencing gate, external lighting poles etc. as indicated in the approved drawings.

24.4.2 PCC 1:4:8 (1 cement : 4 coarse sand : 8 stone aggregate, 40mm nominal size) shall be measured below all foundations of towers, equipment support structures, buildings, fire fighting water tanks, covered car parking, cable trench, roads, under flooring, rail-cum-road, transformer foundation, reactor foundation, drain, cable trench crossings, culverts, fence, gate etc. as indicated in the approved drawings.

24.4.3 PCC 1:5:10 (1 Cement: 5 sand: 10 Stone aggregate, 40mm nominal size) shall be provided for site surfacing in switchyard, roof water proofing etc.

All other PCC required for the completion of the work including hold fasts of doors/windows/rolling shutters, fixing of plumbing pipes, bedding concrete for sewer lines, embedment of electrical conduits etc. shall not be measured and deemed included in the composite rates quoted by the bidder for respective works. Water proofing compound wherever specified shall be added without any extra cost.

#### **24.5 RCC**

Measurement of reinforced cement concrete at all locations shall be made and shall include all leads, lifts, formwork, grouting of pockets and underpinning, (but shall exclude reinforcement & miscellaneous structural steel like inserts etc.), of M25 design mix (Minimum). This shall also include pre-cast RCC work and addition of water proofing compound wherever required for which no additional payment shall be made. Assessment of concreting work which is already executed shall be examined via standard quality test process before the construction work start. The quantity shall be measured in cubic meters as per lines and levels indicated in the drawings. No deduction shall be made for volume occupied by reinforcement/inserts/sleeves and for openings having cross-sectional area up to 0.1 Sq.M.

#### **24.6 Steel Reinforcement**

Reinforcement steel shall be measured in length (actual or theoretical as per drawing whichever is less) including hooks, if any, separately for different diameters as actually used in RCC work, excluding overlaps. From the length so measured, the weight of reinforcement shall be calculated in metric tonnes on the basis of sectional weights as adopted by British Standards/equivalent International standards. Assessment of rebar of executed work shall be done before construction work start and remedial measures shall be taken if found defective. Wastage, overlaps, couplings, welded joints, spacer bars, chairs, stays, hangers and annealed steel wire or other methods for binding and placing shall not be measured and cost of these items shall be deemed to be included in the rates for reinforcement.

#### **24.7 Stone filling over grating in Transformer/Reactor foundation**

Measurement of stone (40mm nominal size) filling over gratings of transformer/reactor foundations shall be made as per theoretical volume of the space to be filled in the transformer foundation as per approved drawings. This shall be measured in Cu.M.

#### **24.8 Miscellaneous structural steel**

Measurement for Supply, fabrication, transportation and erection of all miscellaneous structural steel work for rails alongwith rail fixing details and gratings with supports for transformers/reactors, Cable trenches with covers (Chequered plate covers, cable supports, earthing cleats and edge protection angles etc), all other steel fittings and fixtures, inserts and embedment in concrete of transformer/reactor foundation and cable trenches shall be made as per approved drawings. The unit rate for this item shall be inclusive of cutting, grinding, drilling, bolting, welding, pre- heating of the welded joints, applying a priming coat of steel primer and anti-corrosive bitumastic paint/ synthetic enamel paint in general but with Zinc Phosphate Primer (Two packs) for grating and support for grating in Transformer foundation. (Wherever specified), setting of all types of embedment in concrete, etc. Steel required for foundation bolts, nuts and bolt, doors, windows, ventilators, louvers, rolling shutters, chain link fencing, gratings in drains, soil pipes, plumbing pipes, floor traps, embedment's required for rainwater harvesting, septic tank, soak pit, roof truss and purlins required for fire water tank, etc. shall not be considered for payment and measurements. Quantity shall be measured in metric tonnes.



## **24.9 Roads**

- A). The measurement for the concrete road shall be made on the basis of area in square meter (M2) of top concrete completed surface of the road and shall be deemed to include all items such as excavation, compaction, rolling, watering, WBM, shoulder, etc complete as per approved drawing but excluding concreting and reinforcement which shall be paid separately under respective items of BPS.
- B) The measurement of bituminous road shall be made on the basis of area in square meter (M2), of the top bituminous completed surface of the road and shall include all items such as excavation, compaction, rolling, watering, sub base course, WBM, shoulder, premix carpet etc complete as per approved drawing.
- C) The measurement of strengthening of existing road (bituminous road) shall be made on the basis of area in square meter (M2), of the top bituminous completed surface of the road including premix carpet etc but excluding item of granular sub base course which shall be paid separately under respective item of BPS.

## **24.10 Anti-weed Treatment and Stone Spreading**

The measurement shall be done for the actual area in square metres of stone spreading provided in the switchyard .It includes providing and spreading of 100mm thickness of uncrushed/crushed/broken stone of 40mm nominal size as per relevant BS codes/equivalent International standards for the specified area. Application of anti weed treatment including material shall not be measured separately and item would be deemed to be included in the quoted rate of stone spreading in switchyard.

## **24.11 Chain Link Fencing and gate**

The measurement shall be made in running metres of the fence provided as per approved drawing. The rate shall be including the post, fencing, MS Flat, painting, brick work and plaster of toe wall etc. complete but excluding the concrete. The switch yard gate shall be measured in numbers.

## **24.12 Cable Trenches and Cable trench Crossings**

Earthwork, PCC, RCC, reinforcement steel, RCC hume pipes and miscellaneous steel required for construction of Cable Trenches and cable trench crossings shall be measured under respective items of Bid price schedule (BPS) as described in clauses of aforesaid paras. No additional payment for brick work, plaster and PVC

pipes used for cable trench crossings and sealing of trench mouth shall be admissible.

#### **24.13 Drains & Culverts**

PCC (1:2:4 and 1:4:8) for drains and culverts shall be measured under respective items of Bid price schedule (BPS) as described in clauses of aforesaid paras . All other items like excavation, brick work, plaster and stone pitching except RCC hume pipes required for completion of drains and culverts shall be deemed to be included in the quoted rate of drain. The quantity for each type of drain section shall be measured in running meters. However, RCC hume pipes used in culverts shall be measured under under respective item of Bid price schedule (BPS) as described in clause of hume pipes.

#### **24.14 External Finishing of RCC Framed Buildings/structures:**

The item shall be measured per square meter area basis. Contractor has to assess the quantity as per requirement of Control room cum administrative building, Fire Fighting Pump House, fire fighting water tank, switchyard panel room, residential and non residential buildings, covered car parking and quote for the same separately. This shall include following items.

- 1) External plastering/cement wash : 18mm Cement plaster in two coats under layer 12 mm thick cement plaster 1:5 (1 cement: 5 coarse Sand) finished with a top layer of 6 mm thick cement plaster 1:6 (1 cement: 6 fine Sand) for all buildings and fire fighting water tank .
- 2) Providing and applying two or more coats of Acrylic smooth exterior paint over an under coat of suitable primer on new cement plaster surfaces of the control room building, auxiliary building, fire fighting pump house building, fire fighting water tank, panel room , residential and non residential buildings and covered car parking. It shall be inclusive of required tools, scaffolding, materials and other painting accessories etc. as per recommendations of manufacturer.

#### **24.15 Hume Pipe**

Hume pipe shall be measured diameter-wise and laid as per approved drawings and shall be measured in running meters. The item shall be inclusive of excavation, laying, back filling, jointing etc. but excluding concrete and reinforcement (if any).

#### **24.16 Building**

The measurement of all items except excavation, concrete, reinforcement steel of each type of buildings shall be made on area in Square Meter basis. However,

the quantity of excavation, concrete, reinforcement shall be measured in respective items of BPS and described in above paras. The structural steel used for cable tray support, earthing cleat, chequered plates for internal cable trenches of building and panel room wherever applicable shall be measured and paid under miscellaneous steel item of BPS and described above paras. The structural steel and foundation bolts for fixing equipments with foundations/raft within buildings shall not be measured separately which shall be deemed to be included in the quoted rates per square meter of buildings. External Finishing shall be measured and paid in respective items of BPS and described in above paras. The rest of the entire work required to complete the building in all respect as per drawings prepared by contractor and approved by NEA/Consultant shall be deemed to be included in this item rate per square meter area basis.

#### **24.17 Rain Water Harvesting**

This is a lump sum item. The contractor shall be required to complete the work in all respect as per drawings prepared by contractor and approved by NEA/Consultant. All the items including excavation, miscellaneous steel, brick work, fillings of boulders, gravel, sand, pipes etc. shall be deemed to be included in this lump sum rate. However, the concrete (all types) and the reinforcement shall be measured and paid under respective item of BPS and described in above paras.

#### **24.18 Rail cum Road**

The measurement for the rail cum road shall be made in square metres of top concrete completed surface of the rail cum road and shall include all items such as excavation, compaction, rolling, watering, WBM etc. complete as per approved drawing but excluding concrete, reinforcement, structural steel and rails with rail fixing details which shall be measured separately under respective item of BPS and described in above paras.

#### **24.19 Septic Tank and Soak Pit**

This is a lump sum item. The contractor shall be required to complete the work in all respect as per drawings furnished by the contractor and approved by NEA/Consultant. All the items including excavation, masonry work, all types of fillings, all types of pipes including plumbing and vent pipes, all type of fittings etc. shall be deemed to be included in this lump sum rate. However, the concrete (all types) and the reinforcement shall be measured and paid under the respective item mentioned above.

## **24.20 FireWater Tank**

This is a lump sum item. The contractor shall be required to complete the work in all respect as per approved drawings. The items including brick work if any, and miscellaneous steel including steel embedment Rungs, roof truss, corrugated AC Sheet roofing, door, pipe sleeves, internal finish, etc. shall be deemed to be included in this lump sum cost. However, the items like excavation, concrete (all types), reinforcement steel, external finish shall be measured and paid under the respective item of BPS and described in above paras.

## **24.21 External water supply from Bore-well/ other source of water supply arrangement to Fire water tank, Control Room building ,Residential and non residential buildings**

The external water supply from Bore-well shall be measured diameter-wise in running meters. It shall include all the items such as excavation, piping, pipe fittings, painting, brickwork, sand filling, concrete, valves, chambers cutting chases in walls, openings in RCC and repairs, etc. required to complete the job.

## **24.22 External Sewage System of Control Room Building and other Buildings of Township.**

It shall be measured diameter wise in running meters. It shall include all the items such as excavation, piping, pipe fittings, manholes, gali trap, gali chamber casing in concrete and repairs etc required to complete the job. Any modification in the existing sewage system, if required, shall be done by the Contractor without any extra cost implicated to NEA/Consultant.

## **25.0 MISCELLANEOUS GENERAL REQUIREMENTS**

- 25.1 Dense concrete with controlled water cement ratio as per BS-code shall be used for all underground concrete structures such as pump-house, tanks, water retaining structures, cable and pipe trenches etc. for achieving water-tightness.
- 25.2 All joints including construction and expansion joints for the water retaining structures shall be made water tight by using PVC ribbed water stops with central bulb. However, kicker type (externally placed) PVC water stops shall be used for the base slab and in other areas where it is required to facilitate concreting. The minimum thickness of PVC water stops shall be 5 mm and minimum width shall be 230 mm.
- 25.3 All steel sections and fabricated structures which are required to be transported on sea shall be provided with anti-corrosive paint to take care of sea worthiness.

- 25.4 All mild steel parts used in the water retaining structures shall be hot-double dip galvanised. The minimum coating of the zinc shall be 750 gm/sq. m. for galvanised structures and shall comply with relevant BS. Galvanizing shall be checked and tested in accordance with relevant BS. The galvanizing shall be followed by the application of an etching primer and dipping in black bitumen in accordance with BS: 3416.
- 25.5 A screed concrete layer not less than 100 mm thick and of grade not weaker than M10 conforming to relevant BS shall be provided below all water retaining structures. A sliding layer of bitumen paper or craft paper shall be provided over the screed layer to destroy the bond between the screed and the base slab concrete of the water retaining structures.
- 25.6 Bricks having minimum 75 kg/cm<sup>2</sup> compressive strength can only be used for masonry work. Contractor shall ascertain himself at site regarding the availability of bricks of minimum 75 kg/cm<sup>2</sup> compressive strength before submitting his offer. The contractor may use concrete blocks of equivalent compressive strength in place of brick work.
- 25.7 Doors and windows on external walls of the buildings (other than areas provided, with insulated metal claddings) shall be provided with RCC sun-shade over the openings with 300 mm projection on either side of the openings. Projection of sunshade from the wall shall be minimum 450 mm over window openings and 750 mm over door openings.
- 25.8 All stairs shall have maximum riser height of 150 mm and a minimum tread width of 300 mm. Minimum width of stairs shall be 1500 mm. Service ladder shall be provided for access to all roofs. RCC fire escape staircase if required as per local bye laws, shall be provided in control buildings.
- 25.9 Angles 50x50x6 mm (minimum) with lugs shall be provided for edge protection all round cut outs/openings in floor slab, edges of drains supporting grating covers, edges of RCC cable/pipe trenches supporting covers, edges of manholes supporting covers, supporting edges of manhole precast cover and any other place where breakage of corners of concrete is expected.
- 25.10 Anti termite chemical treatment for buildings shall be given to all column pits, wall trenches, foundations, filling below the floors etc. as per relevant International/BS.
- 25.11 Hand-railing minimum 900mm high shall be provided around all floor/roof openings, projections/balconies, walk ways, platforms, steel stairs etc. All handrails and ladder pipes shall be 32 mm nominal bore MS pipes (medium class) and shall be galvanised (medium-class as per relevant BS). All rungs for

ladder shall also be galvanised as per relevant BS.

For RCC stairs, hand railing with 20 mm square MS bars, balustrades with suitable MS flats & aluminium handrails shall be provided.

- 25.12 For all civil works covered under this specification, design Mix of Minimum M25 grade as per relevant International /BS shall be used. Reinforcement steel shall be of minimum Fe 500 grade.

The material specification, workmanship and acceptance criteria shall be as per relevant clauses of applicable International/BS standard.

- 25.13 Items/components of buildings not explicitly covered in the specification and BPS but required for completion of the project shall be deemed to be included in the scope.

- 25.14 Requirement of sulphate resistant cement (SRC) for sub structural works shall be decided in accordance with the International/BS Standards based on the findings of the detailed soil investigation to be carried out by the Bidder.

- 25.15 Foundation system adopted by Bidder shall ensure that relative settlement and other criteria shall be as per provision in relevant BS and other International Standards.

- 25.16 All water retaining structures designed as uncracked section shall also be tested for water tightness at full water level in accordance with relevant international/BS standards.

- 25.17 Construction joints shall be as per International/BS standard..

- 25.18 All underground concrete structures like basements, pumps houses, water retaining structures etc. shall have plasticizer cum water proofing cement additive conforming to relevant BS. The concrete surface of these structures in contact with earth shall also be provided with two coat of bituminous painting for water/damp proofing.

In case of water leakage in the above structures, The Method shall be applied as per relevant international standard/BS standard for repairing the leakage.

- 25.19 All building/construction materials shall conform to the best quality specified in relevant International /BS standard.

## **26.0 INTERFACING**

The proper coordination & execution of all interfacing civil works activities like

fixing of conduits in roofs/walls/floors, fixing of foundation bolts, fixing of lighting fixtures, fixing of supports/embedment's, provision of cut outs etc. shall be the sole responsibility of the Contractor. He shall plan all such activities in advance and execute in such a manner that interfacing activities do not become bottlenecks and dismantling, breakage etc. is reduced to minimum.

## **27.0 STATUTORY RULES**

- 27.1 Contractor shall comply with all the applicable statutory rules pertaining to factories act (as applicable for the State). Fire Safety Rules of Tariff Advisory-Committee and Water and sewerage Act for pollution control etc.
- 27.2 Provisions for fire proof doors, no. of staircases, fire escape stairs ,fire separation wall, plastering on structural members (in fire prone areas) etc. shall be made according to the recommendations of Local Advisory Committee.
- 27.3 Statutory clearance and norms of Local Pollution Control Board shall be followed as per Water Act for effluent quality from plant.

## **28.0 FIELD QUALITY PLAN**

All tests as required in accordance to BS codes or equivalent International standards have to be carried out. The contractor shall prepare field quality plan for civil works as per relevant /BS codes/equivalent International Standards during detailed engineering stage and submit to NEA/Consultant for approval within ONE month after award of work.

## **29.0 BRITISH STANDARD CODES**

Major British standard Codes for civil work have been given in the following list. This list is illustrative but not exhaustive. However, for design and engineering relevant BS codes or equivalent International standards shall be referred by the contractor. Relevant portion of BS codes or equivalent international standards referred by the contractor for the design shall be made available to NEA/Consultant if necessary during detailed engineering stage.

<b>Sr. No.</b>	<b>Standard No.</b>	<b>Title</b>	<b>Year</b>
1	BS 41	Structural steel sections. Specification for hot-rolled sections	2005
2	BS 13771	Methods of test for soils for civil engineering purposes . General requirements and sample preparation	1990
3	BS 4449	Steel for the reinforcement of concrete. Weldable reinforcing steel. Bar, coil and decoiled product. Specification (with A2:2009)	2005
4	BS 4482	Steel fabric for the reinforcement of concrete. Specific	2005

		ation	
5	BS 4483	Steel fabric for the reinforcement of concrete. Specific ation	2005
6	BS EN 102102	Hot finished structural hollow sections of non-alloy and fine grain steels. Tolerances, dimensions and sectional properties	2006
7	BS EN 100561	Specification for structural steel equal and unequal angles. Dimensions	1999
8	BS EN ISO 800001	Quantities and units. General	2013
9	BS 5930	Code of practice for site investigations (with A2:2010)	1999
10	BS EN 199311	Eurocode 3. Design of steel structures. General rules and rules for buildings	2005
11	NA to BS EN 199311	UK National Annex to Eurocode 3. Design of steel structures. General rules and rules for buildings	2008
12	BS EN 199315	Eurocode 3. Design of steel structures. Plated structural elements	2006
13	NA to BS EN 199315	UK National Annex to Eurocode 3. Design of steel structures. Plated structural elements	2008
14	BS EN 199318	Eurocode 3. Design of steel structures. Design of joints	2005
15	NA to BS EN 199318	UK National Annex to Eurocode 3. Design of steel structures. Design of joints	2008
16	BS 60732	Precast concrete masonry units. Guide for specifying precast concrete masonry units	2008
17	BS 7668	Weldable structural steels. Hot finished structural hollow sections in weather resistant steels. Specification	2004
18	BS EN 19971	Eurocode 7. Geotechnical design. General rules	2004
19	NA to BS EN 19971	UK National Annex to Eurocode 7. Geotechnical design. General rules	2007
20	BS EN 19923	Eurocode 2. Design of concrete structures. Liquid retaining and containing structures	2006
21	BS EN 199211	Eurocode 2. Design of concrete structures. General rules and rules for buildings	2004
22	NA to BS EN 199211	UK National Annex to Eurocode 2. Design of concrete structures. General rules and rules for buildings	2005
23	BS 75334	Pavements constructed with clay, natural stone or concrete pavers. Code of practice for the construction of pavements of precast concrete flags or natural stone slabs	2006
24	BS EN 1971	Cement. Composition, specifications and conformity criteria for common cements	2011
25	BS 743	Specification for materials for damp-proof courses	1970
26	BS 8122	Testing aggregates. Methods for determination of density	1995
27	BS 952-1	Glass for glazing. Classification	1995
28	BS 952-2	Glass for glazing. Terminology for work on glass	1980
29	BS EN 12620	Aggregates for concrete	2013



30	BS 1125	Specification for WC flushing cisterns (including dual flush cisterns and flush pipes)	1987
31	BS 1188	Specification for ceramic wash basins and pedestals	1974
32	BS 1199 and 1200	Specifications for building sands from natural sources	1976
33	BS EN 13310	Kitchen sinks. Functional requirements and test methods	2003
34	BS 1245	Pedestrian doorsets and door frames made from steel sheet. Specification	2012
35	BS 1254	Specification for WC seats (plastics)	1981
36	BS 1370	Specification for low heat Portland cement	1979
37	BS EN 1008	Mixing water for concrete. Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete	2002
38	BS 3505	Specification for unplasticized polyvinyl chloride (PVC-U) pressure pipes for cold potable water	1986
39	BS EN 15743	Supersulfated cement. Composition, specifications and conformity criteria	2010
40	BS EN ISO 3766	Construction drawings. Simplified representation of concrete reinforcement	2003
41	BS 8666	Scheduling, dimensioning, bending and cutting of steel reinforcement for concrete. Specification	2005
42	BS 4514	Unplasticized PVC soil and ventilating pipes of 82.4 mm minimum mean outside diameter, and fittings and accessories of 82.4 mm and of other sizes. Specification	2001
43	BS 4551	Mortar. Methods of test for mortar and screed. Chemical analysis and physical testing (with A2:2013)	2005
44	BS EN 122001	Plastics rainwater piping systems for above ground external use. Unplasticized poly (vinyl chloride) (PVC-U). Specifications for pipes, fittings and the system	2000
45	BS EN 1462	Brackets for eaves gutters. Requirements and testing	2004
46	BS EN 607	Eaves gutters and fittings made of PVC-U. Definitions, requirements and testing	2004
47	BS 6262	Code of practice for glazing for buildings	1982
48	BS EN 14411	Ceramic tiles. Definitions, classification, characteristics, evaluation of conformity and marking	2012
49	BS 6510	Steel framed windows and glazed doors. Specification	2010
50	BS EN 636	Plywood. Specifications	2012
51	NA to BS EN 19923	UK National Annex to Eurocode 2. Design of concrete structures. Liquid retaining and containment structures	2007
52	BS EN 1339	Concrete paving flags. Requirements and test methods	2003
53	BS EN 1340	Concrete kerb units. Requirements and test methods	2003

# CHAPTER-15: CONTROL AND RELAY PANELS

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#### **APPENDIX-A      TEST PROGRAMME FOR DISTANCE RELAYS**

# CHAPTER 15: CONTROL, RELAY & PROTECTION PANELS

## 1. TYPE OF PANELS

### 1.1 Simplex Panel

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

### 1.2 Duplex Panel

Duplex panel shall be walk-in tunnel type comprising two vertical front and rear panel sections connected back-on-back by formed sheet steel roof tie members and a central corridor in between. The corridor shall facilitate access to internal wiring and external cable connections. In case of number of duplex panels located in a row side by side, the central corridor shall be aligned to form a continuous passage. Both ends of the corridor shall be provided with double leaf doors with lift off hinges. Doors shall have handles either with built-in locking facility or shall be provided with pad-locks. Separate cable entries shall be provided for the front and rear panels. However, inter-connections between front and back panels shall be by means of inter panel wiring at the top of the panel.

## 2. CONSTRUCTIONAL FEATURES

- 2.1. Control and Relay Board shall be of panels of simplex or duplex type design as indicated in bill of quantity. It is the responsibility of the Contractor to ensure that the equipment specified and such unspecified complementary equipment required for completeness of the protective/control schemes be properly accommodated in the panels without congestion and if necessary, **either add more number of panels or** provide panels with larger dimensions. No price increase at a later date on this account shall be allowed. However, the width of panels that are being offered to be placed in existing switchyard control rooms, should be in conformity with the space availability in the control room.
- 2.2. Panels shall be completely metal enclosed and shall be dust, moisture and vermin proof. The enclosure shall provide a degree of protection not less than IP-31 in accordance with IEC 60529 (Part-1).
- 2.3. Panels shall be free standing, floor mounting type and shall comprise structural frames completely enclosed with specially selected smooth finished, cold rolled sheet steel of thickness not less than 3 mm for weight bearing members of the panels such as base frame, front sheet and door frames, and 2.0mm for sides, door, top and bottom portions. There shall be sufficient reinforcement to provide level transportation and installation.
- 2.4. All doors, removable covers of panels shall be gasketed all around with synthetic gaskets Neoprene/EPDM. However, XLPE gaskets can also be used

for fixing protective glass doors. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh

- 2.5. Design, materials selection and workmanship shall be such as to result in neat appearance, inside and outside with no welds, rivets or bolt head apparent from outside, with all exterior surfaces true and smooth.
- 2.6. Panels shall have base frame with smooth bearing surface, which shall be fixed on the embedded foundation channels/insert plates. Anti vibration strips made of shock absorbing materials that shall be supplied by the contractor, which shall be placed between panel & base frame.
- 2.7. Cable entries to the panels shall be from the bottom. Cable gland plate fitted on the bottom of the panel shall be connected to earthing of the panel/station through a flexible braided copper conductor rigidly.
- 2.8. Relay/protection panels of modern modular construction would also be acceptable.

### **3. MOUNTING**

- 3.1. All equipment on and in panels shall be mounted and completely wired to the terminal blocks ready for external connections. The equipment on front of panel shall be mounted flush.
- 3.2. Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent devices and are readily accessible without use of special tools. Terminal marking on the equipment shall be clearly visible.
- 3.3. The Contractor shall carry out cut out, mounting and wiring of the free issue items supplied by others which are to be mounted in his panel in accordance with the corresponding equipment manufacturer's drawings. Cut outs if any, provided for future mounting of equipment shall be properly blanked off with blanking plate.
- 3.4. The centre lines of switches, push buttons and indicating lamps shall not be less than 750mm from the bottom of the panel. The centre lines of relays, meters and recorders shall not be less than 450mm from the bottom of the panel.
- 3.5. The centre lines of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Like wise the top lines of all meters, relays and recorders etc. shall be matched.
- 3.6. No equipment shall be mounted on the doors.
- 3.7. At existing station, panels shall be matched with other panels in the control room in respect of dimensions, colour, appearance and arrangement of equipment (centre lines of switches, push buttons and other equipment) on the front of the panel.

### **4. PANEL INTERNAL WIRING**

- 4.1. Panels shall be supplied complete with interconnecting wiring provided between all electrical devices mounted and wired in the panels and between the devices

and terminal blocks for the devices to be connected to equipment outside the panels. When panels are arranged to be located adjacent to each other all inter panel wiring and connections between the panels shall be carried out internally

- 4.2. All wiring shall be carried out with 650V grade, single core, stranded copper conductor wires with PVC insulation. The minimum size of the multi-stranded copper conductor used for internal wiring shall be as follows:
- All circuits except current transformer circuits and voltage transfer circuits meant for energy metering - one 1.5mm sq. per lead.
  - All current transformer circuits - one 2.5 sq.mm per lead.
  - Voltage transformer circuit (for energy meters): Two 2.5 mm sq. per lead.
- 4.3. All internal wiring shall be securely supported, neatly arranged, readily accessible and connected to equipment terminals and terminal blocks. Wiring gutters & troughs shall be used for this purpose.
- 4.4. Auxiliary bus wiring for AC and DC supplies, voltage transformer circuits, annunciation circuits and other common services shall be provided near the top of the panels running throughout the entire length of the panels.
- 4.5. Wire termination shall be made with solderless crimping type and tinned copper lugs, which firmly grip the conductor. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wire and shall not fall off when the wire is disconnected from terminal blocks. All wires directly connected to trip circuit breaker or device shall be distinguished by the addition of red coloured unlettered ferrule.
- 4.6. Longitudinal troughs extending throughout the full length of the panel shall be preferred for inter panel wiring. Inter-connections to adjacent panel shall be brought out to a separate set of terminal blocks located near the slots of holes meant for taking the inter-connecting wires.
- 4.7. Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipments.

## **5. TERMINAL BLOCKS**

- 5.1. All internal wiring to be connected to external equipment shall terminate on terminal blocks. Terminal blocks shall be 650 V grade and have 10 Amps. continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Markings on the terminal blocks shall correspond to wire number and terminal numbers on the wiring diagrams. All terminal blocks shall have shrouding with transparent unbreakable material.
- 5.2. Disconnecting type terminal blocks for current transformer and voltage transformer secondary leads shall be provided. Also current transformer secondary leads shall be provided with short circuiting and earthing facilities.
- 5.3. At least 20% spare terminals shall be provided on each panel and these spare

terminals shall be uniformly distributed on all terminal blocks.

- 5.4. Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors of external cable on each side
- All CT & PT circuits: minimum of two of 2.5mm Sq. copper.
  - AC/DC Power Supply Circuits: One of 6mm Sq. Aluminium.
  - All other circuits: minimum of one of 2.5mm Sq. Copper.
- 5.5. There shall be a minimum clearance of 250mm between the first row of terminal blocks and the associated cable gland plate or panel side wall. Also the clearance between two rows of terminal blocks edges shall be minimum of 150mm.
- 5.6. Arrangement of the terminal block assemblies and the wiring channel within the enclosure shall be such that a row of terminal blocks is run in parallel and close proximity along each side of the wiring-duct to provide for convenient attachment of internal panel wiring. The side of the terminal block opposite the wiring duct shall be reserved for the external cable connections. All adjacent terminal blocks shall also share this field wiring corridor. All wiring shall be provided with adequate support inside the panels to hold them firmly and to enable free and flexible termination without causing strain on terminals.
- 5.7. The number and sizes of the Owner's multi core incoming external cables will be furnished to the Contractor after placement of the order. All necessary cable terminating accessories such as gland plates, supporting clamps & brackets, wiring troughs and gutters etc. (except glands & lugs) for external cables shall be included in the scope of supply.

## **6. PAINTING**

**The painting shall be carried out as detailed in Chapter 2–GTR.**

## **7. MIMIC DIAGRAM**

- 7.1. Coloured mimic diagram and symbols showing the exact representation of the system shall be provided in the front of control panels.
- 7.2. Mimic diagram shall be made preferably of anodised aluminium or plastic of approved fast colour material, which shall be screwed on to the panel and can be easily cleaned. The mimic bus shall be 2mm thick. The width of the mimic bus shall be 10mm for bus bars and 7mm for other connections. Painted overlaid mimic is also acceptable.
- 7.3. Mimic bus colour will be decided **during detailed Engineering.**
- 7.4. When semaphore indicators are used for equipment position, they shall be so mounted in the mimic that the equipment in close position shall complete the continuity of mimic.
- 7.5. Indicating lamp, one for each phase, for each bus shall be provided on the mimic to indicate bus charged condition.

## **8. NAME PLATES AND MARKINGS**

- 8.1. All equipment mounted on front and rear side as well as equipment mounted

inside the panels shall be provided with individual name plates with equipment designation engraved. Also on the top of each panel on front as well as rear side, large and bold nameplates shall be provided for circuit/feeder designation.

- 8.2. All front mounted equipment shall also be provided at the rear with individual name plates engraved with tag numbers corresponding to the one shown in the panel internal wiring to facilitate easy tracing of the wiring.
- 8.3. Each instrument and meter shall be prominently marked with the quantity measured e.g. KV, A, MW, etc. All relays and other devices shall be clearly marked with manufacturer's name, manufacturer's type, serial number and electrical rating data.
- 8.4. Name Plates shall be made of non-rusting metal or 3 ply lamincoid. Name plates shall be black with white engraving lettering.
- 8.5. Each switch shall bear clear inscription identifying its function e.g. 'BREAKER' '52A', "SYNCHRONISING" etc. Similar inscription shall also be provided on each device whose function is not other-wise identified. If any switch device does not bear this inscription separate name plate giving its function shall be provided for it. Switch shall also have clear inscription for each position indication e.g. "Trip- Neutral-Close", "ON-OFF", "R-Y-B-OFF" etc
- 8.6. All the panels shall be provided with name plate mounted inside the panel bearing LOA No & Date, Name of the Substation & feeder and reference drawing number.

## **9. MISCELLANEOUS ACCESSORIES**

- 9.1. **Plug Point:** 230V, Single phase 50Hz, AC socket with switch suitable to accept 5 Amps and 15 Amps pin round standard Indian plug, shall be provided in the interior of each cubicle with ON-OFF switch.
- 9.2. **Interior Lighting:** Each panel shall be provided with a fluorescent lighting fixture rated for 230 Volts, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch. Adequate lighting shall also be provided for the corridor in Duplex panels.
- 9.3. **Switches and Fuses:** Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with Fuses. Selection of the main and sub-circuit Fuses rating shall be such as to ensure selective clearance of sub-circuit faults. Voltage transformer circuits for relaying and metering shall be protected by fuses. All fuses shall be HRC cartridge type conforming to IS: 13703 mounted on plug-in type fuse bases. The short time fuse rating of Fuses shall be not less than 9 KA. Fuse carrier base shall have imprints of the fuse 'rating' and 'voltage'.
- 9.4. **Space Heater:** Each panel shall be provided with a thermostatically connected space heater rated for 230V, single phase, 50 Hz AC supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with switch unit.

## **10. EARTHING**



- 10.1. All panels shall be equipped with an earth bus securely fixed. Location of earth bus shall ensure no radiation interference from earth systems under various switching conditions of isolators and breakers. The material and the sizes of the bus bar shall be at least 25 X 6 sq.mm copper with threaded holes at a gap of 50 mm with provision of bolts and nuts for connection with cable armours and mounted equipment etc for effective earthing. When several panels are mounted adjoining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply of Contractor. Provision shall be made for extending the earth bus bars to future adjoining panels on either side.
- 10.2. Provision shall be made on each bus bar of the end panels for connecting Substation earthing grid. Necessary terminal clamps and connectors for this purpose shall be included in the scope of supply of Contractor.
- 10.3. All metallic cases of relays, instruments and other panel mounted equipment including gland plate, shall be connected to the earth bus by copper wires of size not less than 2.5 sq. mm. The colour code of earthing wires shall be green.
- 10.4. Looping of earth connections which would result in loss of earth connection to other devices when the loop is broken, shall not be permitted. However, looping of earth connections between equipment to provide alternative paths to earth bus shall be provided.
- 10.5. VT and CT secondary neutral or common lead shall be earthed at one place only at the terminal blocks where they enter the panel. Such earthing shall be made through links so that earthing may be removed from one group without disturbing continuity of earthing system for other groups.
- 10.6. An electrostatic discharge **arrangement** shall be provided in each panel **so as to discharge human body before he handles the equipments inside the panels.**
- 11. INDICATING INSTRUMENTS & TRANSDUCERS FOR CONTROL PANEL:**
- All instruments, meters and transducers shall be enclosed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. All megawatt, megavar, Bus voltage and frequency indicating instruments shall be provided with individual transducers and these shall be calibrated along with transducers to read directly the primary quantities. They shall be accurately adjusted and calibrated at works and shall have means of calibration check and adjustment at site. The supplier shall submit calibration certificates at the time of delivery. However no separate transducers are envisaged for digital bus voltmeters and digital frequency meters and the indicating meters provided in the synchronising equipment.
- 11.1. Indicating Instruments**
- 11.1.1. Unless otherwise specified, all electrical indicating instruments shall be of digital type suitable for flush mounting.
- 11.1.2. Instruments shall have 4-digit display; display height being not less than 25 mm

- 11.1.3. Instrument shall confirm to relevant IEC and shall have an accuracy class of 1.5 or better. Watt and Var meters shall have an indication of (+) and (-) to indicate EXPORT and IMPORT respectively.
- 11.1.4. Digital voltage and frequency meters shall be of class: 0.5 and shall have digital display of 5 and 4 digits respectively, with display size, not less than 25mm (height).

## **11.2. Transducers**

- 11.2.1. Transducers (for use with Indicating Instruments and Telemetry/Data Communication application) shall in general conform to IEC:688-1
- 11.2.2. The transducers shall be suitable for measurement of active power, reactive power, voltage, current and frequency in three phase four wire unbalanced system.
- 11.2.3. The input to the transducers will be from sub-station current & potential transformers. The output shall be in milli ampere D.C. proportional to the input & it shall be possible to feed the output current directly to the telemetry terminal or indicating instruments.
- 11.2.4. The transducer characteristic shall be linear throughout the measuring range.
- 11.2.5. The transducer output shall be load independent.
- 11.2.6. The input & output of the transducer shall be galvanically isolated.
- 11.2.7. Each transducer shall be housed in a separate compact case and have suitable terminals for inputs & outputs.
- 11.2.8. The transducers shall be suitably protected against transient high peaks of voltage & current.
- 11.2.9. The transducer shall withstand indefinitely without damage and work satisfactorily at 120% of the rated voltage and 120% of the rated input current as applicable.
- 11.2.10. All the transducers shall have an output of 4-20 mA.
- 11.2.11. The response time of the transducers shall be less than 1 second.
- 11.2.12. The accuracy class of transducers shall be 1.0 or better for voltage/current transducer, 0.5 or better for watt/VAR transducer and 0.2 or better for frequency transducer.
- 11.2.13. The transducers shall have a low AC ripple on output less than 1%.
- 11.2.14. The transducer shall have dual output.

## **12. ANNUNCIATION SYSTEM for Control Panel**

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

flush on the top of the control panels.

- 12.3. The annunciation facia shall be provided with translucent plastic window for alarm point with approximate size of 35mm x 50mm. The facia plates shall be engraved in black lettering with respective inscriptions. Alarm inscriptions shall be engraved on each window in not more than three lines and size of the lettering shall not be less than 5 mm.
- 12.4. Each annunciation window shall be provided with two white lamps in parallel to provide safety against lamp failure. Long life lamps shall be used. The transparency of cover plates and wattage of the lamps provided in the facia windows shall be adequate to ensure clear visibility of the inscriptions in the control room having high illumination intensity (350 Lux), from the location of the operator's desk.
- 12.5. All Trip facia shall have red colour and all Non-trip facia shall have white colour.
- 12.6. The audible alarm shall be provided by Buzzer/ Hooter /Bell having different sounds and shall be used as follows.
- |        |                         |
|--------|-------------------------|
| Hooter | Alarm Annunciation      |
| Bell   | Annunciation DC failure |
| Buzzer | AC supply failure       |
- 12.7. Sequence of operation of the annunciator shall be as follows :

Sl. NO.	Alarm Condition	Fault Contact	Visual Annunciation	Audible Annunciation
1.	Normal	Open	OFF	OFF
2.	Abnormal	Close	Flashing	ON
3.	Accept Push Button Pressed	Close	Steady On	OFF
		Open	Steady On	OFF
4.	Reset Push Button Pressed	Close	On	OFF
		Open	Off	OFF
5.	Lamp Test Push Button Pressed	Open	Steady On	OFF

- 12.8. Audible annunciation for the failure of DC supply to the annunciation system shall be provided and this annunciation shall operate on 230 Volts AC supply. On failure of the DC to the annunciation system for more than 2 or 3 seconds (adjustable setting), a bell shall sound. A separate push button shall be provided for the cancellation of this audible alarm alone but the facia window shall remain steadily lighted till the supply to annunciation system is restored.
- 12.9. A separate voltage check relay shall be provided to monitor the failure of supply (230V AC) to the scheme mentioned in Clause above. If the failure of supply exists for more than 2 to 3 seconds, this relay shall initiate visual and

audible annunciation. Visual and audible annunciation for the failure of AC supply to the annunciation system shall be provided and this annunciation shall operate on Annunciation DC and buzzer shall sound.

12.10. The annunciation system described above shall meet the following additional requirements :

- a) The annunciation system shall be capable of catering to at least 20 simultaneous signals at a time.
- b) One set of the following push buttons shall be provided on each control panel:
  - Reset push button for annunciation system
  - Accept push button for annunciation system
  - Lamp test push button for testing the facia windows
- c) One set of the following items shall be provided common for all the control panel (not applicable for extension of substation) :
  - Flasher relay for annunciation system
  - Push button for Flasher test
  - Three Push buttons for test of all audible alarm systems
- d) These testing circuits shall be so connected that while testing is being done, it shall not prevent the registering of any new annunciation that may land during the test.
- e) The annunciation shall be repetitive type and shall be capable of registering the fleeting signal. Minimum duration of the fleeting signal registered by the system shall be 15 milli seconds.
- f) In case of static annunciator scheme, special precaution shall be taken to ensure that spurious alarm condition does not appear due to influence of external electromagnetic/ electrostatic interference on the annunciator wiring and switching disturbances from the neighbouring circuits within the panels and the static annunciator shall meet the high voltage susceptibility test , impulse voltage withstand test , high frequency disturbance test– class III and fast transient disturbance test –level III as per IEC 60255.

12.11. The annunciation system to be supplied for existing sub-stations shall be engineered as an extension to the existing scheme.

### **13. SWITCHES**

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

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

- Breaker, Isolator control switches : Pistol grip, black
- Synchronising switches : Oval, Black, Keyed handle (one common removable handle for a group of switches or locking facility having common key)
- synchronising Selector switches : Oval or knob, black
- Instrument switches : Round, knurled, black
- Protection Transfer switch : Pistol grip, lockable and black.
- 13.3. The control switch of breaker and isolator shall be of spring return to neutral type. The switch shall have spring return from close and trip positions to "after close" and "after trip" positions respectively.
- 13.4. Instrument selection switches shall be of maintained contact (stay put) type. Ammeter selection switches shall have make-before-break type contacts so as to prevent open circuiting of CT secondary when changing the position of the switch. Voltmeter transfer switches for AC shall be suitable for reading all line-to-line and line-to-neutral voltages for non- effectively earthed systems and for reading all line to line voltages for effectively earthed systems.
- 13.5. Synchronising switches shall be of maintained contact (stay put) type having a common removable handle for a group of switches. The handle shall be removable only in the OFF position and it shall be co-ordinated to fit into all the synchronising switches. These switches shall be arranged to connect the synchronising equipment when turned to the 'ON' position. One contact of each switch shall be connected in the closing circuit of the respective breaker so that the breaker cannot be closed until the switch is turned to the 'ON' position.
- 13.6. Lockable type of switches which can be locked in particular positions shall be provided when specified. The key locks shall be fitted on the operating handles.
- 13.7. The contacts of all switches shall preferably open and close with snap action to minimise arcing. Contacts of switches shall be spring assisted and contact faces shall be with rivets of pure silver or silver alloy. Springs shall not be used as current carrying parts
- 13.8. The contact combination and their operation shall be such as to give completeness to the interlock and function of the scheme.
- 13.9. The contact rating of the switches shall be as follows :

Description	Contact Rating in Amps		
	220V DC	50V DC	230V AC
Make and carry	10	10	10
Continuously			

Make and carry for 0.5 sec.	30	30	30
Break for Resistive load	3	20	7
Break for Inductive load with L/R = 40m sec.	0.2	-	-

#### **14. INDICATING LAMPS**

- 14.1. Indicating lamps shall be of cluster LED type suitable for panel mounting with rear terminal connections. Lamps shall be provided with series connected resistors preferably built in the lamp assembly. Lamps shall have translucent lamp covers to diffuse lights coloured red, green, amber, clear white or blue as specified. The lamp cover shall be preferably of screwed type, unbreakable and moulded from heat resisting material.
- 14.2. The lamps shall be provided with suitable resistors.
- 14.3. Lamps and lenses shall be interchangeable and easily replaceable from the front of the panel. Tools, if required for replacing the bulbs and lenses shall also be included in the scope of the supply.
- 14.4. The indicating lamps with resistors shall withstand 120% of rated voltage on a continuous basis.

#### **15. POSITION INDICATORS (if Applicable)**

- 15.1. Position indicators of "SEMAPHORE" type shall be provided when specified as part of the mimic diagrams on panels for indicating the position of circuit breakers, isolating/earthing switches etc. The indicator shall be suitable for semi-flush mounting with only the front disc projecting out and with terminal connection from the rear. Their strips shall be of the same colour as the associated mimic.
- 15.2. Position indicator shall be suitable for DC Voltage as specified. When the supervised object is in the closed position, the pointer of the indicator shall take up a position in line with the mimic bus bars, and at right angles to them when the object is in the open position. When the supply failure to the indicator occurs, the pointer shall take up an intermediate position to indicate the supply failure.
- 15.3. The rating of the indicator shall not exceed 2.5 W.
- 15.4. The position indicators shall withstand 120% of rated voltage on a continuous basis.

#### **16. SYNCHRONISING EQUIPMENT**

- 16.1. For sub-station equipped with sub-station Automation system, the requirement

of synchronisation is specified in chapter Sub-station Automation System and the same shall prevail. For other sub-station which is not equipped with Sub-station automation system following shall be applicable as per requirement.

- 16.1. The synchronising instruments shall be mounted either on a synchronising trolley or on a synchronising panel. The panel/ trolley shall be equipped with double analog voltmeters and double analog frequency meters, synchroscope and lamps fully wired. The size of voltmeters and frequency meters provided in the synchronising panel shall not be less than 144 X 144 sq.mm. Suitable auxiliary voltage transformers wherever necessary shall also be provided for synchronising condition. In case the synchroscope is not continuously rated, a synchroscope cut-off switch shall be provided and an indicating lamp to indicate that the synchroscope is energised, shall also be provided
- 16.1. Synchronising check relay with necessary ancillary equipment's shall be provided which shall permit breakers to close after checking the requirements of synchronising of incoming and running supply. The phase angle setting shall not exceed 35 degree and have voltage difference setting not exceeding 10%. This relay shall have a response time of less than 200 milliseconds when the two system conditions are met within present limits and with the timer disconnected. The relay shall have a frequency difference setting not exceeding 0.45% at rated value and at the minimum time setting. The relay shall have an adjustable time setting range of 0.5-20 seconds. A guard relay shall be provided to prevent the closing attempt by means of synchronising check relay when control switch is kept in closed position long before the two systems are in synchronism
- 16.1. The synchronising panel shall be draw out and swing type which can be swivelled in left and right direction. The synchronising panel shall be placed along with control panels and the number of synchronising panel shall be as indicated in BPS. The incoming and running bus wires of VT secondary shall be connected and run as bus wires in the control panels and will be extended to synchronising panel for synchronisation of circuit breakers. The selector switch provided for each circuit breaker in respective control panels shall be lockable type with a common key so that only one selector switch is kept in synchronising mode at a time.
- 16.1. Alternatively, the trolley shall be of mobile type with four rubber-padding wheels capable of rotating in 360 degree around the vertical axis. Suitable bumpers with rubber padding shall be provided all around the trolley to prevent any accidental damage to any panel in the control room while the trolley is in movement. The trolley shall have two meter long flexible cord fully wired to the instruments and terminated in a plug in order to facilitate connecting the trolley to any of the panels. The receptacle to accept the plug shall be provided on the panel.
- 16.1. At existing sub-stations, the synchronising scheme shall be engineered to be compatible with the existing synchronising scheme and synchronising socket/switch on the panel. In substations, where synchronising panels are available, the bidder shall carry out the shifting of the above panels, if

required, to facilitate the extension of control panel placement.

## **17. RELAYS**

- 17.1. All relays shall conform to the requirements of IS: 3231/IEC-60255/IEC 61000 or other applicable standards. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear.
- 17.2. All protective relays shall be of numerical type and communication protocol shall be as per IEC 61850. Further, the test levels of EMI as indicated in IEC 61850 shall be applicable to these relays.
- 17.3. All protective relays shall be in draw out or plug-in type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied loose and shall be included in contractor's scope of supply.
- 17.4. All AC operated relays shall be suitable for operation at 50 Hz. AC Voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for 1 amp CT secondary. All DC operated relays and timers shall be designed for the DC voltage specified, and shall operate satisfactorily between 80% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.
- 17.5. The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. also required for the complete protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme; contacts shall be silver faced with spring action. Relay case shall have adequate number of terminals for making potential free external connections to the relay coils and contacts, including spare contacts.
- 17.6. Timers shall be of solid state type. Time delay in terms of milliseconds obtained by the external capacitor resistor combination is not preferred and shall be avoided.
- 17.7. No control relay, which shall trip the power circuit breaker when the relay is de-energised, shall be employed in the circuits.
- 17.8. Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
- 17.9. Auxiliary seal-in-units provided on the protective relays shall preferably be of shunt reinforcement type. If series relays are used the following shall be strictly ensured:
  - (a) The operating time of the series seal-in-unit shall be sufficiently shorter than that of the trip coil or trip relay in series with which it operates to ensure definite operation of the flag indicator of the relay.
  - (b) Seal-in-unit shall obtain adequate current for operation when one or more



relays operate simultaneously.

- (c) Impedance of the seal-in-unit shall be small enough to permit satisfactory operation of the trip coil on trip relays when the D.C. Supply Voltage is minimum.
  - (d) Trip-circuit seal-in is required for all trip outputs, irrespective of the magnitude of the interrupted current. The trip-circuit seal-in logic shall not only seal-in the trip output(s), but also the relevant initiation signals to other scheme functions, (e.g. initiate signals to the circuit-breaker failure function, reclosing function etc.), and the alarm output signals.
  - (e) Two methods of seal-in are required, one based on the measurement of AC current, catering for those circumstances for which the interrupted current is above a set threshold, and one based on a fixed time duration, catering for those circumstances for which the interrupted current is small (below the set threshold).
  - (f) For the current seal-in method, the seal-in shall be maintained until the circuit-breaker opens, at which time the seal-in shall reset and the seal-in method shall not now revert to the fixed time duration method. For this seal-in method, the seal-in shall be maintained for the set time duration. For the line protection schemes, this time duration shall be independently settable for single- and three-pole tripping.
  - (g) Seal-in by way of current or by way of the fixed duration timer shall occur irrespective of whether the trip command originates from within the main protection device itself (from any of the internal protection functions), or from an external device with its trip output routed through the main protection device for tripping. Trip-circuit seal-in shall not take place under sub-harmonic conditions (e.g. reactor ring down).
- 17.10. The setting ranges of the relays offered, if different from the ones specified shall also be acceptable if they meet the functional requirements.
- 17.11. Any alternative/additional protections or relays considered necessary for providing complete effective and reliable protection shall also be offered separately. The acceptance of this alternative/ additional equipment shall lie with the OWNER.
- 17.12. All relays and their drawings shall have phase indications as R-Red, Y-yellow, B-blue
- 17.13. For numerical relays, the scope shall include the following:
- a) Necessary software and hardware to up/down load the data to/from the relay from/to the personal computer installed in the substation. However, the supply of PC is not covered under this clause.
  - b) The relay shall have suitable communication facility for future connectivity to SCADA. The relay shall be capable of supporting IEC-61850 protocol.
  - c) In case of line protection and transformer/reactor protection, the features like fault recorder and event logging function as available including available as optional feature in these relays shall be supplied and activated at no extra

cost to the owner. Also necessary software/ hardware for automatic uploading to station HMI/DR work station (as applicable) shall be supplied. It is to be clearly understood that these shall be in addition to Fault recorder function as specified at clause no. 28.

## **18. TRANSMISSION LINE PROTECTION**

- 18.1. All relays shall be suitable for series compensated line.
- 18.2. The line protection relays are required to protect the line and clear the faults on line within shortest possible time with reliability, selectivity and full sensitivity to all type of faults on lines. The general concept is to have two main protections having equal performance requirement specially in respect of time as called Main-I and Main-II for 220KV transmission lines and Main and back up protection for 132 KV transmission lines.
- 18.3. The Transmission system for which the line protection equipment are required is **indicated in Chapter 1 – General Technical Specification (GTS)**
- 18.4. The maximum fault current could be as high as 63kA but the minimum fault current could be as low as 20% of rated current of CT secondary. The starting & measuring relays characteristics should be satisfactory under these extremely varying conditions.
- 18.5. The protective relays shall be suitable for use with capacitor voltage transformers having non-electronic damping and transient response as per IEC.
- 18.6. Fault Recorder, Distance to fault Locator and Over voltage relay (stage -1/2) functions if offered as an integral part of line protection relays, shall be acceptable provided these meet the technical requirements as specified in the respective clauses.
- 18.7. Auto reclose relay function if offered as an integral part of line distance protection relay, shall be acceptable **for 132 KV lines only** provided the auto reclose relay feature meets the technical requirements as specified in the respective clause.
- 18.8. The following protections shall be provided for each of the Transmission lines:  
**For 220KV**  
**Main-I:** Numerical distance protection scheme  
**Main-II:** Numerical distance protection scheme of a make different from that of Main –I  
  
**For 132KV**  
**Main:** Numerical distance protection scheme  
**Back up:** Directional Over Current and Earth fault Protection  
The detailed description of line protections is given here under.
- 18.9. **Main-I and Main-II Distance Protection scheme:**

- (a) shall have continuous self monitoring and diagnostic feature
- (b) shall be non-switched type with separate measurements for all phase to phase and phase to ground faults
- (c) shall have stepped time-distance characteristics and three independent zones (zone 1, zone-2 and zone-3)
- (d) shall have mho or quadrilateral or other suitably shaped characteristics for zone-1, zone-2 and zone-3
- (e) shall have following maximum operating time (including trip relay time, if any) under given set of conditions and with CVT being used on line (with all filters included)

**(i) for 220 KV lines:**

**For Source to Impedance ratio: 4 15**

Relay setting (Ohms) (10 or 20) and 2 2

Fault Locations 50 50

(as % of relay setting)

Fault resistance (Ohms) 0 0

Maximum operating time 40 for all faults 45 for 3 ph. Faults & 60 for all other faults  
(Milliseconds)

**(ii) for 132 KV lines:**

A relaxation of 5 ms in above timings is allowed for 132 KV lines.

- (f) The relay shall have an adjustable characteristics angle setting range of 30 - 85 degree or shall have independent resistance(R) and reactance (X) setting.
- (g) shall have two independent continuously variable time setting range of 0-3 seconds for zone-2 and 0-5 seconds for zone-3
- (h) shall have resetting time of less than 55 milli-seconds (including the resetting time of trip relays)
- (i) shall have facilities for offset features with adjustable 10-20% of Zone-3 setting
- (j) shall have variable residual compensation
- (k) shall have memory circuits with defined characteristics in all three phases to ensure correct operation during close-up 3 phase faults and other adverse conditions and shall operate instantaneously when circuit breaker is closed to zero-volt 3 phase fault
- (l) shall have weak end in-feed feature
- (m) shall be suitable for single & three phase tripping
- (n) shall have a continuous current rating of two times of rated current. The voltage circuit shall be capable of operation at 1.2 times rated voltage. The relay shall also be capable of carrying a high short time current of 70 times

rated current without damage for a period of 1 sec.

- (o) shall be provided with necessary self reset type trip duty contacts for completion of the scheme (Minimum number of these trip duty contacts shall be four per phase) either through built in or through separate high speed trip relays. Making capacity of these trip contacts shall be 30 amp for 0.2 seconds with an inductive load of  $L/R > 10$  mill seconds. If separate high speed trip relays are used, the operating time of the same shall not be more than 10 milliseconds
- (p) shall be suitable for use in permissive under reach/ over reach/ blocking communication mode
- (q) shall have suitable number of potential free contacts for Carrier aided Tripping, Auto reclosing, CB failure, Disturbance recorder & Data acquisition system
- (r) include power swing blocking protection which shall
  - have suitable setting range to encircle the distance protection described above
  - block tripping during power swing conditions
  - release blocking in the event of actual fault
- (s) include fuse failure protection which shall monitor all the three fuses of C.V.T. and associated cable against open circuit
  - inhibit trip circuits on operation and initiate annunciation
  - have an operating time less than 7 milliseconds
  - remain inoperative for system earth faults
- (t) include a directional back up Inverse Definite Minimum Time (IDMT) earth fault relay with normal inverse characteristics as per IEC 60255-3 as a built in feature or as a separate unit for 220KV transmission lines
- (u) Must have a current reversal guard feature.

#### 18.10. **Back-up Directional Over Current and Earth fault protection scheme**

- (a) shall have three over current and one earth fault element(s) which shall be either independent or composite unit(s)
- (b) shall include necessary VT fuse failure relays for alarm purposes
- (c) **over current elements** shall
  - have IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting
  - have a variable setting range of 50-200% of rated current
  - have a characteristic angle of 30/45 degree lead
  - include hand reset flag indicators or LEDs
- (d) **earth fault element** shall

- have IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting
- have a variable setting range of 20-80% of rated current
- have a characteristic angle of 45/60 degree lag
- include hand reset flag indicators or LEDs
- include necessary separate interposing voltage transformers or have internal feature in the relay for open delta voltage to the relay

18.11. **LINE OVER VOLTAGE PROTECTION RELAY** shall

- monitor all three phases
- have two independent stages
- stage- I & II as built-in with line distance relays Main I & II respectively are acceptable
- 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
- have an adjustable setting range of 100-170% of rated voltage with a time delay of 100-200 mill seconds for the second stage
- be tuned to power frequency
- provided with separate operation indicators (flag target) for each stage relays
- have a drop-off to pick-up ratio greater than 95%
- provide separate out-put contacts for each 'Phase' and stage for breaker trip relays, event logger and other scheme requirements

18.12. All trip relays used in transmission line protection scheme shall be of self/electrical reset type depending on application requirement.

19. **CIRCUIT BREAKER PROTECTION:**

This shall include following functions:

19.1. **Numerical AUTO RECLOSING** function shall

- have single phase reclosing facilities
- have a continuously variable single phase dead time range of 0.1-2 seconds
- have a continuously variable reclaim time range of 5-300 seconds
- 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.
- be of single shot type
- have priority circuit to closing of both circuit breakers in case one and half breaker arrangements to allow sequential closing of breakers
- However, Auto-reclose as in built function of bay controller unit (BCU) (if

supplied) provided for sub-station automation system is also acceptable.

19.2. **LOCAL BREAKER BACK-UP PROTECTION SCHEME** shall

- (a) be triple pole type
- (b) have an operating time of less than 15 milli seconds
- (c) have a resetting time of less than 15 milli seconds
- (d) have three over current elements
- (e) be arranged to get individual initiation from the corresponding phase of main protections of line for each over current element. However, common three phase initiation is acceptable for other protections and transformer /reactor equipment protections
- (f) have a setting range of 20-80% of rated current
- (g) have a continuous thermal withstand two times rated current irrespective of the setting
- (h) have a timer with continuously adjustable setting range of 0.1-1 seconds
- (i) have necessary auxiliary relays to make a comprehensive scheme
- (j) be similar relays for complete scope of work as per specification**

**20. REACTOR PROTECTION**

20.1. **Differential Protection Relay** shall

- (a) be triple pole type
- (b) have operation time less than 25 milli-seconds at 5 times setting
- (c) be tuned to system frequency
- (d) have current setting range of 10 to 40% of 1 Amp. or a suitable voltage setting range
- (e) be high impedance / biased differential type
- (f) be stable for all external faults

20.2. **Restricted Earth Fault Protection Relay** shall

- (a) be single pole type
- (b) be of current/voltage operated high impedance type
- (c) have a current setting of 10-40% of 1 Amp./have a suitable voltage setting range
- (d) be tuned to system frequency
- (e) have a suitable non-linear resistor to limit the peak voltage to 1000 Volts

20.3. **Back up impedance protection Relay** shall

- (a) be triple pole type, with faulty phase identification/ indication

- (b) be single step polarised 'mho' distance/ impedance relay suitable for measuring phase to ground and phase to phase faults
- (c) have adequate ohmic setting range to cover at least 60% of the impedance of the reactor and shall be continuously variable
- (d) have an adjustable characteristic angle of 30-80 degree
- (e) have a definite time delay relay with a continuously adjustable setting range of 0.2-2.0 seconds
- (f) include VT failure relay which shall block the tripping during VT fuse failure condition

Further, Reactor auxiliary protections contacts (Buchholz, PRV, Oil Temperature, Winding Temperature etc.) can be wired suitably in above protections or provide separate Flag relays/Auxiliary relays as per scheme requirements.

## **21. TRANSFORMER PROTECTION**

All transformer protection functions may be grouped into Group-I and Group-II protections in the following manner:

Group-I Protection: Following protection functions may be provided in Group-I Transformer protection relay:

- a) Differential Protection as per clause no. 21.1
- b) Over fluxing Protection for HV side as per clause no. 21.2
- c) Direction Over current and earth fault protection for HV side as per clause no. 21.4
- d) Over Load Protection as per clause no. 21.5

Group-II Protection: Following protection functions may be provided in Group-II Transformer protection relay:

- e) REF Protection as per clause no. 21.3
- f) Over fluxing Protection for IV/LV side as per clause no. 21.2
- g) Direction Over current and earth fault protection for IV/LV side as per clause no. 21.4
- h) Neutral Current Relay for Single Phase Transformer Bank

The various protections as built-in function of Group I/II protections shall be accepted only if the functional requirements of corresponding protections as specified in clause no. 21.1 to 21.6 are met otherwise separate protection relay(s) shall be offered.

### **21.1. Transformer differential protection scheme shall**

- (a) be triple pole type, with faulty phase identification/ indication
- (b) have an operating time not greater than 30 milli seconds at 5 times the rated current

- (c) have three instantaneous high set over-current units
- (d) have an adjustable bias setting range of 20-50%
- (e) be suitable for rated current of 1 Amp.
- (f) have second harmonic or other inrush proof features and also should be stable under normal over fluxing conditions. Magnetising inrush proof feature shall not be achieved through any intentional time delay e.g. use of timers to block relay operation or using disc operated relays
- (g) have an operating current setting of 15% or less
- (h) include necessary separate interposing current transformers for angle and ratio correction or have internal feature in the relay to take care of the angle & ratio correction
- (i) have a fault recording feature to record graphic form of instantaneous values of following analogue channels during faults and disturbances for the pre fault and post fault period:
  - current in all three windings in nine analogue channels in case of 400kV class and above transformers or 6 analogue channels for lower voltage transformers and Voltage in one channel

The disturbance recorder shall have the facility to record the following external digital channel signals apart from the digital signals pertaining to differential relay:

1. REF protection operated
2. HV Breaker status (Main and tie)
3. IV Breaker status
4. Bucholz /OLTC Bucholz alarm / trip etc.
5. WTI/OTI/PRD alarm/trip of transformer etc.

Necessary hardware and software, for automatic up-loading the data captured by disturbance recorder to the personal computer (DR Work Station) available in the substation, shall be included in the scope.

#### 21.2. **Over Fluxing Protection Relays** shall

- (a) operate on the principle of Voltage to frequency ratio and shall be phase to phase connected
- (b) have inverse time characteristics, matching with transformer over fluxing withstand capability curve
- (c) provide an independent 'alarm' with the time delay continuously adjustable between 0.1 to 6.0 seconds at values of 'v/f' between 100% to 130% of rated values
- (d) tripping time shall be governed by 'v/f' Vs. time characteristics of the relay
- (e) have a set of characteristics for Various time multiplier settings. The



maximum operating time of the relay shall not exceed 3 seconds and 1.5 seconds at 'v/f' values of 1.4 and 1.5 times, the rated values, respectively.

- (f) have an accuracy of operating time, better than  $\pm 10\%$
- (g) have a resetting ratio of 95 % or better

21.3. **Restricted Earth Fault Protection** shall

- (a) be single pole type
- (b) be of current/voltage operated type
- (c) have a current setting range of 10-40% of 1 Amp./ have a suitable voltage setting range
- (d) be tuned to the system frequency

21.4. **Back-up Over Current and Earth fault protection scheme with high set feature**

- (a) Shall have three over current and one earth fault element(s) which shall be either independent or composite unit(s).
- (b) The scheme shall include necessary VT fuse failure relays for alarm purposes
- (c) Over current relay shall
  - have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 50-200% of rated current
  - have low transient, over reach high set instantaneous unit of continuously variable setting range 500-2000 % of rated current
  - have a characteristic angle of 30/45 degree lead
  - include hand reset flag indicators or LEDs.
- (d) Earth fault relay shall
  - have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current
  - have low transient, over reach high set instantaneous unit of continuously variable setting range 200-800 % of rated current
  - have a characteristic angle of 45/60 degree lag
  - include hand reset flag indicators or LEDs
  - include necessary separate interposing voltage transformers or have internal feature in the relay for open delta voltage to the relay

- 21.5. **Transformer Overload Protection Relay** shall
- (a) be of single pole type
  - (b) be of definite time over-current type
  - (c) have one set of over-current relay element, with continuously adjustable setting range of 50-200% of rated current
  - (d) have one adjustable time delay relay for alarm having setting range of 1 to 10.0 seconds, continuously.
  - (e) have a drop-off/pick-up ratio greater than 95%.
- 21.6. **Transformer Neutral Current Protection relay** (for 1-Phase transformer bank neutral) shall
- (a) have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current
- 21.7. **Further, Transformer auxiliary protections contacts (Buchholz, PRV, Oil Temperature, Winding Temperature, OLTC Buchholz etc.) can be wired suitably in above protections or provide separate Flag relays/Auxiliary relays as per scheme requirements.**

## **22. TEE DIFFERENTIAL PROTECTION RELAYS**

- 22.1. **TEE-1 Differential protection relay** shall
- (a) be triple pole type
  - (b) have an operating time less than 30 milliseconds at 5 times the rated current
  - (c) have three instantaneous high set over current units
  - (d) have an adjustable bias setting range of 20-50%
  - (e) have an operating current setting of 15% of 1 Amp or less
- 22.2. **TEE-2 Differential Protection relay** shall
- (a) be triple pole type
  - (b) have operating time less than 25 milliseconds at 5 times setting
  - (c) be tuned to system frequency
  - (d) have current setting range of 20 to 80% of 1 Amp
  - (e) be voltage operated, high impedance type
  - (f) be stable for all external faults
  - (g) be provided with suitable non linear resistors across the relay to limit the peak voltage to 1000 volts

## **23. TRIP CIRCUIT SUPERVISION RELAY**

- (a) The relay shall be capable of monitoring the healthiness of each 'phase' trip-coil and associated circuit of circuit breaker during 'ON' and 'OFF' conditions.
- (b) The relay shall have adequate contacts for providing connection to alarm and event logger.
- (c) The relay shall have time delay on drop-off of not less than 200 milli seconds and be provided with operation indications for each phase

24. **TRIPPING RELAY**

**High Speed Tripping Relay shall**

- (a) be instantaneous (operating time not to exceed 10 milli-seconds).
- (b) reset within 20 milli seconds
- (c) be D.C. operated
- (d) have adequate contacts to meet the requirement of scheme, other functions like auto-reclose relay, LBB relay as well as cater to associated equipment like event logger, Disturbance recorder, fault Locator, etc.
- (e) be provided with operation indicators for each element/coil.

25. **DC SUPPLY SUPERVISION RELAY**

- (a) The relay shall be capable of monitoring the failure of D.C. supply to which, it is connected.
- (b) It shall have adequate potential free contacts to meet the scheme requirement.
- (c) The relay shall have a 'time delay on drop-off' of not less than 100 milli seconds and be provided with operation indicator/flag.

26. **BUS BAR PROTECTION**

26.1. Single bus bar protection scheme shall be provided for each main bus and transfer bus (as applicable) for 220KV and 132 KV voltage levels

26.2. Each Bus Bar protection scheme shall

- (a) have maximum operating time up to trip impulse to trip relay for all types of faults of 25 milli seconds at 5 times setting value.
- (b) operate selectively for each bus bar
- (c) give hundred percent security up to 63 KA fault level for 220KV and 31.5 KA for 132 KV
- (d) incorporate continuous supervision for CT secondary against any possible open circuit and if it occurs, shall render the relevant zone of protection inoperative and initiate an alarm
- (e) not give false operation during normal load flow in bus bars
- (f) incorporate clear zone indication

- (g) be of phase segregated and triple pole type
  - (h) provide independent zones of protection (including transfer bus if any). If the bus section is provided then each side of bus section shall have separate set of bus bar protection schemes
  - (i) include individual high speed electrically reset tripping relays for each feeder. However, in case of distributed Bus bar protection, individual trip relay shall not be required if bay unit is having trip duty contacts for breaker tripping.
  - (j) be transient free in operation
  - (k) include continuous D.C. supplies supervision
  - (l) not cause tripping for the differential current below the load current of heaviest loaded feeder. Contractor shall submit application check for the same.
  - (m) shall include necessary C.T. switching relays wherever C.T. switching is involved and have 'CT' selection incomplete alarm
  - (n) include protection 'IN/OUT' switch for each zone
  - (o) shall include trip relays, CT switching relays (if applicable), auxiliary CTs (if applicable) as well as additional power supply modules, input modules etc. as may be required to provide a Bus-bar protection scheme for the complete bus arrangement i.e. for all the bays or breakers including future bays as per the Single line diagram for new substations. However for extension of bus bar protection scheme in existing substations, scope shall be limited to the bay or breakers covered under this specification. Suitable panels (if required) to mount these are also included in the scope of the work.
  - (p) In case of distributed Bus bar Protection, the bay units for future bays may be installed in a separate panel and the same shall be located in switchyard panel room where bus bar protection panel shall be installed.
- 26.3. Built-in Local Breaker Backup protection feature as a part of bus bar protection scheme shall also be acceptable.
- 26.4. At existing substations, Bus-bar protection scheme with independent zones for each bus, will be available. All necessary co-ordination for 'AC' and 'DC' interconnections between existing schemes (Panels) and the bays proposed under the scope of this contract shall be fully covered by the bidder. Any auxiliary relay, trip relay, flag relay and multi tap auxiliary CTs (in case of biased differential protection) required to facilitate the operation of the bays covered under this contract shall be fully covered in the scope of the bidder.
- 26.5. The test terminal blocks (TTB) to be provided shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material with boxes and barriers moulded integrally. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting and testing

facilities for CT circuits.

**27. WEATHER PROOF RELAY PANELS (If Applicable)**

- (a) This panel shall include necessary number of electrically reset relays each with at least eight contacts for isolator auxiliary contacts multiplication and for changing the CT and DC circuits to relevant zones of bus bar protection.
- (b) The panel shall be sheet steel enclosed and shall be dust, weather and vermin proof. Sheet steel used shall be at least 2.0 mm thick and properly braced to prevent wobbling.
- (c) The enclosures of the panel shall provide a degree of protection of not less than IP-55 (as per IEC-60529).
- (d) The panel shall be of free standing floor mounting type or pedestal mounting type as per requirement.
- (e) The panel shall be provided with double hinged doors with padlocking arrangement.
- (f) All doors, removable covers and panels shall be gasketed all around with synthetic gaskets Neoprene/EPDM. However, XLPE gaskets can also be used for fixing protective glass doors. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh
- (g) Cable entries shall be from bottom. Suitable removable cable gland plate shall be provided on the cabinet for this purpose.
- (h) All sheet steel work shall be degreased, pickled, phosphated and then applied with two coats of zinc chromates primer and two coats of finishing synthetic enamel paint, both inside and outside. The colour of the finishing paint shall be light grey.
- (i) Suitable heaters shall be mounted in the panel to prevent condensation. Heaters shall be controlled by thermostats so that the cubicle temperature does not exceed 30°C. On-off switch and fuse shall be provided. Heater shall be suitable for 230V AC supply Voltage.
- (j) The test terminal blocks (TTB) to be provided shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material with boxes and barriers moulded integrally. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting and testing facilities for CT circuits.

**28. FAULT RECORDER**

- 28.1. The fault recorder shall be provided for transmission line and the fault recorder as in-built feature of line distance relay is also acceptable provided the requirements of following clauses are met.

- 28.2. Fault recorder shall be microprocessor based and shall be used to record the graphic form of instantaneous values of voltage and current in all three phases, open delta voltage & neutral current, open or closed position of relay contacts and breakers during the system disturbances.
- 28.3. The Fault recorder shall consist of individual acquisition units, one for each feeder and an Evaluation unit which is common for the entire Substation. Whenever, more than one acquisition units are connected to an Evaluation unit, necessary hardware and software shall also be supplied for on line transfer of data from all acquisition units to Evaluation unit.
- 28.4. The acquisition unit is connected with evaluation unit being supplied as described in chapter 17 sub-station automation through bus conforming to IEC 61850. In case of extension sub-station which is equipped with Sub-station Automation System based on IEC 61850, one set of evaluation software shall be supplied and loaded in existing fault recorder evaluation unit. Automatic uploading of disturbance files from acquisition unit to evaluation unit shall be done through existing station bus only conforming to IEC 61850. Necessary configuration/updation including hardware if any shall be in the scope of the contractor.
- 28.5. In case of extension of existing substation(s) which are without sub-station automation system, one set of Evaluation unit shall be supplied for each substation where ever disturbance recorders are required to be supplied along with necessary evaluation software as specified above. The Evaluation unit shall consist of a desktop personal computer (including at least 17" TFT colour monitor, mouse and keyboard) and printer. The desktop PC shall have Pentium - IV processor or better and having a clock speed 3.0GHz or better. The hard disk capacity of PC shall not be less than 300 GB and RAM capacity shall not be less than 3 GB
- 28.6. The evaluation unit hardware, for substations having SAS, shall be as described in clause no. 4.0 of chapter sub-station automation system.
- 28.7. Fault recorder shall have atleast 8 analogue and 16 digital channels for each feeder.
- 28.8. Acquisition units shall acquire the Disturbance data for the pre fault and post fault period and transfer them to Evaluation unit automatically to store in the hard disk. The acquisition units shall be located in the protection panels of the respective feeders.
- 28.9. The acquisition unit shall be suitable for inputs from current transformers with 1A rated secondary and capacitive voltage transformers with 63.5V (phase to neutral voltage) rated secondary. Any device required for processing of input signals in order to make the signals compatible to the Fault recorder equipment shall form an integral part of it. However, such processing of input signals shall in no way distort its waveform.
- 28.10. The equipment shall be carefully screened, shielded, earthed and protected as may be required for its safe functioning. Also, the Fault recorder shall have stable software, reliable hardware, simplicity of maintenance and immunity from the effects of the hostile environment of EHV switchyard which

are prone to various interference signals typically from large switching transients.

- 28.11. Necessary software for transferring the data automatically from local evaluation unit to a remote station and receiving the same at the remote station through owner's PLCC/VSAT/LEASED LINE shall be provided.
- 28.12. Evaluation software shall be provided for the analysis and evaluation of the recorded data made available in the PC under WINDOWS environment. The Software features shall include repositioning of analog and digital signals, selection and amplification of time and amplitude scales of each analogue and digital channel, calculation of MAX/MIN frequency, phase difference values, recording of MAX/MIN values etc. of analogue channel, group of signal to be drawn on the same axis etc, listing and numbering of all analogue and digital channels and current, voltage, frequency and phase difference values at the time of fault/tripping. Also, the software should be capable of carrying out Fourier /Harmonic analysis of the current and voltage wave forms. The Disturbance records shall also be available in COMTRADE format (IEEE standard- Common Format for Transient data Exchange for Power System)
- 28.13. The Evaluation unit shall be connected to the printer to obtain the graphic form of disturbances whenever desired by the operator.
- 28.14. Fault recorder acquisition units shall be suitable to operate from 220V DC or 110V DC as available at sub-station. Evaluation unit along with the printer shall normally be connected to 230V, single phase AC supply. In case of failure of AC supply, Evaluation unit and printer shall be switched automatically to the station DC through Inverter of adequate capacity which shall form a part of Fault recorder system. The inverter of adequate capacity shall be provided to cater the requirement specified in chapter sub-station automation clause no. 8.0 and DR evaluation unit.
- 28.15. The acquisition unit shall have the following features
- (a) Facility shall exist to alarm operator in case of any internal faults in the acquisition units such as power supply fail, processor / memory fail etc and same shall be wired to annunciation system.
  - (b) The frequency response shall be 5 Hz on lower side and 250 Hz or better on upper side.
  - (c) Scan rate shall be 1000 Hz/channel or better.
  - (d) Pre-fault time shall not be less than 100 milliseconds and the post fault time shall not be less than 2 seconds (adjustable). If another system fault occurs during one post-fault run time, the recorder shall also be able to record the same. However, the total memory of acquisition unit shall not be less than 5.0 seconds
  - (e) The open delta voltage and neutral current shall be derived either through software or externally by providing necessary auxiliary transformers.
  - (f) The acquisition unit shall be typically used to record the following

digital channels :

- 1 Main CB R phase open
- 2 Main CB Y phase open
- 3 Main CB B phase open
- 4 Main-1 carrier received
- 5 Main-1 protection operated
- 6 Main/Tie /TBC Auto reclosed operated
- 7 Over Voltage -Stage-1 /2 operated
- 8 Reactor / Stub/TEE-1/2/UF protection operated
- 9 Direct Trip received
- 10 Main-2 carrier received
- 11 Main- 2/ Back Up protection operated
- 12 Bus bar protection operated
- 13 LBB operated of main /tie/TBC circuit breaker
- 14 Tie/TBC CB R phase open
- 15 Tie/TBC CB Y phase open
- 16 Tie/TBC CB B phase open

- (g) In case the Fault recorder is in-built part of line distance protection, above digital channels may be interfaced either externally or internally.
- (h) Any digital signal can be programmed to act as trigger for the acquisition unit. Analog channels should have programmable threshold levels for triggers and selection for over or under levels should be possible.

28.16. The **colour laser** printer shall be provided which shall be compatible with the desktop PC and shall use Plain paper. The print out shall contain the Feeder identity, Date and time (in hour, minute and second up to 100th of a second), identity of trigger source and Graphic form of analogue and digital signals of all the channels. Two packets of **A4 size** paper (500 sheets in each packet) suitable for printer shall be supplied.

28.17. Each Fault recorder shall have its own time generator and the clock of the time generator shall be such that the drift is limited to  $\pm 0.5$  seconds/day, if allowed to run without synchronisation. Further, Fault recorder shall have facility to synchronise its time generator from Time Synchronisation Equipment having output of following types

- Voltage signal : (0-5V continuously settable, with 50m Sec. minimum pulse duration)
- Potential free contact (Minimum pulse duration of 50 m Sec.)
- IRIG-B



- RS232C

The recorder shall give annunciation in case of absence of synchronising within a specified time.

28.18. Substations where Time Synchronisation Equipment is not available, time generator of any one of the Fault recorders can be taken as master and time generators of other Fault recorders and Event loggers in that station shall be synchronised to follow the master.

29. **DISTANCE TO FAULT LOCATOR** shall

- a) be electronic or microprocessor based type
- b) be 'On-line' type
- c) be suitable for breaker operating time of 2 cycles
- d) have built-in display unit
- e) the display shall be directly in percent of line length or kilometres without requiring any further calculations
- f) have an accuracy of 3% or better for the typical conditions defined for operating timings measurement of distance relays
- g) The above accuracy should not be impaired under the following conditions:
  - presence of remote end infeed
  - predominant D.C. component in fault current
  - high fault arc resistance
  - severe CVT transients
- h) shall have mutual zero sequence compensation unit if fault locator is to be used on double circuit transmission line
- i) built in feature of line distance relay is acceptable provided the requirements of above clauses are met

30. **TIME SYNCHRONISATION EQUIPMENT**

30.1. The Time synchronisation equipment shall receive the co-ordinated Universal Time (UTC) **transmitted** through Geo Positioning Satellite System (GPS) and synchronise equipments to the Nepal Standard Time in a substation.

30.2. Time synchronisation equipment shall include antenna, all special cables and processing equipment etc.

30.3. It shall be compatible for synchronisation of Event Loggers, Disturbance recorders and SCADA at a substation through individual port or through Ethernet realised through optic fibre bus.

30.4. Equipment shall operate up to the ambient temperature of 50 degree centigrade and 80% humidity.

30.5. The synchronisation equipment shall have 2 micro-second accuracy. Equipment shall give real time corresponding to IST (taking into consideration all factors like voltage, & temperature variations, propagation & processing

delays etc).

- 30.6. Equipment shall meet the requirement of IEC 60255 for storage & operation.
- 30.7. The system shall be able to track the satellites to ensure no interruption of synchronisation signal.
- 30.8. The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse, as per requirement.
- 30.9. The equipment offered shall have six (6) output ports. Various combinations of output ports shall be selected by the customer, during detailed engineering, from the following :
- Potential free contact (Minimum pulse duration of 50 milli Seconds.)
  - IRIG-B
  - RS232C
  - SNTP Port
- 30.10. The equipment shall have a periodic time correction facility of one second periodicity.
- 30.11. Time synchronisation equipment shall be suitable to operate from 220V DC or 110V DC as available at Substation.
- 30.12. Equipment shall have real time digital display in hour, minute, second (24 hour mode) & have a separate time display unit to be mounted on the top of control panels having display size of approx. 100 mm height.

### **31. RELAY TEST KIT**

- 31.1. One relay test kit shall comprise of the following equipment as detailed here under
- |               |   |
|---------------|---|
| 3 sets        | Relay tools kits  |
| 2 nos.        | Test plugs <b>for TTB</b>                                     |
| <b>2 nos.</b> | Test plugs for using with modular type relays (if applicable) |

### **32. TYPE TESTS**

- 32.1. The reports for following type tests shall be submitted during detailed engineering for the Protective relays, Fault Recorder, Fault locator and Disturbance recorder:
- a) Insulation tests as per IEC 60255-5
  - b) DC Voltage dips and interruptions/Variation as per IEC 6100-4-29.
  - c) High frequency disturbance test as per IEC 61000-4 16, Class IV (Not applicable for electromechanical relays)
  - d) Electrostatic discharges as per IEC 61000-4-2, level; 4 (not applicable for Electromechanical relays)
  - e) Fast transient test as per IEC 61000, Level IV (Not applicable for

electromechanical relays)

- f) Relay characteristics, performance and accuracy test as per IEC 60255
- Steady state Characteristics and operating time
  - Dynamic Characteristics and operating time for distance protection relays and current differential protection relays
  - Conformance test as per IEC 61850-10.

For Fault recorder, Disturbance recorder; only performance tests are intended under this item.

- g) Tests for thermal and mechanical requirements as per IEC 60255-6
- h) Tests for rated burden as per IEC 60255-6
- i) Contact performance test as per IEC 60255-0-20 (not applicable for Distance to fault locator and Disturbance recorder)

In case there is a change either in version or in model (Except firmware) of the relay, the contractor has to submit the type test reports for the offered revision/model.

- 32.2. Steady state & Dynamic characteristics test reports on the distance protection relays, as type test, shall be based on test programme specified in Appendix A on simulator/network analyser/PTL. Alternatively, the files generated using Electromagnetic transient Programme (EMTP) can also be used for carrying out the above tests. Single source dynamic tests on transformer differential relay shall be/ should have been conducted based on general guidelines specified in CIGRE committee 34 report on Evaluation of characteristics and performance of Power system protection relays and protective systems.

### 33. **CONFIGURATION OF RELAY AND PROTECTION PANELS**

The following is the general criteria for the selection of the equipments to be provided in each type of panel. However, contractor can optimise the requirement of panels by suitably clubbing the feeder protection and CB relay panels. It may be noted that Main-I and Main-II protections for line can not be provided in single panel. 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, TBC<br>Bus section, Bus Reactor and Transformer |
| b | Ammeter with Selector switch | 1 set for each line reactor  |

c	Wattmeter with transducer	1 set for each line, transformer
d	Varmeter with transducer	1 set for each line, transformer, Bus reactor
e	Varmeter with transducer	1 set for each Line Reactor
f	CB Control switch	1 no. for each Circuit breaker
g	Isolator Control switch	1 no. for each isolator
h	Semaphore	1 no. for each earth switch
i	Red indicating lamp	1 no. for each Circuit breaker
j	Red indicating lamp	1 no. for each isolator
k	Green indicating lamp	1 no. for each Circuit breaker
l	Green indicating lamp	1 no. for each isolator
m	White indicating lamp (DC healthy lamp)	2 nos for each feeder
n	Annunciation windows with associated annunciation relays	18 nos for each feeder
o	Push button for alarm Accept/reset/lamp test	3 nos for each control panel
p	Synchronising Socket	1 no. for each Circuit Breaker if required
q	Synchronising selector Switch required	1 no. for each Circuit Breaker switch if required
r	Protection Transfer Switch	1 no. for each breaker in case of DMT /DM*/SMT scheme(Except TBC

s	Mimic to represent SLD	Lot	in all control panels
t	Voltmeter with selector reactor Switch	1 no	for each line, transformer , bus
u	Cut out, mounting and wiring for RWTI and selector switch	Lot	for transformers/reactors

**Notes:**

- 1 For transformer feeders, all equipments of control panel shall be provided separately for HV and MV sides.
2. In case of incomplete diameter (D and I type layouts), control panel shall be equipped fully as if the diameter is complete, unless otherwise specified. Annunciation relays shall also be provided for the same and if required, necessary panel shall be supplied to accommodate the same.
3. The above list of equipments mentioned for control panel is generally applicable unless it is defined elsewhere and in case of bay extension in existing substations, necessary equipments for matching the existing control panel shall be supplied.
4. Common synchronising switch is also acceptable in Synchronising trolley for new Substations. In this case. individual synchronising selector switch is not required for each Circuit Breaker in control panel
5. Each line /HV side of transformer/MV/LV side of transformer /Bus reactor /TBC /BC/ Bus Section shall be considered as one feeder for above purpose.

**LINE PROTECTION PANEL (220 & 132kV)**

The Line Protection panel for transmission lines shall consist of following protection features/schemes

Sl. No.	Description	220kV	132kV
1.	Main-1 Numerical Distance protection scheme	1 Set	1 Set
2.	Main-2 Numerical Distance protection scheme	1 Set	NIL

Sl. No.	Description	220kV	132kV
3.	Over Voltage Protection Scheme	NIL	NIL
4.	Fault Recorder	1 Set	NIL
5.	Distance to fault Locator	1 Set	1 Set
6.	3 Phase Trip Relays	2 Nos.	2 Nos.
7.	Flag relays, carrier receive relays, aux. Relays, timers etc as per scheme requirements	As required	As required
8.	Under Voltage protection relay for isolator/earth switch	2 Nos	2 Nos
9.	Cut-out and wiring with TTB for supplied energy meter	1 Set	1 Set
10.	Directional Back up Over current and E/F protection scheme	1 Set	1 Set

In a substation where 220 KV lines are under the scope of the contract, bidder is required to give identical Main-1 and Main-2 distance protection schemes for all voltage levels.

**a) 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.	-----
11	Revenue Energymeter (As per T.S. Chapter-1)	1No.	1No.

**\$ BCU for 220kV&132kV Bays has been included in the BOQ details of SAS.**

**c) 33kV BREAKER RELAY PANEL**

**(Acceptable as Part of Line /transformer Relay panel)**

The breaker relay panel for 33kV shall comprise of the following :

	Without A/R
1. DC supply supervision relay	2 no.
2.Trip circuit supervision relays	2 nos.
3. Emergency CB TNC Switches	1 No.
4. Flag relays, aux. relays, timers, trip relays etc. As per scheme requirements. (Acceptable as part of BCU)	Lot

**d) TRANSFORMER PROTECTION PANEL (220/132kV)**

The protection panel for Auto transformer/Transformer shall consists of the following features/schemes:

S. No.	Description	HV side	MV/LV side
1.	Transformer Differential Protection scheme	1 Nos.	Nil
2.	Restricted Earth fault protection scheme	1 no.	1 no@
@ Not applicable for auto-transformer			
3.	Directional back up O/C and E/F relay with non directional high set feature	1 set	1 set
4.	Over Fluxing Protection scheme	1 no.	--
5.	Overload protection scheme	1 nos.	NIL
6.	Three phase trip relays	2 nos.	2 nos.
7.	CVT selection relays as per scheme requirement	Lot	Lot
8.	Cut-out and wiring with TTB for supplied energy meter	1 set	1 set
9.	Transformer Neutral Current relay for 1-Phase transformer bank	1 Set	
10.	Flag Relays/Aux. Relays for wiring Transformer auxiliary protection contacts such as Buchholz, Oil Temperature, Winding Temperature, PRV, OLTC Buchholz etc. as per scheme requirements	As required	

The above protection schemes may be clubbed in Group-I/II as per clause no. 21 of technical specification.

e)

**REACTOR PROTECTION PANEL (220kV & 132kV)**

The protection panel for Reactor shall consist of the following protection features/schemes:

Sl. No.	Description	Qty.
1.	Reactor Differential Protection scheme	1 no.
2.	Restricted Earth fault Protection scheme	1 no.
3.	Reactor back up impedance protection scheme	1 set
4.	Three phase trip relays	2 nos.
5.	CVT selection relay as per scheme requirement	Lot
6.	Flag Relays/Aux. Relays for wiring Reactor auxiliary protection contacts such as Buchholz, Oil Temperature, Winding Temperature, PRV etc. as per scheme requirements	As required

f)

**BREAKER RELAY PANEL (220kV & 132kV)**

The breaker relay panel shall comprise of the following:

Sl.	Description	With A/R	Without A/R
-----	-------------	----------	-------------



No.

- |  |             |             |
|--|-------------|-------------|
| 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.

**34. ERECTION AND MAINTENANCE TOOL EQUIPMENTS**

All special testing equipment required for the installation and maintenance of the apparatus, instruments devices shall be furnished in relevant schedule

**35. TROPICALISATION**

Control room will be normally air-cooled/air- conditioned. All equipments shall however be suitable for installation in a tropical monsoon area having hot, humid climate and dry and dusty seasons with ambient conditions specified in the specification. All control wiring, equipment and accessories shall be protected against fungus growth, condensation, vermin and other harmful effects due to tropical environment.

## Test programme for distance relays

### General Comments:

1. These test cases are evolved from the report of working group 04 of study committee 34 (Protection) on evaluation of characteristics and performance of power system protection relays and protective systems. For any further guidelines required for carrying out the tests, reference may be made to the above document.
2. The test shall be carried out using network configuration and system parameters as shown in the figure-1
3. All denotations regarding fault location, breakers etc are referred in figure –1
4. The fault inception angles are referred to R- N voltage for all types of faults
5. The fault inception angle is zero degree unless otherwise specified
6. Where not stated specifically, the fault resistance ( $R_f$ ) shall be zero or minimum as possible in simulator
7. Single pole circuit breakers are to be used
8. The power flow in double source test is 500 MW

### System parameters

System voltage =400KV

CTR= 1000/1

PTR = 400000/110 (with CVT, the parameters of CVT model are shown in figure –2)

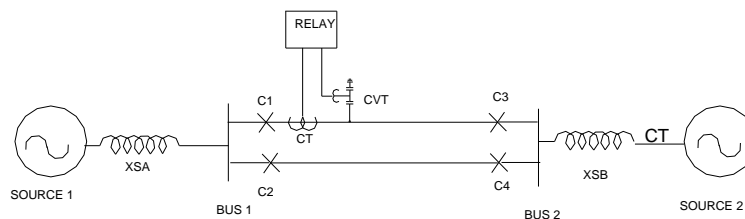


FIGURE 1

**Line parameters/km**Positive Sequence Resistance, (r1) = 0.02897  $\Omega$ Positive Sequence Reactance (x1) = 0.3072  $\Omega$ Zero Sequence Resistance (r0) = 0.2597  $\Omega$ Zero Sequence Reactance (x1) = 1.0223  $\Omega$ Zero Sequence Mutual Resistance (rm) = 0.2281  $\Omega$ Zero Sequence Mutual Reactance (xm) = 0.6221  $\Omega$ **Zero Sequence susceptance (bo) = 2.347  $\mu$  mho**Positive Sequence susceptance (b1) = 3.630  $\mu$  mho

Type of line	Short		Long
Secondary line impedance	2 $\Omega$		20 $\Omega^*$
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 $\Omega$ (5500 MVA)	109.09 $\Omega$ (1467 MVA)	290.9 $\Omega$ (550 MVA)

\* Alternatively , the tests can be done with 10  $\Omega$  secondary impedance and source impedance may accordingly be modified

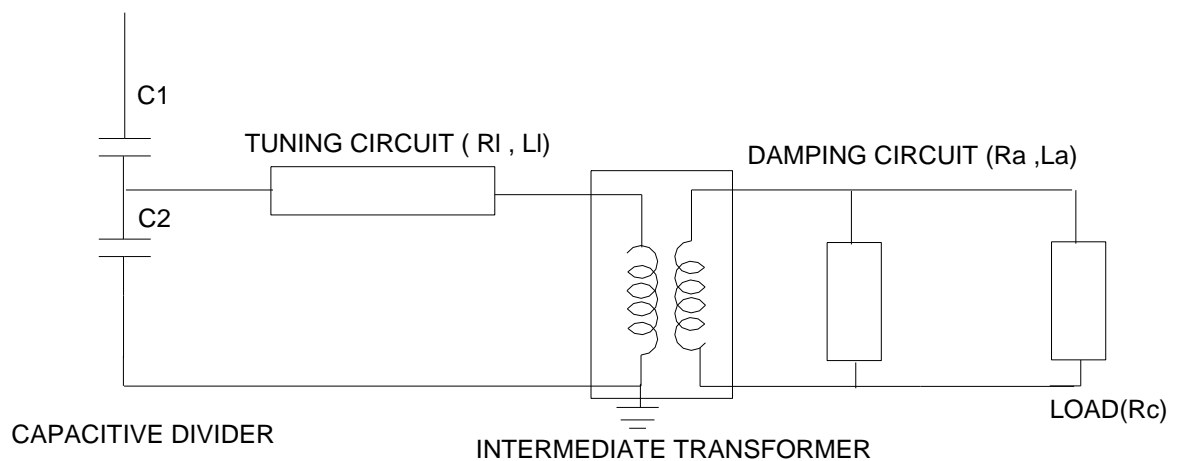
**CVT Model**

Figure-2

XC1	1.455 $\mu$ mho
XC2	27.646 $\mu$ mho
RI	320 $\Omega$
XLI	34243 $\Omega$
Ra	4.200 $\Omega$
Xla	197.92 $\Omega$
Rc	14.00 $\Omega$
Transformation ratio of Intermediate transformer	181.8

Details of fault cases to be done

Sl no	Description	Single source with short line (2 $\Omega$ )		Single source long line (20 $\Omega$ )	Double source with short double line (2 $\Omega$ )	Double source with long single line (20 $\Omega$ )
		CLOSE C1, OPEN C2,C3,C4		CLOSE C1, OPEN C2,C3,C4	CLOSE C1, C2,C3,C4	CLOSE C1,C3 OPEN C2,C4
		SIR=4	SIR=15	SIR =4	SIR = 4	SIR=4
1	Dynamic accuracy for zone 1	Tests to be done at 2 locations ( 84 % and 76 % of line length ) X 4 faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°, 90°)= 16 cases	Tests to be done at 2 locations ( 84 % and 76 % of line length ) X 4 faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°,90°)= 16 cases	Tests to be done at 2 locations ( 84 % and 76 % of line length ) X 4 faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°,90°)= 16 cases		Tests to be done at 2 locations (84% and 76% of line length) X 4 faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°, 90°)= 16 cases
2	Operating time for	Tests to be done at 3	Tests to be done at 3	Tests to be done at 3	Tests to be done at 1	Tests to be done at 1

Sl no	Description	Single source with short line (2 $\Omega$ )		Single source long line (20 $\Omega$ )	Double source with short double line (2 $\Omega$ )	Double source with long single line (20 $\Omega$ )
	zone 1 at SIR =4	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	locations (0 % , 40 % and 64 % of line length ) X 4 faults (RN , YB, YBN, RYB) X 4 fault inception angle (0°,30°,60°a nd 90°)= 48 cases	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	location (40 % of line length) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°,30°,60° and 90°)= 16 cases	location (40 % of line length ) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°,30°,60° and 90°)= 16cases
3	Operating time for zone II and Zone III	Tests to be done at 1 location ( 100 % of line length ) X 1 faults (RN, YB, YBN, RYB) X 2 zones (II and III) = 2 cases	Tests to be done at 1 location (100 % of line length) X 1 faults (RN , YB, YBN, RYB) X 2 zones (II and III) = 2 cases	Tests to be done at 1 location (100 % of line length ) X 1 faults (RN , YB, YBN, RYB) X 2 Zones (II and III) = 2 cases		
4	Switch on to fault feature			Tests to be done at 2 location ( 0 % and 32 %) X 1 faults (RYB) Any fault inception angle = 2 cases		
5	Operation during current reversal				Tests to be done at 2 location (0 % and 80 % of line length ) X 1 faults ( RN) X 1 fault inception angle (0	

Si n o	Description	Single source with short line (2 $\Omega$ )		Single source long line (20 $\Omega$ )	Double source with short double line (2 $\Omega$ )	Double source with long single line (20 $\Omega$ )
					degrees) = 2 cases	
		CLOSE C1, OPEN C2,C3,C4		CLOSE C1, OPEN C2,C3,C4	CLOSE C1, C2,C3,C4	CLOSE C1,C3 OPEN C2,C4
		SIR=4	SIR=15	SIR =4	SIR = 4	SIR=4
6	Operation at simultaneous faults				Tests to be done at 2 location (8 % and 64 % of line length ) X 2 faults ( RN in circuit 1 to BN in circuit 2 and RN in circuit 1 to RYN in circuit 2 in 10 ms) X 1 fault inception angle ( 0 ° ) = 4 cases (*1)	
7	Directional sensitivity					Tests to be done at 1 location (0% reverse) X 6 faults ( RN ,YB, YBN , RYB,RN with Rf=13.75 ohm(sec) and RYN with Rf= 13.75 Ohm (sec) X 2 fault inception angle (0° ,90° ) = 12cases
8	Limit for fault resistance					Tests to be done at 2 location ( 0% and 68 % of line length) X

Si n o	Description	Single source with short line (2 $\Omega$ )		Single source long line (20 $\Omega$ )	Double source with short double line (2 $\Omega$ )	Double source with long single line (20 $\Omega$ )
						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 16: PLCC**

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## **CHAPTER 16: PLCC**

### **1. GENERAL**

- 1.1 All the PLCC equipment covered under the package shall conform to the requirements of the latest edition of the relevant IEC Specifications or equivalent National Standards,

### **2. Standard and Drawing**

- 2.1 The IEC Specifications and international publication relevant to the equipment covered under this specification shall include but not be limited to the list given at Annexure - 'C' of Chapter 2 - GTR:

### **3. Location of Equipment**

- 3.1 The PLCC Equipment and Line traps as specified shall be installed at the respective ends of the transmission lines. The Contractor shall be responsible for coordinating the equipment supplied by him with the already existing carrier equipment at the respective sub-stations. Contractor shall also be responsible for collecting all the necessary information/data from the respective sub-stations/concerned Electricity Authority for the installation of the equipment.

### **4. Frequency Planning**

- 4.1 For planning frequency and output power of carrier terminals Bidders may plan for a minimum receive signal to noise ratio of 25 dB for the speech channels without companders. The noise power in 2.1 kHz band (300-2400 Hz) may be taken as -13 dBm referred to the coupling point of the H.T. line. An additional minus two and a half dB may be assumed for psophometric factor. As far as coupling loss (phase to phase) is concerned the Bidders may assume the same as 6dB at one coupling end for evaluating SNR. For protection channels the minimum SNR shall not be less than 15 dB under adverse weather. A safety margin of 9 dB shall be taken over and above these SNR values in order to cater for variations in line attenuation from the computed value as inhand reserve. Frequency and output power of PLC terminals for protection shall be planned such that the protection signal is received with full reliability even when one of the phase is earthed or is on open circuit on the line side causing an additional minimum loss of 6 dB.

The Bidder shall indicate the noise power in the bandwidth used for protection signaling and shall submit the SNR calculations for speech as well as protection

channels on all the line section given in at the proposed frequencies. Sample calculations for SNR requirement and power allocation over different channels must be furnished along with the bid. Maximum permissible line attenuation shall be clearly brought out in these calculations. Further, Bidder shall submit details of frequency planning done (including computer studies carried out and facilities available) for PLCC links on EHV lines in the past in the relevant schedule of DRS. Bidder must enclose one copy of computer study result done in the past along with the Bid.

- 4.2 Successful Bidder shall be fully responsible for the coordination required with concerned Office of NEA for finalising the frequency plan.
- 4.3 The frequency plan will be referred to concerned Department for clearance and in case any change in the Contractor's recommended carrier frequency and power output is proposed by these authorities, the Contractor shall have to modify his proposal accordingly. Change of power output shall, however, not involve repeater stations.

## 5. **Proposed Arrangement**

- 5.1 The power line carrier communication equipment required by the OWNER is to provide primarily efficient, secure and reliable information link for carrier aided distance protection and direct tripping of remote-end breaker and also for speech communication between 220 kV sub-stations. It shall include separate carrier terminals of multipurpose type for speech and protection purposes. All carrier terminals including those for protection shall be suitable for point to point speech communication also.

- 5.2 For security reasons each 220kV transmission line shall be protected by Main-I and Main-II protections as given below :

Main-I            Numerical Distance protection with permissive inter-tripping.

Main-II           Distance protection of a different measuring technique than that of relay under Main I.

132kV transmission lines shall have Main I protection same as above along with backup overcurrent and earth fault protections.

- 5.3 The requirement of carrier information on each link covered under this specification is as below :
- a) In case of 220 KV/132 KV lines, speech and data channel can also be used for protection wherever possible.

- b) One speech channel with a facility to superimpose data signals upto 1200Baud.

However, the number of channels for protection signaling , speech and data communication for SAS and Load dispatch centre shall be as per the BOQ given in price schedule.

- 5.4 The equipment for protection signals shall have high degree of reliability and speed. It shall be guaranteed to function reliably in the presence of noise impulse caused by isolator or breaker operation. It shall also be possible to effect direct tripping of breaker at one end when the other end breaker opens out either manually or by relays such as Bus fault relay etc.
- 5.5 The time intervals between receipt of a trip command on the transmit side, its transmission over the carrier link, reception at the far end and giving command to the trip relays at the distant end shall not exceed 20 mS. for permissive inter-tripping and 30 m sec. for direct inter-tripping even for the longest line section. The above timings are inclusive of operating time for auxiliary relays and interposing relays, if any, included in the PLCC equipment.
- 5.6 The requirement of protection signaling channel is such that security against incorrect signals being received shall be at least two to three orders higher than reliability against a signal not being received.
- 5.7 For reasons of security and reliability, phase to phase coupling for 220kV S/C lines shall be employed. Inter-circuit coupling shall be used for 220/132kV D/C lines and phase to ground coupling shall be used for 132 KV S/C lines. Double differential coupling shall also be considered for double circuit lines. Bidders must furnish detailed write-up on methods of coupling and recommend suitable coupling mode for double-circuit lines along-with the bids. The coupling arrangement shall be fully optimized by the Contractor after conducting detailed study of every line section individually, taking into account the temperature variations, transpositions, earth resistivity, conductor configuration, carrier channels requirements, security and reliability criteria and other relevant details. The line attenuation shall be calculated for complete range of frequencies. The earth resistivity data, existing frequency networks and other relevant details of each line will be furnished to the Contractor for carrying out the computer studies and frequency planning. The Contractor shall complete the computer studies wherever required and submit the frequency plan and optimum coupling details within a period of one month from the date of receipt of above data.
- 5.8 The Contractor shall have to check and prove through the results of his computer studies that attenuation due to transpositions in the EHV lines is within limits and the offered equipment will perform satisfactorily.

- 5.9 The Bidder shall submit curves illustrating ‘incorrect tripping’ and “Failure to trip” probability plotted against corona noise level, in the presence of impulse noise due to switching of isolator and circuit breaker etc. Details of field tests and laboratory tests for successful operation of his equipment, under such adverse conditions shall be furnished by the Bidder. These are to be related to end-to-end signaling and shall take into account the type of communication link e.g. account shall be taken of transpositions in the phase to phase coupled H.T. line. Details of field tests and laboratory tests for successful operation of the equipment under the above circumstances shall be submitted by the Bidder illustrating the above parameters.

6. **LINE TRAP**

- 6.1 Line trap shall be broad band tuned for its entire carrier frequency range. Resistive component of impedance of the line trap within its carrier frequency blocking range shall not be less than 570 ohms for 220kV and 132 kV systems..
- 6.2 Line trap shall be provided with a protective device in the form of surge arrestors which shall be designed and arranged such that neither significant alteration in its protective function nor physical damage shall result from either temperature rise or the magnetic field of the main coil at continuous rated current or rated short time current. The protective device shall neither enter into operation nor remain in operation, following transient actuation by the power frequency voltage developed across the line trap by the rated short time current.
- The lightning arrestor shall be station class current limiting active gap type. Its rated discharge current shall be 10 kA. Coordination, however, shall be done by taking 20 kA at 8/20 micro-sec. discharge current into account. Bidder has to furnish full justification in case the use of gap-less metal oxide arrestor is recommended by them.
- 6.3 The lightning arrestor provided with the line trap of each rating shall fully comply with the requirements of IEC-60099-1 Part-I. It shall conform to type tests as applicable and type test certificate for the same shall be submitted by the Bidder.
- 6.4 The lightning arrestor provided with the line trap shall be subject to routine and acceptance tests as per IEC-60099-1 (Part-I).
- 6.5 Radio interference voltage for 245/132 kV shall not exceed 500 micro volts at 163/97 kV (rms) respectively.
- 6.6 Line trap shall be equipped with the bird barriers.
- 6.7 Line trap shall conform to IEC 60353 (latest) fulfilling all the technical requirements. The rated short time current for 1 Second shall be 31.5/40/50/63 kA

as per requirement. The mH. rating shall be 0.2/0.5/1.0 mH depending on frequency plan.

6.8 The Bidder shall indicate continuous current rating of the line trap at 65 deg. C ambient.

6.9 Reports for the following type tests on each type of line trap shall be submitted as per clause 9.2 of GTR .

1. Measurement of Inductance of the main coil.
2. Measurement of temperature rise.
3. Insulation test.
4. Short time current test.
5. Corona Extinction Voltage test (procedure for this shall be mutually agreed ).
6. Radio Interference Voltage measurement test (procedure for this shall be mutually agreed ).

6.10 The Bidder must enclose with his bid the reports of type and routine tests conducted on similar equipment earlier as per IEC-60353.

6.11 Welding

All the welding included in the manufacture of line traps shall be performed by personnel and procedure qualified in accordance with ASME-IX/IEC Standard and all the critical welds shall be subject to NDT as applicable.

6.12 Line Trap Mounting

6.12.1 The Line Trap shall be suitable for outdoor pedestal or suspension mounting and shall be mechanically strong enough to withstand the stresses due to maximum wind pressure of 260 kg/square meter.

6.12.2 For pedestal mounting, each line trap shall be mounted on a tripod structure formed by three insulator stacks arranged in a triangular form. All the accessories and hardware, mounting stool including bolts for fixing the line trap on insulators shall be of non-magnetic material and shall be supplied by the Contractor.

6.12.3 For suspension mounting, Contractor shall be required to coordinate the mounting arrangement with the existing arrangement. Non-magnetic suspension hook/link of adequate length and tensile strength to provide necessary magnetic clearance between the line trap and suspension hardware shall be supplied by the Contractor.

- 6.13 Terminal Connectors
- 6.13.1 The line traps shall be suitable for connecting to 4" IPS Aluminium tube or 3" IPS Al. tube or ACSR single/twin/Quad bundle conductor with horizontal or vertical take off. Necessary connector shall be supplied by the Contractor.
- 6.13.2 No part of clamp or connector (including hardware) shall be of magnetic material.
- 6.13.3 Clamps and connectors shall be designed corona controlled. All nuts and bolts shall be suitably shrouded.
- 6.13.4 Radio interference Voltage for 245/132 kV shall not exceed 500 microvolts at 163/97 kV (rms) respectively.
- 6.13.5 Clamps/connectors shall be designed for the same current ratings as line trap and temperature rise shall not exceed 35 deg. C over 50 deg. C ambient. No current carrying part shall be less than 10 mm thick.
- 6.13.6 Clamps/connectors type Test reports shall also be submitted for following:
- a) Visual Corona Extinction Test
  - b) Radio Interference Voltage Measurement
- 6.13.7 Bidders are required to submit alongwith their bid typical drawings clearly indicating the above mentioned features of the line traps, line trap mounting arrangement and terminal connectors. For suspension mounted line traps, Bidder shall submit drawings showing single point as well as multipoint (normally 3 point) suspension arrangements.

## 7. COUPLING DEVICE

- 7.1 The coupling devices shall be interposed between the capacitor voltage transformer and coaxial line to the PLC transmitter/receiver, and in conjunction with the capacitor voltage transformer shall ensure :
- a) Efficient transmission of carrier frequency signals between the carrier frequency connection and the power line.
  - b) Safety of personnel and protection of the low voltage parts and installation, against the effects of power frequency voltage and transient over voltages.
- 7.2 The coupling device, in conjunction with the CVT shall form an electric filter of band pass type :

- a) It shall match characteristic impedance of H.T. line to impedance of the carrier frequency connection.
- b) Galvanic isolation between primary and secondary terminals of the coupling device shall be performed by the above mentioned transformer.
- c) Power frequency currents derived by the CVT may be drained to the earth by a separate inductance termed drain coil of suitable rating.
- d) Voltage surges coming from the power line at the terminals of the coupling device shall be limited by a non-linear surge arrester of suitable rating in the primary side. Requirement of a gas type voltage arrester in secondary side of the coupling device shall have to be fully justified, but in any case the input circuit of PLC. equipment shall have protective devices in the form of zener diodes and surge suppressers.

The surge arrester shall have power frequency spark over voltage coordinated with the equipment ahead of it.

- e) For direct and efficient earthing of its primary terminals, the coupling device shall be equipped with an earthing switch. The Earth Switch shall be available for earthing of CVT-HT terminals, when the coupling filter units are removed from circuit for maintenance/ replacement. The design shall take due regard of requirements for safety in accordance with the Electricity Rules of Nepal.

7.3 Two numbers 'phase to earth' type coupling filters shall be used to achieve 'phase to phase'/'inter-circuit coupling'. Connection between secondaries of the two phase to earth type coupling device shall be through a balancing transformer/hybrid such that reliable communication shall be ensured even when one of the coupled phase is earthed or open circuited on the line side.

7.4 Coupling device shall conform to IEC-60481 and shall have the following carrier frequency characteristics as applicable to a phase to earth type coupling device:

- a) Nominal line side impedance      400 ohms for 220/132 kV line
- b) Nominal equipment side impedance      75 ohms (unbalanced)
- c) Composite loss      Not more than 2 dB
- d) Return Loss      Not less than 12 dB

- e) Bandwidth                      Shall suit the frequency plan between 36 and 500 kHz
- f) Nominal peak                  Not less than 650 Watt.  
envelope power  
(for Inter-modulation product 80 dB down)

- 7.5            The coupling device shall be suitable for outdoor mounting. Temperature of metallic equipment mounted outdoor is expected to rise upto 65 deg. C during the maximum ambient temperature of 50 deg. C specified. The equipment offered by the Bidder shall operate satisfactorily under these conditions.
- 7.6            The H.T. Terminal of coupling device shall be connected to H.F. Terminal of the CVT by means of 6 mm sq. copper wire with suitable lugs & taped with 11 kV insulation by the contractor.
- 7.7            Coupling device shall have at least two terminals for carrier equipment connection. Bidder shall confirm that such a parallel connection to coupling device directly will not result in any additional attenuation.
- 7.8            The coupling device including the drainage coil, surge arrester and earthing switch shall conform to type tests and shall be subject to routine tests as per IEC-60481.

Routine tests shall include but not be limited to the following :

- i) Composite loss and return loss tests on coupling device.
- ii) Turns ratio test and insulation tests on the balancing transformer.
- iii) Milli volt drop test, power frequency voltage test and mechanical operation test on earthing switch.
- iv) Power frequency spark over test for lightning arrester as per relevant IEC.

- 7.9            Reports for the following type tests on coupling device shall be submitted as per clause 9.2 of GTR .

- 1.)Return loss test.
- 2)Composite loss test.
- 3)Distortion and inter modulation test .



4) Impulse voltage test.

5) Tests on Arrestors

Bidder shall furnish, along with his bid copies of all type and routine test conducted earlier on similar coupling device in accordance with relevant standards.

## **8. High Frequency Cable**

8.1 High frequency cable shall connect the coupling device installed in the switchyard to the PLC terminal installed indoor.

8.2 The cable shall be steel armoured and its outer covering shall be protected against attack by termites. Bidder shall offer his comments on method employed by him for earthing of screen and submit full justification for the same with due regard to safety requirements.

Bidder must enclose in his bid a detailed construction drawing of the cable being offered, with mechanical and electrical parameters.

8.3 Impedance of the cable shall be such as to match the impedance of the PLC terminal on one side and to that of the coupling device on the other side over the entire carrier frequency range of 40-500 kHz.

8.4 Conductor resistance of cable shall not exceed 16 ohms per Km at 20°C.

8.5 The cable shall be designed to withstand test voltage of 4 kV between conductor and outer sheath for one minute.

8.6 Bidder shall specify attenuation per Km of the cable at various carrier frequencies in the range of 40 to 500 kHz. The typical attenuation figures for H.F. cable shall be in the range of 1 to 5 dB/km in the frequency range of 40-500 kHz.

8.7 The H.F. cable shall conform to type tests and be subjected to routine tests as per IEC -61196-1/IEC60811-1/IS-11967/IS5026/ International standard.

8.8 All HF cables within the scope of this specification shall be laid and termination shall be carried out by the Contractor.

8.9 The cables shall be supplied wound on drums containing nominal length of 500 meters each. However, exact requirement of drum lengths shall be finalised during detailed engineering to avoid joint in HF cable and its wastage.

## 9. Power Line Carrier Terminal

9.1 As already indicated the information link shall be provided for speech, protection, telex and data services.

9.2 PLC terminal shall use Amplitude Modulation and shall have single side band transmission mode. These shall be equipped for fixed frequency duplex working.

Characteristic input and output parameters of the SSB PLC terminals shall be as per IEC-60495, unless otherwise specified.

9.3 The salient features are detailed out below :

- |    |  |   |
|----|--|---|
| a) | Mode of transmission   | Amplitude Modulation single side band with suppressed carrier or reduced carrier.   |
| b) | Carrier frequency  | 40 to 500 kHz range   |
| c) | Nominal carrier frequency band in either direction of transmission | 4.0 kHz   |
| d) | Power output (PEP) at HF terminal                                  | 20/40/80 Watt   |
| e) | Frequency difference between a pair of PLC terminals               | Frequency difference between <u>VF</u> signal at the transmitting and receiving ends will not exceed 2 Hz with suppressed carrier. With reduced carrier frequency difference shall be zero. This shall include permissible ambient temperature variation and supply frequency and voltage variation of (+) 15% and (-) 10%. |
| f) | Automatic gain control   | For 40 dB change in carrier frequency signal level within the regulation range, change in VF receive levels of both speech and other signals shall be less than 1dB.  |
| g) | Supply voltage   | 48 V DC + 15%, - 10%. (Positive pole earthed)   |

- 9.4 All the PLC terminals shall be of multipurpose type. The Bidder shall confirm that the total transmission time for teleprotection shall not exceed 20 ms for permissive and 30 ms for direct tripping signals. Speech and teleprotection channels shall independently fulfill the SNR requirements out of the power allocated to its channel from the total power of the PLC terminals.
- Detailed calculation for SNR requirement and power allocation over different channels should be furnished alongwith the bid.
- 9.5 In the input circuit of the PLC terminal protective devices shall be provided in the form of zener diodes or surge suppressers in order to eliminate any surge transfer through the coupling device or the surge induced in the connecting path of H.F. cable.
- 9.6 To improve voice transmission characteristics for the system, compressors and expanders shall be provided. The companders shall have at least 2:1 compression ratio with a corresponding expansion ratio of 1:2. The operating range of compander shall be compatible with the audio power levels specified for 4 wire operation. The improvement gained by companders shall however not be taken into account for power allocation and shall be in-hand reserve.
- 9.7 Sudden changes in input level to the receiver shall not cause false tripping. The Bidder shall clearly indicate in his offer the methods adopted to ensure above phenomenon. The receiver design shall also provide protection against false tripping from random noise.
- 9.8 Fail-safe devices shall be provided, so that a malfunction in one unit or subassembly cannot cause damage elsewhere in the system. All plug-in equipment shall be fitted with features to prevent improper insertion. The electrical cables shall not be routed across sharp edges or near sources of high temperature. The adjustments, which are susceptible to misadjustment from accidental contact/vibration, shall be equipped with suitable locking devices.
- 9.9 The PLC set shall be designed to give guaranteed performance from 0 deg. C to 50 deg. C ambient temperature. The thermal capability of the equipment shall be so designed that the equipment remains operational successfully upto 60 deg. C ambient temperature. Any ventilation fans provided for circulation of air inside the cabinets shall conform to relevant Nepalese/International Standards..
- 9.10 The terminals shall be provided with built-in indicating instrument to facilitate checking of important voltages and current values and signal levels in different parts of the PLC Terminals. Protection fuses shall be provided in all important circuits and fuses shall be so mounted as allow their easy inspection and replacement. All test points shall be easily accessible.

The carrier set shall be provided with suitable supervision and alarm facilities. Individual parts of the carrier set should be accessible from front, making it possible to place the carrier cabinets side-by-side. All components and parts of the carrier set shall be suitably tropicalised.

- 9.11 PLC terminals shall be housed in floor mounting sheet metal cabinets, suitable for mounting on concrete plinth as well as channel frame by means of nuts and bolts or welding. All the panels shall be properly earthed to the OWNER's earthing grid by the Contractor. Contractor shall submit detailed drawings for earthing connections.
- 9.12 All the panels shall be protected against moisture ingress and corrosion during storage. Panels shall be properly dried before they are installed and energized. Bidder shall indicate measures adopted to prevent ingress of moisture during operation.
- 9.13 All cabinets having PLC terminals shall be provided with lamps of sufficient wattage for interior illumination with switch. Each panel shall be provided with 230 V AC single phase socket with switch to accept 5 & 15A Nepalese standard /International plugs.
- 9.14 A name plate shall be provided on the front door of each cabinet indicating channel function, transmitter frequency and direction etc.
- 9.15 Reports for the following type tests for PLC Terminals shall be submitted as per clause 9.2 of GTR .  
Tests to determine various characteristics of PLC terminals as per IEC –60495.
- a)Voltage variation
  - b)Carrier frequency range band.
  - c)Frequency accuracy
  - d)Transmit/Receive frequency difference.
  - e)Automatic gain control
  - f)Harmonic distortion
  - g) Selectivity
  - h)Output impedance, Return loss&Tapping loss
  - i)Return loss, Af inputs/Outputs

- j)Balance to ground
- k)Limiter action
- l)Spurious emission
- m)Carrier frequency levels and levels
- n)Attenuation distortion
- o)Noise generated within terminal
- p)Near and far end cross talk
- q)Group delay distortion
- r)Conducted noise
- s)Telephone signaling channel
- t)Speech levels
- u)Voltage withstand test
- v)Insulation test

- 9.16 Heat Soaking of panels  
All the solid state equipment/system panels shall be subjected to the Heat Soaking as per the following procedure :

All solid state equipment shall be burn-in for minimum of 120 hours continuously under operation condition. During the last 48 hours of testing, the ambient temperature of the test chamber shall be 50°C. Each PLC panel shall be complete with all associated sub-systems and the same shall be in operation during the above test. During the last 48 hours of the above test, the temperature inside the panel shall be monitored with all the doors closed. The temperature of the panel interior shall not exceed 65°C.

## 10. **SPEECH COMMUNICATION**

- 10.1 PLC equipment offered shall provide telephone communication between the stations where the transmission lines are terminating. The equipment shall be suitable for providing the following facilities :

- a) It shall be possible for subscriber at any of the stations to contact the subscriber at all other stations connected in the system as shown in the specification drawing by dialing his call number. To achieve this a EPAX with 4 wire interface & remote subscriber units shall be provided/available at different stations.
- b) The equipment shall contain all normal facilities like ring back tone, dial tone, engage tone & priority tone, and suitable pulses to establish and disconnect communication between subscribers.
- c) The equipment shall be provided with necessary alarm circuits and fuses etc.
- d) The equipment shall be of 4 kHz bandwidth on either direction and be suitable for providing superimposed data and teleprinter facilities at a later date without major modifications and high cost. The Bidder shall clearly indicate in his bid the provision made in his proposal for future development and the extent to which such additional facilities can be added at a later date.
- e) The system shall be completely automatic with definite number allocated for each telephone. The numbering scheme for telephones, exchange and tie lines shall be developed by the Bidder and indicated in the bid. Final numbering scheme shall be fully coordinated with the existing/ proposed future systems by the Contractor.
- f) Arrangement for over-riding facilities shall be provided by means of priority keys wherever specified. The over-riding facility shall enable cutting-in ongoing calls with the priority key and ask the concerned parties to finish their conversation. The wanted number should then get automatically connected without having to redial the number.
- g) All the carrier telephone conversations shall be secret and it should not be possible for anybody to over hear the conversation going on between any two parties excepting those provided with over-riding facilities.
- h) The necessary cables for connecting all the telephone instruments ordered for at each sub-station (including wiring and termination) shall be provided by the Contractor. These telephone instruments shall be located within control room building at respective sub-station.
- i) The cabinets housing the equipment for EPAX, four wire E/M interface & remote subscriber units (four wire) shall have mounting arrangement similar to that for PLC terminals.
- j) All the terminals for speech shall be with Transit Band Pass Filter suitable for tuning at site and shall be wired for addition of VFTs in future.

- k) Equipment for speech communication must be fully compatible with OWNER's existing equipment. Any interfaces required for proper matching and connection with the OWNER's existing equipment shall be provided by the Contractor.
- l) Terminals for protection shall be suitable for speech between two ends of each transmission line or on tandem operation basis with back to back connection at the intermediate stations.
- n) Each PLC terminal for speech as well as protection purposes shall be provided with a plug-in type service telephone and buzzer. Further, 4 wire remote telephone instruments (parallel to service telephone) shall also be provided on one PLC terminal for protection for each link. These instruments shall be located in respective Switchyard control room to enable the operator to make emergency calls on point-to-point basis. Each such instrument shall be equipped with a buzzer and 'press-to-call' key and shall not require any additional power supply units.

## 10.2 **Remote End Four Wire 'E/M' Interface & Subscriber Unit**

10.2.1 The remote end four wire 'E/M' interface & subscriber units, wherever specified, shall be of electronic type and be suitable for working on fixed frequency power line carrier systems with E & M signaling. This shall be housed in the carrier set and be fully wired to the power line carrier terminal equipment.

10.2.2 This unit shall receive and register various signals, on PLCC Channels, from remote end exchanges or other remote end subscriber units and associated four wire interface unit.

10.2.3 The four wire interface unit shall be equipped for routing transit calls and shall be supplied pre-wired to handle calls for minimum eight directions, in a form suitable for transmission over PLCC.

10.2.4 The bidder shall also indicate the total number of trunk-line capacity, available with each four-wire interface unit.

The unit shall be suitable for connecting two-wire telephone sets. Further, the associated telephone cables for locating two subscriber lines, within the control room is in the scope of this specification.

## 10.3 **Network Protection Equipment (Protection Coupler)**

- 10.3.1 The Bidder shall offer voice frequency transmission equipment which shall work on frequency shift or coded signal principle for transmission/reception of protection signals as single purpose channel. The equipment shall be suitable for connection to the power line carrier terminal.
- 10.3.2 The voice frequency transmission equipment shall not only be insensitive to corona noise but shall also remain unaffected by impulse type noise which are generated by electrical discharge and by the opening and closing of circuit breakers, isolators, earthing switches etc. The equipment shall also be made immune to a field strength of 10V/m expected to be caused by portable radio transmitters in the range of 20-1000 MHz. In his offer, bidder shall clearly explain as to what measures have been taken to make the equipment insensitive to corona noise, white noise and to impulse noise of an amplitude larger than the wanted signal and submit full field test and laboratory test reports. The guarantee on design data shall not be acceptable.
- 10.3.3 The equipment shall be unaffected by spurious tripping signals. The Bidder shall submit proof as to how this is achieved satisfactorily.
- 10.3.4 The equipment shall be suitable for transmission of direct and permissive trip signal as well as blocking signals for protective gear of power system. The equipment shall be operated in the audio frequency range in speech band or above speech band as superimposed channel in 4 kHz band of SSB carrier. The equipment shall operate with full duplex frequency shift mode of operation or by switching between two frequencies in case of coded signals. The protection signaling equipment shall be of solid state design, modular in construction and have a proven operating record in similar application over EHV systems. Details regarding application of the equipment over 220kV systems shall be submitted along with the bid. Each protection signaling equipment shall provide:
- i) Transmission facilities for minimum three protection signals.
  - ii) Reception facilities for minimum three protection signals.
- 10.3.5 The equipment shall be designed for remote tripping/ blocking on permissive basis and direct tripping for reactor fault and others. The overall time of PLC, VFT and transmission path for permissive trip/blocking shall be 20 m. Sec. or less and for direct tripping 30 m. Sec. or less even for the longest line section.

Operating time lower than specified above may be preferred provided they fulfill the requirements of security and reliability as mentioned below :

False - trip probability  $10^{-5}$   
(Noise burst of any amplitude)

Fail to trip probability  $10^{-2}$



for S/N 6 dB in 3.1 kHz Band  
(white Noise Measurement)

10.3.6 It may be emphasized that specified time, as mentioned above is composed of the following :

- a) Back-to-back signal delay in frequency shift or coded signals protection equipment.
- b) Back-to-back delay in PLC terminal.
- c) Delay in transmission line.
- d) Operation time of interposing relay, if any, in frequency shift or coding equipment.

Reference is invited in this regard to the guide lines expressed in CIGRE Publication “Teleprotection” report by Committee 34 and 35.

10.3.7 The following transfer criteria shall be provided by the equipment:

- a) Transmit side

One number potential free NO (normally open) contact of protective relays (To be supplied by the OWNER) of under noted rating for each of the following functions:

- i) Permissive trip command
- ii) Direct trip command

Contact Rating:

Maximum voltage	: 660 Volts
Maximum current rating	: 5 amps
Maximum power rating	: 1250 W/VA

- b) Receive Side

Voice frequency transmission equipment for network protection shall be provided with one potential free NO (normally open) contact of the under noted rating for each of the following functions:

- i) Permissive trip command

ii) Direct trip command

Contact Rating:

Rated voltage	:	250 Volts DC
Rated current	:	0.1 A DC
Other Parameters	:	As per IEC-60255-25

c) Alarm

In addition, the voice frequency protection terminal shall provide at least one number potential free change over contact of the following rating for alarm purposes.

Rated voltage	:	250 volts DC
Rated current	:	0.1 A DC
Other Parameters	:	As per IEC-60255-25

10.3.8 The Contractor shall submit drawings showing inter-connection between PLCC and protection panels for approval by the OWNER.

10.3.9 It has to be ensured that under no circumstances protection channel should share the power. Each protection channel shall be able to transmit power for which system is designed. For example, a 40 W PLC terminal shall transmit 40 Watt (max.) for protection channel alone in the event of fault. Speech and super-imposed data channels, in the same protection terminal must get disconnected momentarily during the operation of protection channels.

10.3.10 The equipment shall be constructed such that in permissive line protection system, operational reliability of the protection channel may be checked over the carrier link by means of a loop test. It shall be possible to carry out the above test from either end of the carrier link. During healthy condition of the transmission line, the loop test shall not initiate a tripping command. In the event of a system fault, while loop test is in progress, protection signal shall over-ride the test signal.

10.4.11 The equipment shall be complete with built in counters for counting the number of trip commands sent and number of trip commands received.

10.3.12 Reports for the following tests as per clause 9.2 of GTR shall be submitted for approval for protection coupler and the relays associated with PLCC equipment for network protection signaling equipment and interface unit with protective relay units if any :

1) Protection coupler ( As per IEC 60834 -1)

- a)Power supply variation
- b)Power supply interruption
- c)Reflected noise
- d)Reverse polarity
- e)Interference by discrete frequency
- f)Transmission time
- g) Interference by frequency deviation. ( Wherever applicable)
- h)Alarm function
- g)Security
- h)Dependability
- i)Voltage withstand test
- j)Insulation test.
- j) Electrical fast transient test (along with carrier terminal)
- k)HF disturbance test (along with carrier terminal)
- l)Electro static discharge test (along with carrier terminal)
- m)Radiated electromagnetic field susceptibility test (along with carrier terminal)
- n)Environment test (as per IEC 60068)

## 2. **Relays.**

- a) Impulse voltage withstand test as per IEC 60255-4
- b) High Frequency Disturbance test as per IEC 610004-4

## 11. **Mandatory Testing & Maintenance Equipment**

*Print testing kit for PLCC terminal, E/M interface & subscriber unit, Protection coupler* comprising of following items of reputed make in addition to any other special items required for testing and maintenance of this equipment packed in a carrying brief case:

1. Screw driver set with multi up fixing feature
2. Nose pliers
3. Cutting pliers
4. Ordinary Pliers
5. Adjustable wrench
6. Soldering iron with tip earthed
  - a) 150 watts - 1 No.
  - b) 35 Watts - 1 No
  - c) 10 watts - 1 No.

operated with isolated (step down) transformer having provision for interchangeable taps.
7. Desoldering pump
8. Print extender
9. Print puller
10. Large selection of test leads
11. Solder wire
12. Large selection of plugs, jacks & pistol probes compatible with equipment supplied
13. Dummy load
14. Interface card/print for Tx to Rx loop-back
15. Test oscillator/tone generator with indicating meters - either built in or separate
16. ESD wrist band
17. ESD conducting mat

## 12. LIST OF COMMISSIONING TESTS

The following tests shall be carried out on complete system/subsystem during commissioning:

1. Composite loss and return loss on coupling device using dummy load.
2. Composite loss (Attenuation) for HF Cable coupling device.
3. End to end attenuation measurement for verification of optimum coupling mode. Test shall be done for all combinations.
4. End to end return loss for optimum coupling mode.
  - a. open behind line trap.
  - b. grounded behind line trap.
5. If end to end return loss for optimum coupling mode is not satisfactory, same shall be measured for other coupling modes also.
6. Adjustment of Tx/Rx levels on PLCC equipment as per test schedule.
7. AF frequency response (end to end) for the entire 4 kHz Bandwidth for speech and teleoperation channels.
8. Measurement of noise in 2 KHZ bandwidth with and without line energised.
9. SNR (test-one) with line energised noting down weather conditions.
10. Transmission time for teleprotection and other data channels.
11. Observation of Tx/Rx levels (test-tone) for each channel at both ends by sequential switching on/off parallel channels using dummy load and also with the transmission line.
12. Observation of end to end and trunk dialing performance.
13. Observation of end-to-end protection signaling (command sent & received) in conjunction with protective relays, noting down transmission/receipt of unwanted commands under switching operations in the switchyard during protective relay testing.

### Notes

1. All measurements for link attenuation, composite loss and return loss shall be carried out for the entire range of carrier frequencies with specific attention to the frequencies.
  - i. within coupling device bandwidth.
  - ii. within line trap bandwidth, and
  - iii. operating frequencies.
2. Following tests shall be carried out independently at each and
  - i. Composite loss & return loss for coupling device.
  - ii. Attenuation test for HF cable + coupling device.
  - iii. Levels and other local adjustments (on dummy load).  
Final adjustment shall be on end to end basis.
  - iv. Test for loading by parallel channels with dummy load.  
This test can be done alongwith tests for coupling device.
  - v. Protection signaling under local loop test (dummy load).
3. Necessary test instruments required for all the above tests shall be brought by commissioning engineers of the contractor.

## **CHAPTER 17: SUBSTATION AUTOMATION SYSTEM**

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ANNEXURE-I  
ANNEXURE-II

LIST OF ANALOGUE AND DIGITAL INPUT  
LIST OF IO POINTS TO BE TRANSMITTED TO RSCC

## CHAPTER 17: SUBSTATION AUTOMATION SYSTEM

### 1.0 GENERAL

1.1. The substation automation system shall be offered from a manufacturer who must have designed, manufactured, tested, installed and commissioned substation automation system which must be in satisfactory operation on 220kV system or higher for at least 2 (Two) years as on the date of bid opening.

1.2. The Substation Automation System (SAS) shall be installed to control and monitor all the sub-station equipment from remote control centre (RCC) as well as from local control centre.

The SAS shall contain the following main functional parts:

- Bay control Intelligence Electronic Devices (IEDs) for control and monitoring.
- Station Human Machine Interface (HMI)
- Redundant managed switched Ethernet Local Area Network communication infrastructure with hot standby.
- Gateway for remote control via industrial grade hardware (to RCC) through IEC60870-5-101 protocol.
- Gateway for remote supervisory control (to RSCC), the gateway should be able to communicate with RSCC on IEC 60870-5-101 protocol. The specific protocol to be implemented is enclosed as Appendix-I.. It shall be the bidder's responsibility to integrate his offered system with existing RSCC system for exchange of desired data. The requirement of IO point shall be worked out by the bidder as per criterion enclosed as Appendix-II for data exchange with RLDCs.
- Remote HMI.

1.3. Peripheral equipment like printers, display units, key boards, Mouse etc. It shall enable local station control via a PC by means of human machine interface (HMI) and control software package, which shall contain an extensive range of supervisory control and data acquisition (SCADA) functions. It shall include communication gateway, intelligent electronic devices (IED) for bay control and inter IED communication infrastructure. An architecture drawing for SAS is enclosed.

1.4. The communication gateway shall facilitate the information flow with remote control centres. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions.



## 2. System design

### 2.1 General system design

The Substation Automation System (SAS) shall be suitable for operation and monitoring of the complete substation including future extensions as given in Chapter 1 - GTS.

The systems shall be of the state-of-the art suitable for operation under electrical environment present in Extra high voltage substations, follow the latest engineering practice, ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

The offered SAS shall support remote control and monitoring from Remote Control centres via gateways.

The system shall be designed such that personnel without any background knowledge in Microprocessor-based technology are able to operate the system. The operator interface shall be intuitive such that operating personnel shall be able to operate the system easily after having received some basic training.

The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signalling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records.

Maintenance, modification or extension of components may not cause a shutdown of the whole substation automation system. Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

**Bidder shall offer the Bay level unit (a bay comprises of one circuit breaker and associated disconnecter, earth switches and instrument transformer), bay mimic along with relay and protection panels and PLCC panels (described in other sections of technical specifications) housed in air-conditioned *Switchyard Panel Room* suitably located in switchyard and Station HMI in Control Room building for overall optimisation in respect of cabling and control room building..**

### 2.2 System architecture

The SAS shall be based on a decentralized architecture and on a concept of bay-oriented, distributed intelligence.

Functions shall be decentralized, object-oriented and located as close as possible to the process.

The main process information of the station shall be stored in distributed databases. The typical SAS architecture shall be structured in two levels, i.e. in a station and a bay level.

At bay level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The IEDs should be directly connected to the switchgear without any need for additional interposition or transducers.

Each bay control IED shall be independent from each other and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station.

The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fibre-optic cables, thereby guaranteeing disturbance free communication. The fibre optic cables shall be run in G . I conduit pipes. Data exchange is to be realised using IEC 61850 protocol with a redundant managed switched Ethernet communication infrastructure

The communication shall be made in fault tolerant ring in redundant mode, excluding the links between individual bay IEDs to switch wherein the redundant connections are not envisaged, such that failure of one set of fiber shall not affect the normal operation of the SAS. However failure of fiber shall be alarmed in SAS. Each fiber optic cable shall have four (4) spare fibers

At station level, the entire station shall be controlled and supervised from the station HMI. It shall also be possible to control and monitor the bay from the bay level equipment at all times.

Clear control priorities shall prevent operation of a single switch at the same time from more than one of the various control levels, i.e. RCC, station HMI, bay level or apparatus level. The priority shall always be on the lowest enabled control level.

The station level contains the station-oriented functions, which cannot be realised at bay level, e.g. alarm list or event list related to the entire substation, gateway for the communication with remote control centres.

The GPS time synchronising signal (as specified in the section relay & protection) for the synchronization of the entire system shall be provided.

The SAS shall contain the functional parts as described in para 1.2 above.

## **2.3 FUNCTIONAL REQUIREMENTS**

The high-voltage apparatus within the station shall be operated from different places:

- Remote control centres
- Station HMI.
- Local Bay controller IED (in the bays)

Operation shall be possible by only one operator at a time.

The operation shall depend on the conditions of other functions, such as interlocking, 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 15 – Control, Relay & Protection Panels.

**3.1.2.2. Bay Monitoring Function:**

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated in the Bay control/protection unit.

**3.2. System level functions**

**3.2.1. Status supervision**

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, transformer tap changer etc., shall be supervised continuously. Every detected change of position shall be immediately displayed in the single-line diagram on the station HMI screen, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in the case of spontaneous position changes.

The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.

The SAS shall also monitor the status of sub-station auxiliaries. The status and control of auxiliaries shall be done through separate one or more IED and all alarm and analogue values shall be monitored and recoded through this IED.

**3.2.2. Measurements**

The analogue values acquired/calculated in bay control/protection unit shall be displayed locally on the station HMI and in the control centre. The abnormal values must be discarded. The analogue values shall be updated every 2 seconds.

Threshold limit values shall be selectable for alarm indications.

**3.2.3. Event and alarm handling**

Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All, or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time-tagged with a time resolution of 1 ms. The tentative list for various feeders and systems are enclosed as Annexure-I

### **3.2.4. Station HMI**

#### **3.2.4.1. Substation HMI Operation:**

On the HMI the object has to be selected first. In case of a blocking or interlocking conditions are not met, the selection shall not be possible and an appropriate alarm annunciation shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object.

Control operation from other places (e.g. REMOTE) shall not be possible in this operating mode.

#### **3.2.4.2. Presentation and dialogues**

##### **General**

The operator station HMI shall be a redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear on the screen via mouse clicks.

The HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log.

An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from any screen selected by the operator.

The following standard pictures shall be available from the HMI:

- Single-line diagram showing the switchgear status and measured values
- Control dialogues with interlocking or blocking information details. This control dialogue shall tell the operator whether the device operation is permitted or blocked.
- Measurement dialogues
- Alarm list, station / bay-oriented
- Event list, station / bay-oriented
- System status

#### **3.2.4.3. HMI design principles**

Consistent design principles shall be adopted with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

The object status shall be indicated using different status colours for:

- Selected object under command
- Selected on the screen
- Not updated, obsolete values, not in use or not sampled
- Alarm or faulty state
- Warning or blocked

- Update blocked or manually updated
- Control blocked
- Normal state

#### **3.2.4.4. Process status displays and command procedures**

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap-changers shall be displayed in the station single-line diagram.

In order to ensure a high degree of security against undesired operation, a "select-before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen, and all other switchgear shall be blocked. As communication between control centre and device to be controlled is established, the operator shall be prompted to confirm the control action and only then final execute command shall be accepted. After the "execution" of the command the operated switching symbol shall flash until the switch has reached its new position.

The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level.

After command execution the operator shall receive a confirmation that the new switching position has been reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

#### **3.2.4.5. System supervision & display**

The SAS system shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are recorded as a faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication infrastructure and remote communication links, and printers at the station level, etc.

#### **3.2.4.6. Event list**

The event list shall contain events that are important for the control and monitoring of the substation.

The event and associated time (with 1 ms resolution) of its occurrence has to be displayed for each event.

The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.

A printout of each display shall be possible on the hard copy printer.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible



to store all events in the computer for at least one month. The information shall be obtainable also from a printed event log.

The chronological event list shall contain:

- Position changes of circuit breakers, isolators and earthing devices
- Indication of protective relay operations
- Fault signals from the switchgear
- Indication when analogue measured values exceed upper and lower limits. Suitable provision shall be made in the system to define two level of alarm on either side of the value or which shall be user defined for each measurands.
- Loss of communication.

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

- Date and time
- Bay
- Device
- Function e.g. trips, protection operations etc.
- Alarm class

#### **3.2.4.7. Alarm list**

Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control centre. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated.

The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

- The date and time of the alarm
- The name of the alarming object
- A descriptive text
- The acknowledgement state.

Whenever an alarm condition occurs, the alarm condition must be shown on the alarm list and must be displayed in a flashing state along with an audible alarm. After acknowledgement of the alarm, it should appear in a steady (i.e. not flashing) state and the audible alarm shall stop. The alarm should disappear only if the alarm condition has physically cleared and the operator has reset the alarm with a reset command. The state of the alarms shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent).

Filters for selection of a certain type or group of alarms shall be available as for events.

#### **3.2.4.8. Object picture**

When selecting an object such as a circuit breaker or isolator in the single-line diagram, the associated bay picture shall be presented first. In the selected object picture, all attributes like

- Type of blocking
- Authority
- Local / remote control
- RSCC / SAS control
- Errors
- etc.,

shall be displayed.

#### **3.2.4.9. Control dialogues**

The operator shall give commands to the system by means of mouse click located on the single-line diagram. Data entry is performed with the keyboard. Dedicated control dialogues for controlling at least the following devices shall be available:

- Breaker and disconnector
- Transformer tap-changer

#### **3.2.5. User-authority levels**

It shall be possible to restrict activation of the process pictures of each object (bays, apparatus...) within a certain user authorisation group. Each user shall then be given access rights to each group of objects, e.g.:

- Display only
- Normal operation (e.g. open/close of switchgear)
- Restricted operation (e.g. by-passed interlocking)
- System administrator

For maintenance and engineering purposes of the station HMI, the following authorisation levels shall be available:

- No engineering allowed
- Engineering/configuration allowed
- Entire system management allowed

The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

#### **3.2.6. Reports**

The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise:

- Trend reports:
  - Day (mean, peak)
  - Month (mean, peak)
  - Semi-annual (mean, peak)
  - Year (mean, peak)
- Historical reports of selected analogue Values:
  - Day (at 15 minutes interval)
  - Week
  - Month
  - Year

It shall be possible to select displayed values from the database in the process display on-line. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.

Following printouts shall be available from the printer and shall be printed on demand:

- i. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.
- ii. Weekly trend curves for real and derived analogue values.
- iii. Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.
- iv. Provision shall be made for logging information about breaker status like number of operation with date and time indications along with the current value it interrupts (in both condition i.e. manual opening and fault tripping)
- v. Equipment operation details shift wise and during 24 hours.
- vi. Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each feeder and transformer as well as Tap Positions, temperature and status of pumps and fans for transformers.
- vii. Printout on adjustable time period as well as on demand system frequency and average frequency.
- viii. Reports in specified formats which shall be handed over to successful bidder. The bidder has to develop these reports. The

reports are limited to the formats for which data is available in the SAS database.

**3.2.7. Trend display (historical data)**

It shall be possible to illustrate all types of process data as trends - input and output data, binary and analogue data. The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen. Adjustable time span and scaling ranges must be provided.

It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

**3.2.8. Automatic disturbance file transfer**

All recorded data from the IEDs with integrated disturbance recorder as well as dedicated disturbance recording systems shall be automatically uploaded (event triggered or once per day) to a dedicated computer and be stored on the hard disc.

**3.2.9. Disturbance analysis**

The PC-based work station shall have necessary software to evaluate all the required information for proper fault analysis.

**3.2.10. IED parameter setting**

It shall be possible to access all protection and control IEDs for reading the parameters (settings) from the station HMI or from a dedicated monitoring computer. The setting of parameters or the activation of parameter sets shall only be allowed after entering a password.

**3.2.11. Automatic sequences**

The available automatic sequences in the system should be listed and described, (e.g. sequences related to the bus transfer). It must be possible to initiate pre-defined automatic sequences by the operator and also define new automatic sequences.

**3.3. Gateway**

**3.3.1 Communication Interface**

The Substation Automation System shall have the capability to support simultaneous communications with multiple independent remote master stations,

The Substation Automation System shall have communication ports as follows:

- (a) Two ports for Remote Control Centre
- (b) Two ports for Regional System Coordination Centre (RSCC)

The communication interface to the SAS shall allow scanning and control

of defined points within the substation automation system independently for each control centre. The substation automation system shall simultaneously respond to independent scans and commands from employer's control centres (RCC & RSCC). The substation automation system shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to each remote control centre. Also, each control centre's data scan and control commands may be different for different data points within the substation automation system's database.

### **3.3.2 Remote Control Centre Communication Interface**

Employer will supply communication channels between the Substation Automation System and the remote control centre. The communication channels provided by Employer will consist either of power line carrier, microwave, optical fibre, VSAT or leased line , the details of which shall be provided during detailed Engineering .

### **3.3.3 Interface equipment:**

The Contractor shall provide interface equipment for communicating between Substation Automation system and Remote control centre and between Substation Automation system and Regional System Coordination Centre (RSCC). However, the communication channels available for this purpose are specified in Chapter 1 - GTS.

In case of PLCC communication any modem supplied shall not require manual equalization and shall include self-test features such as manual mark/space keying, analogue loop-back, and digital loop-back. The modems shall provide for convenient adjustment of output level and receive sensitivity. The modem should be stand alone complete in all respects including power supply to interface the SAS with communication channel. The configuration of tones and speed shall be programmable and maintained in non-volatile memory in the modem. All necessary hardware and software shall also be in the scope of bidder.

### **3.3.4 Communication Protocol**

The communication protocol for gateway to control centre must be open protocol and shall support IEC 60870-5-101 and IEC 61850 for all levels of communication for sub-station automation such as Bay to station HMI, gateway to remote station etc..

## **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 220 kV bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer). The Bay level unit shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All bay level interlocks are to be incorporated in the Bay level unit so as to permit control from the Bay level unit/ local bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out of service.

The bay control unit to be provided for the bays shall be preferably installed in the CB relay panel/feeder protection panel for respective bay.

The bay control unit for future bay (if required as per Chapter 1 – Project Specification Requirement) shall be installed in a separate panel.

The Bay level unit shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 61850. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.

#### **4.2.1 Input/Output (I/O) modules**

The I/O modules shall form a part of the bay level unit and shall provide coupling to the substation equipment. The I/O modules shall acquire all switchgear information (i.e. data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear. The measured values of voltage and current shall be from the secondaries of instrument transformers. The digital inputs shall be acquired by exception with 1 ms resolution. Contact bouncing in digital inputs shall not be assumed as change of state

#### **4.3 Switchyard Panel Room:**

The switchyard panel room shall be constructed to house Bay level units, bay mimic, relay and protection panels, PLCC panels etc.. The layout of equipment/panel shall be subject to Owner's approval. The switchyard panel room shall be provided with necessary illuminations, fire alarm system with at least two detectors with necessary power supply if required and it shall be wired to SAS. The detailed constructional requirement of switchyard panel room is detailed in chapter 14 civil of technical specification and air conditioning requirement of switchyard panel room shall be as detailed in chapter 10 Air conditioning system of technical specification. The air conditioner provided in switchyard panel room shall be monitored from substation automation system.

#### **4.4 Extendibility in future**

Offered substation automation system shall be suitable for extension in future for additional bays. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the employer. During such event, normal operation of the existing substation shall be unaffected and system shall not require a shutdown. The contractor shall provide all necessary software tools along with source codes to perform addition of bays in future and complete integration with SAS by the user. These software tools shall be able to configure IED, add additional analogue variable, alarm list, event list, modify interlocking logics etc. for additional bays/equipment which shall be added in future.



## **5.0 Software structure**

The software package shall be structured according to the SAS architecture and strictly divided in various levels. Necessary firewall shall be provided at suitable points in software to protect the system. An extension of the station shall be possible with lowest possible efforts. Maintenance, modification or an extension of components of any feeder may not force a shut-down of the parts of the system which are not affected by the system adaptation.

### **5.1.1 Station level software**

#### **5.1.1.1 Human-machine interface (HMI)**

The base HMI software package for the operator station shall include the main SAS functions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. Systems shall contain a library with standard functions and applications.

### **5.1.2 Bay level software**

#### **5.1.1.1 System software**

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. The lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance engineer for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage. In case of restoration of links after failure, the software along with hardware shall be capable of automatically synchronising with the remaining system without any manual interface. This shall be demonstrated by contractor during integrated system test.

#### **5.1.1.2 Application software**

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They form part of a library. The application software within the control/protection devices shall be programmed in a functional block language.

#### **5.1.1.3 Network Management System (NMS):**

The contractor shall provide a network management system software for following management functions:

- a. Configuration Management
- b. Fault Management
- c. Performance Monitoring

This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in DR workstation 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 Measurd Values
- ii. Currents
- iii. Voltages
- iv. Time resolution

##### **c. Insulation Tests:**

- i. Dielectric Tests
- ii. Impulse Voltage withstand Test

##### **d. Influencing Quantities**

- i. Limits of operation
- ii. Permissible ripples
- iii. Interruption of input voltage

##### **e. Electromagnetic Compatibility Test:**

- i. 1 MHZ. burst disturbance test
- ii. Electrostatic Discharge Test
- iii. Radiated Electromagnetic Field Disturbance Test
- iv. Electrical Fast transient Disturbance Test
- v. Conducted Disturbances Tests induced by Radio Frequency Field
- vi. Magnetic Field Test

- vii. Emission (Radio interference level) Test.
- viii. Conducted Interference Test
- f. Function Tests:**
  - i. Indication
  - ii. Commands
  - iii. Measured value Acquisition
  - iv. Display Indications
- g. Environmental tests:**
  - i. Cold Temperature
  - ii. Dry Heat
  - iii. Wet heat
  - iv. Humidity (Damp heat Cycle)
  - v. Vibration
  - vi. Bump
  - vii. Shock

## **6.2 Factory Acceptance Tests:**

The supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual bay level IED's applicable type test certificates shall be submitted.

The manufacturing and configuration phase of the SAS shall be concluded by the factory acceptance test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the user. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab. During FAT the entire Sub-station Automation System including complete control and protection system to be supplied under present scope shall be tested for complete functionality and configuration in factory itself. The extensive testing shall be carried out during FAT. The purpose of Factory Acceptance Testing is to ensure trouble free installation at site. No major configuration setting of system is envisaged at site.

If the complete system consists of parts from various suppliers or some parts are already installed on site, the FAT shall be limited to sub-system tests. In such a case, the complete system test shall be performed on site together with the site acceptance test (SAT).

### **6.2.1 Hardware Integration Tests:**

The hardware integration test shall be performed on the specified systems to be used for Factory tests when the hardware has been installed in the factory. The operation of each item shall be verified as an integral part of system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a

configuration capable of supporting software integration and factory testing of the system. The equipment expansion capability shall also be verified during the hardware integration tests. The vendor specifically demonstrates how to add a device in future in SAS during FAT. The device shall be from a different manufacturer than the SAS supplier.

## **6.2.2 Integrated System Tests:**

Integrated system tests shall verify the stability of the hardware and the software. During the tests all functions shall run concurrently and all equipment shall operate a continuous 100 Hours period. The integrated system test shall ensure the SAS is free of improper interactions between software and hardware while the system is operating as a whole.

## **6.3 Site Acceptance Tests:**

The site acceptance tests (SAT) shall completely verify all the features of SAS hardware and software. The bidder shall submit the detailed SAT procedure and SAT procedure shall be read in conjunction with the specification.

## **7.0 SYSTEM OPERATION**

### **7.1 Substation Operation**

#### **7.1.1 NORMAL OPERATION**

Operation of the system by the operator from the remote RCC or at the substation shall take place via industry standard HMI(Human Machine interface) subsystem consisting of graphic colour VDU , a standard keyboard and a cursor positioning device (mouse).

The coloured screen shall be divided into 3 fields :

- i) Message field with display of present time and date
- ii) Display field for single line diagrams
- iii) Navigation bar with alarm/condition indication

For display of alarm annunciation, lists of events etc a separate HMI View node shall be provided.

All operations shall be performed with mouse and/or a minimum number of function keys and cursor keys. The function keys shall have different meanings depending on the operation. The operator shall see the relevant meanings as function tests displayed in the command field (i.e. operator prompting). For control actions, the switchgear (i.e. circuit breaker etc.) requested shall be selectable on the display by means of the cursor keys. The switching element selected shall then appear on the background that shall be flashing in a different color. The operator prompting shall distinguish between:-

- Prompting of indications e.g. fault indications in the switchgear, and

- prompting of operational sequences e.g. execution of switching operations

The summary information displayed in the message field shall give a rapid display of alarm/message of the system in which a fault has occurred and alarm annunciation lists in which the fault is described more fully.

Each operational sequence shall be divided into single operation steps which are initiated by means of the function keys/WINDOW command by mouse. Operator prompting shall be designed in such a manner that only the permissible keys are available in the command field related to the specific operation step. Only those switching elements shall be accessed for which control actions are possible. If the operation step is rejected by the system, the operator prompting shall be supported by additional comments in the message field. The operation status shall be reset to the corresponding preceding step in the operation sequence by pressing one of the function keys. All operations shall be verified. Incorrect operations shall be indicated by comments in the message field and must not be executed.

The offer shall include a comprehensive description of the system. The above operation shall also be possible via WINDOWS based system by mouse.

## **8.0 POWER SUPPLY**

Power for the substation automation system shall be derived from substation 220V DC system.

2No.s of Inverter of minimum 2KVA capacity shall be provided for servers, gateways station HMI disturbance recorder evaluation unit and its peripheral devices e.g. printer etc. In the event of Power failure, necessary safeguard software shall be built for proper shutdown. Inverter shall be connected to 220V DC independent source and should be used to drive 1No. each server/HMI/Gateway so that in case any failure of DC power supply system is not affected.

## **9.0 DOCUMENTATION**

The following documents shall be submitted for employer's approval during detailed engineering:

- (a) System Architecture Drawing
- (b) Hardware Specification
- (c) Functional Design Document
- (d) Clear procedure describing how to add an IED/bay/diameter in future covering all major supplier

The following documentation to be provided for the system in the course of the project shall be consistent, CAD supported, and of similar look/feel. All CAD

drawings to be provide in “dxf” format.

- List of Drawings
- Substation automation system architecture
- Block Diagram
- Guaranteed technical parameters, Functional Design Specification and Guaranteed availability and reliability
- Calculation for power supply dimensioning
- I/O Signal lists
- Schematic diagrams
- List of Apparatus
- List of Labels
- Logic Diagram (hardware & software )
- **Switchyard Panel Room** layout drawing
- Control Room Lay-out
- Test Specification for Factory Acceptance Test (FAT)
- Product Manuals
- Assembly Drawing
- Operator’s Manual
- Complete documentation of implemented protocols between various elements
- Listing of software and loadable in CD ROM
- Other documents as may be required during detailed engineering

Two sets of hard copy and Four sets of CD ROM containing all the as built documents/drawings shall be provided.

## **10.0 TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES**

### **10.1 Training**

Contractor personnel who are experienced instructors and who speak understandable English shall conduct training. The contractor shall arrange on its own cost all hardware training platform required for successful training and understanding in Nepal. The Contractor shall provide all necessary training material. Each trainee shall receive individual copies of all technical manuals and all other documents used for training. These materials shall be sent to Employer at least two months before the scheduled commencement of the particular training course. Class materials, including the documents sent before the training courses as well as class handouts, shall become the property of Employer. Employer reserves the right to copy such materials, but for in-house training and use only. Hands-on training shall utilize equipment identical to that being supplied to Employer.

The Contractor shall quote training prices as indicated in BPS.

The schedule, location, and detailed contents of each course will be finalized during Employer and Contractor discussions.

## 10.2 Computer System Hardware Course

A computer system hardware course shall be offered, but at the system level only. The training course shall be designed to give Employer hardware personnel sufficient knowledge of the overall design and operation of the system so that they can correct obvious problems, configure the hardware, perform preventive maintenance, run diagnostic programs, and communicate with contract maintenance personnel. The following subjects shall be covered:

- (a) System Hardware Overview: Configuration of the system hardware.
- (b) Equipment Maintenance: Basic theory of operation, maintenance techniques and diagnostic procedures for each element of the computer system, e.g., processors, auxiliary memories, LANs, routers and printers. Configuration of all the hardware equipments.
- (c) System Expansion: Techniques and procedures to expand and add equipment such as loggers, monitors, and communication channels.
- (d) System Maintenance: Theory of operation and maintenance of the redundant hardware configuration, failover hardware, configuration control panels, and failover switches. Maintenance of protective devices and power supplies.
- (e) Subsystem Maintenance: Theory of design and operation, maintenance techniques and practices, diagnostic procedures, and (where applicable) expansion techniques and procedures. Classes shall include hands-on training for the specific subsystems that are part of Employer's equipment or part of similarly designed and configured subsystems. All interfaces to the computing equipment shall be taught in detail.
- (f) Operational Training: Practical training on preventive and corrective maintenance of all equipment, including use of special tools and instruments. This training shall be provided on Employer equipment, or on similarly configured systems.

## 10.3 Computer System Software Course

The Contractor shall provide a computer system software course that covers the following subjects:

- (a) System Programming: Including all applicable programming languages and all stand-alone service and utility packages provided with the system. An introduction to software architecture, Effect of tuning parameters (OS software, Network software, database software etc.) on the performance of the system.
- (b) Operating System: Including the user aspects of the operating system, such as program loading and integrating procedures; scheduling, management, service, and utility functions; and system expansion techniques and procedures
- (c) System Initialization and Failover: Including design, theory of operation, and practice
- (d) Diagnostics: Including the execution of diagnostic procedures and

- the interpretation of diagnostic outputs,
- (e) Software Documentation: Orientation in the organization and use of system software documentation.
- (f) Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

#### 10.4 **Application Software Course**

The Contractor shall provide a comprehensive application software courses covering all applications including the database and display building course. The training shall include:

- (a) Overview: Block diagrams of the application software and data flows. Programming standards and program interface conventions.
- (b) Application Functions: Functional capabilities, design, and major algorithms. Associated maintenance and expansion techniques.
- (c) Software Development: Techniques and conventions to be used for the preparation and integration of new software functions.
- (d) Software Generation: Generation of application software from source code and associated software configuration control procedures.
- (e) Software Documentation: Orientation in the organization and use of functional and detailed design documentation and of programmer and user manuals.
- (f) Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

#### 10.5 **Requirement of training:**

The contractor shall provide training for OWNER'S personnel comprehensively covering following courses.

S. No.	Name of Course
1	Computer System Hardware
2	Computer System Software
3	Application Software

#### 11.0 **Maintenance**

##### 11.1 **Maintenance Responsibility during the Guaranteed Availability Period.**

During Guaranteed Availability Period, the Contractor shall take continual actions to ensure the guaranteed availability and shall make available all the necessary resources such as specialist personnel, spare parts, tools, test devices etc. for replacement or repair of all defective parts and shall have prime responsibility for keeping the system operational. **During guarantee period as specified in tender document, contractor shall arrange bi-monthly visit of their representative to site to review the performance of system and in case any defect/shortcoming etc. is observed during the period, the same shall be set right by the**



**contractor within 15 days.**

## **12.0 RELIABILITY AND AVAILABILITY**

The SAS shall be designed so that the failure of any single component, processor, or device shall not render the system unavailable. The SAS shall be designed to satisfy the very high demands for reliability and availability concerning:

- Mechanical and electrical design
- Security against electromagnetic interference (EMI)
- High quality components and boards
- Modular, well-tested hardware
- Thoroughly developed and tested modular software
- Easy-to-understand programming language for application programming
- Detailed graphical documentation and application software
- Built-in supervision and diagnostic functions
- Security
  - Experience of security requirements
  - Process know-how
  - Select before execute at operation
  - Process status representation as double indications
- Distributed solution
- Independent units connected to the local area network
- Back-up functions
- Panel design appropriate to the harsh electrical environment and ambient conditions
- Panel grounding immune against transient ground potential rise

### **Outage terms**

#### **1) Outage**

The state in which substation automation system or a unit of SAS is unavailable for Normal Operation as defined in the clause 7.1 due to an event directly related to the SAS or unit of SAS. In the event, the owner has taken any equipment/ system other than Sub-station Automation System for schedule/forced maintenance, the consequent outage to SAS shall not be considered as outage for the purpose of availability.

#### **2) Actual outage duration (AOD)**

The time elapsed in hours between the start and the end of an outage. The time shall be counted to the nearest 1/4<sup>th</sup> of an hour. Time less than 1/4<sup>th</sup> of an hour shall be counted as having duration of 1/4<sup>th</sup> of an hour.

#### **3) Period Hours (PH)**

The number of hours in the reporting period. In a full year the period hour are 8760h (8784h for a leap year).

#### **4) Actual Outage hours (AOH)**

The sum of actual outage duration within the reporting period

$$AOH = \sum AOD$$

**5) Availability:**

Each SAS shall have a total availability of 99.98 % i.e. the ratio of total time duration minus the actual outage duration to total time duration.

**12.1 Guarantees Required**

The availability for the complete SAS shall be guaranteed by the Contractor. Bidder shall include in their offer the detailed calculation for the availability. The contractor shall demonstrate their availability guaranteed by conducting the availability test on the total sub-station automation system as a whole after commissioning of total Sub-station Automation system. The test shall verify the reliability and integrity of all sub-systems. Under these conditions the test shall establish an overall availability of 99.98%. After the lapse of 1000 Hours of cumulative test time, test records shall be examined to determine the conformance with availability criterion. In case of any outage during the availability test, the contractor shall rectify the problem and after rectification, the 1000 Hours period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.

The contractor has to establish the availability in a maximum period of three months from the date of commencement of the availability test.

After the satisfactory conclusion of test both contractor and employer shall mutually agree to the test results and if these results satisfy the availability criterion, the test is considered to be completed successfully. After that the system shall be taken over by the employer and then the guarantee period shall start.

**13.0 Spares**

**13.1 Consumables:**

All consumables such as paper, cartridges shall be supplied by the contractor till the SAS is taken over by the owner.

**13.2 Availability Spares:**

In addition to mandatory spares as listed in section project for SAS, the bidder is required to list the spares, which may be required for ensuring the guaranteed availability during the guaranteed availability period. The final list of spares shall form part of scope of supply and accordingly the price thereof shall be quoted by the bidder and shall be considered in the evaluation of the bids. During the guaranteed availability period, the spare parts supplied by the Contractor shall be made available to the Contractor for usage subject to replenishment at the earliest. Thus, at the

end of availability period the inventory of spares with the Employer shall be fully replenished by the Contractor. However, any additional spares required to meet the availability of the system (which are not a part of the above spares supplied by the Contractor) would have to be supplied immediately by the Contractor free of cost to the Employer.

#### **14.0 LIST OF EQUIPMENTS**

Quantity of equipments shall be decided by bidder in order to achieve guaranteed reliability and availability as declared by bidder.

- i) Station HMI
- ii) Redundant Station HMI (in Hot-stand by mode)
- iii) Bay level units along with bay mimic as detailed in Chapter 1 – Project Specification Requirement.
- iv) Bay Level Unit for Auxiliary system (as per requirement)
- v) Disturbance Recorder Work Station(Maintenance HMI)
- vi) Colour Laser Printer – 1 No. (For Reports & Disturbance records)
- vii) Dot matrix printers - (one each for Alarms and log sheets)
- viii) All interface equipment for gateway to RCC and RSCC
- ix) Communication infrastructure between Bay level units, Station HMI, Printers, gateways, redundant LAN etc. as required
- x) Remote workstation including HMI and along with one printer
- xi) Modems as per requirement.
- xii) Any other equipment as necessary.

## List of Analogue and Digital Inputs

### Basic Monitoring requirements are:

- Switchgear status indication
- Measurements (U, I, P, Q, f)
- Event
- Alarm
- Winding temperature of transformers & reactors
- ambient temperature
- Status and display of 400V LT system, 220V & 48V DC system
- Status of display of Fire protection system and Air conditioning system.
- Acquisition of all counters in PLCC panels through potential free contacts from PLCC or independently by counting the receive/send commands.
- Acquisition of alarm and fault record from protection relays
- Disturbance records
- Monitoring the state of batteries by displaying DC voltage, charging current and load current etc.
- Tap-position of Transformer

### List of Inputs

The list of input for typical bays is as below:-

#### Analogue inputs

- |      |  |                                     |
|------|--|-------------------------------------|
| i)   | For line<br>Current                      | R phase<br>Y phase<br>B phase       |
|      | Voltage                                  | R-Y phase<br>Y-B phase<br>B-R phase |
| ii)  | For transformer/reactor<br>Current       | R phase<br>Y phase<br>B phase       |
|      | <u>WTI</u> (for transformer and reactor) |                                     |
|      | Tap position (for transformer only)      |                                     |
| iii) | For <u>TBC</u> and bus coupler           |                                     |
|      | Current                                  | R phase<br>Y phase<br>B phase       |

- iv) Common
- a) Voltage for Bus-I, Bus-II and Transfer bus wherever applicable
 

Voltage	R-Y phase
	Y-B phase
	B-R phase
  - b) Frequency for Bus-I and Bus-II
  - c) Ambient temperature (switchyard)
  - d) **Switchyard Panel Room Temperature.**
  - e) **LT system**
    - i) Voltage R-Y, Y-B, B-R of Main Switch Board section-I
    - ii) Voltage R-Y, Y-B, B-R of Main Switch Board section-II
    - iii) Voltage R-Y, Y-B, B-R of Diesel Generator
    - iv) Current from LT transformer-I
    - v) Current from LT transformer-II
    - vi) Current from Diesel Generator
    - vii) Voltage of 220V DCDB-I
    - viii) Voltage of 220V DCDB-II
    - ix) Current from 220V Battery set-I
    - x) Current from 220V Battery set-II
    - xi) Current from 220V Battery charger-I
    - xii) Current from 220V Battery charger-II
    - xiii) Voltage of 48V DCDB-I
    - xiv) Voltage of 48V DCDB-II
    - xv) Current from 48V Battery set-I
    - xvi) Current from 48V Battery set-II
    - xvii) Current from 48V Battery charger-I
    - xviii) Current from 48V Battery charger-II

### 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 <u>PSB</u> ALARM
xxv)	MAIN-I <u>SOTF</u> 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
xlvi)	220V DC-I/II source fail
xlvi)	SPEECH CHANNEL FAIL
xlvi)	PLCC Protection Channel-I FAIL
xlvi)	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)	<u>REF</u> OPTD
ix)	<u>DIF</u> 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)	<u>OTI</u> ALARM/TRIP
xvii)	<u>PRD</u> OPTD
xviii)	OVERLOAD ALARM
xix)	BUCHOLZ TRIP
xx)	BUCHOLZ ALARM
xxi)	OLTC BUCHOLZ ALARM
xxii)	OLTC BUCHOLZ TRIP

- xxiii) OIL LOW ALARM
- xxiv) back-up o/c (HV) optd
- xxv) back-up e/f (HV)optd
- xxvi) 220v DC-I/II source fail
- xxvii) TAP MISMATCH
- xxviii) GR-A PROTN OPTD
- xxix) GR-B PROTN OPTD
- xxx) back-up o/c (MV) optd
- xxxi) back-up e/f (MV)optd

### 3. Transformer bays

- i) Status of each pole of CB, Isolator, Earth switch
- ii) CB trouble
- iii) CB operation/closing lockout
- iv) Pole discrepancy optd
- v) Trip coil faulty
- vi) LBB optd
- vii) Bus bar protn trip relay optd
- viii) REF OPTD
- ix) DIF OPTD
- x) HV BUS CVT ½ FUSE FAIL
- xi) OTI ALARM/TRIP
- xii) PRD OPTD
- xiii) BUCHOLZ TRIP
- xiv) BUCHOLZ ALARM
- xv) OIL LOW ALARM
- xvi) Back-up impedance relay
- xvii) 220v DC-I/II source fail
- xviii) GR-A PROTN OPTD
- xix) GR-B PROTN OPTD

### 4. Line/Bus Reactor bays (as applicable):

- i) Status of each pole of CB, Isolator, Earth switch
- ii) CB trouble
- iii) CB operation/closing lockout
- iv) Pole discrepancy optd
- v) Trip coil faulty
- vi) LBB optd
- vii) Bus bar protn trip relay optd
- viii) REF OPTD
- ix) DIF OPTD
- x) Line/ BUS CVT ½ FUSE FAIL
- xi) OTI ALARM/TRIP
- xii) PRD OPTD
- xiii) BUCHOLZ TRIP
- xiv) BUCHOLZ ALARM
- xv) OIL LOW ALARM
- xvi) Back-up impedance relay
- xvii) 220V DC-I/II source fail
- xviii) GR-A PROTN OPTD
- xix) GR-B PROTN OPTD

## 5      **Bus bar Protection**

- i) Bus bar main-I trip
- ii) Bus bar main-II trip
- iii) Bus bar zone-I CT open
- iv) Bus bar zone-II CT open
- v) Bus transfer CT sup. Optd
- vi) Bus transfer bus bar protn optd
- vii) Bus protection relay fail

## 6.      **Auxiliary system**

- i) Incomer-I On/Off
- ii) Incomer-II On/Off
- iii) 400V Bus-I/II U/V
- iv) 400V bus coupler breaker on/off
- v) DG set bkr on/off
- vi) Alarm/trip signals as listed in Section: DG set
- vii) LT transformer-I Bunchholz Alarm & trip
- viii) LT transformer-II Buchloz Alarm & trip
- ix) LT transformer-I WTI Alarm & trip
- x) LT transformer-II WTI Alarm & trip
- xi) LT transformer-I OTI Alarm & trip
- xii) LT transformer-II OTI Alarm & trip
- xiii) PLCC exchange fail
- xiv) Time sync. Signal absent
- xv) Alarm/trip signals as listed in Section: Battery and Battery charger
- xvi) 220V DC-I earth fault
- xvii) 220V DC-II earth fault
- xviii) Alarm/trip signals as listed in Section: Fire protection system

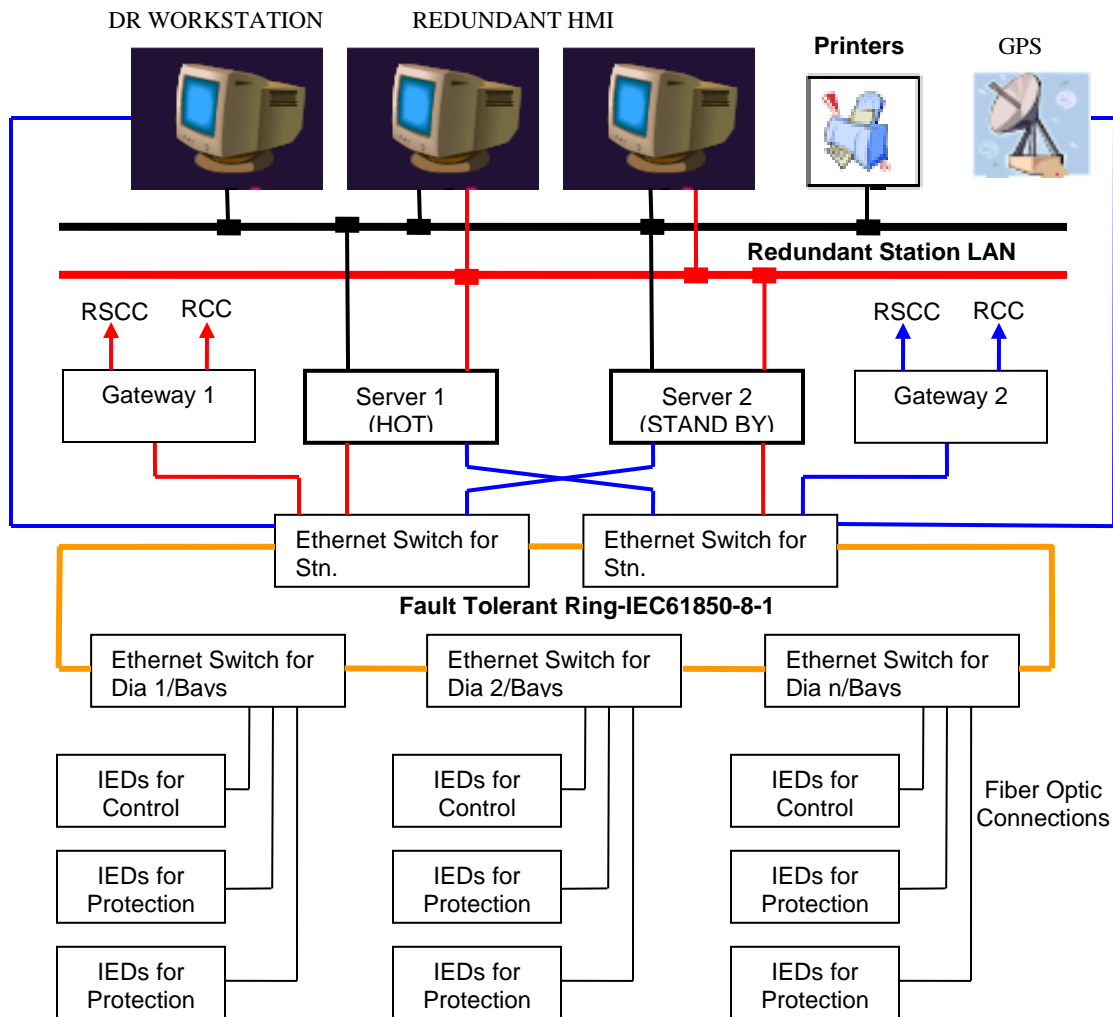
## 7.      **Switchyard Panel Room:**

- i) **AC Compressor 1 ON/OFF**
- ii) **AC Compressor 2 ON/OFF**
- iii) **Fire Detection 1 ON/OFF**
- iv) **Fire Detection 2 On/OFF**
- v) **Switchyard Panel Room Temperature High Alarm**

The exact number and description of digital inputs shall be as per detailed engineering requirement Apart from the above mentioned digital inputs, minimum of 200 inputs shall be kept for future use.



# TYPICAL ARCHITECTURAL DRAWING OF SUBSTATION AUTOMATION SYSTEM



**Note:**

1. The redundant managed bus shall be realized by high speed optical bus using industrial grade components and shall be as per IEC 61850.
2. Inside the sub-station, all connections shall be realized as per IEC 61850 protocol.
3. For gateway, it shall communicate with Remote Supervisory Control Centre (RSCC) on IEC 60870-5-101 protocol.
4. The printer as required shall be connected to station bus directly and can be managed either from station HMI, HMI view node or disturbance recorder work station.
5. The above layout is typical. However if any contractor offers slightly modified architecture based on their standard practice without compromising the working, the same shall be subject to approval during detailed engineering.

## **List of IO Points to be transmitted to RSCC**

- a) MW and MVAR for all lines , transformers, reactors and Capacitors
- b) Voltage of all buses
- c) Frequency of 220kV Bus
- d) All Breakers
- e) All isolators
- f) Tap Position for all transformers
- g) Master protection signal for all feeders, transformers Units and Bus Bar
- h) Loss of Voltage signal for Bus bar
- i) All the points identified in point (e), (h) and (i) above as GPS Time stamped.
- j) Temperature value per substation.
- k) Any other point decided during detailed engineering

# **TECHNICAL SPECIFICATIONS**

## **FOR**

### **Fibre Optic Based Communication Equipments**

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**Section 2:** Network Configuration and Equipment Characteristics

**Section 3:** Environment, EMI, Power Supply, Cabling and Earthing

**Section 4:** Inspection, Test and Availability

**Section 5:** Training and Support Services

**Appendix A:** Bill of Quantity (BOQ)

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**Section-1**  
**Introduction, General Information and General Requirement**

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## **Section 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 RTUs, SCADA system, PLCC equipment, PABX 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.

### **1.3 General Responsibilities and Obligations**

This section describes the general responsibilities and obligations of the Contractor and the Employer.

#### **1.3.1 Responsibilities for the Implementation Plan**

The Bidder's technical proposal shall include a project implementation plan and schedule that is consistent with the implementation plan detailed in this specification. The implementation plan shall be modelled such that it provides fibre optic cabling system support for the activation of this Project. The Implementation plan shall include the activities of both the Contractor and the Employer, showing all key milestones and clearly identifying the nature of all information and project support expected from the Employer. The Employer and Contractor shall finalise the detailed Implementation plan following award of the contract.

#### **1.3.2 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 implement 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.

### **1.3.3 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

#### **1.4 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, IEC 801-2/3/4/5, 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.

----- **End of this Section** -----

## Section 2 Network Configuration and Equipment Characteristics

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## **Section 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 31<sup>st</sup> March 2013. From 1<sup>st</sup> 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-4 (upto 3 MSP protected directions) as identified in the BoQ. The network shall consist of overhead fibre optic links with a minimum bit rate of Synchronous Transport Module-4 (STM-4). 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/RTUs/PMUs. The communications support requirement for SCADA/EMS/RTUs/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 -1200 bps) data channel support
- (d) Voice (2 wires, 4 wires) channel support.
- (e) Data transport supporting Network Management channels
- (f) The connectivity envisaged between RTUs 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 at least 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 Redundancy Requirements and Protection Schemes**

Equipment redundancy and Automatic Protection Schemes (APS) are specified in the Table 2-1. The failure of one element shall not prevent the use of any other that has not failed.

**Table 2-1  
Equipment Redundancy Requirements Summary**

<b>Fiber Optic transmission Equipment :</b>	
<b>SDH equipment</b>	
<b>Power Supply &amp; Converters -----</b>	1:1 APS or distributed power supply
<b>Common Control* Cards -----</b>	1:1 APS
<b>MUX, DROP/INSERT</b>	
<b>Power Supply -----</b>	1:1 APS or distributed power supply
<b>* = Common control cards which are essentially required for operation of the equipment.</b>	

The offered equipment shall support at least SNCP **as per standard ITU-T G.841**. In case the equipment offered by the Bidder does not support the above mentioned minimum protection methods, the bidder shall have to provide all additional equipment needed to provide same level of flexibility, redundancy and functionality at no additional cost to Employer. The bidders shall provide details of protection schemes supported in the Bid document.

The offered equipment shall support automatic switchover function between the redundant modules and all required modules and hardware to support the automatic switch over shall be provided by the Contractor.

#### **2.2.3.8 Lost Signal Recovery**

At any digital signal level, reapplication of a lost signal shall result in automatic resynchronization and full restoration to normal operation without manual intervention. All alarms incident to the signal failure, shall be automatically cleared at the equipment, rack and monitoring levels and normal operation indications restored and reported if applicable.

#### **2.2.3.9 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.

#### 2.2.3.10 General Site Considerations

All fiber optic links up to 175 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.

#### 2.2.3.11 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-2-2:

<b>Table-2-2</b> <b>Optical Fibre Characteristics</b>	
<b>Fibre Description:</b>	Dual-Window Single-Mode (DWSM)
<b>Mode Field Diameter:</b>	8.6 to 9.5 $\mu\text{m}$ ( $\pm 0.6 \mu\text{m}$ )
<b>Cladding Diameter:</b>	125.0 $\mu\text{m} \pm 1 \mu\text{m}$
<b>Mode field Concentricity Error:</b>	$\leq 0.6 \mu\text{m}$
<b>Core-Clad concentricity error:</b>	$\leq 1.0 \mu\text{m}$
<b>Cladding non-circularity</b>	$\leq 1\%$
<b>Cable Cut off Wavelength:</b>	$\leq 1260 \text{ nm}$
<b>1550 loss performance</b>	As per G.652D
<b>Proof Test Level</b>	$\geq 0.69 \text{ Gpa}$
<b>Attenuation coefficient</b>	@ 1310nm $\leq 0.35 \text{ dB/Km}$ @ 1550nm $\leq 0.21 \text{ dB/Km}$
<b>Attenuation variation with wavelength</b> <b>1285 nm - 1330 nm</b> <b>1525 nm – 1575 nm</b>	Attenuation coefficient @ 1310 $\pm 0.05 \text{ dB}$ Attenuation coefficient @ 1550 $\pm 0.05 \text{ dB}$
<b>Point discontinuities</b>	$\leq 0.1 \text{ dB}$
<b>Chromatic Dispersion; Max.:</b>	18.0 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) @ 1288-1339nm 5.3 ps/(nm x km) @ 1271-1360nm
<b>Zero Dispersion Wavelength:</b> <b>Zero Dispersion Slope:</b>	1300 to 1324nm 0.092 ps/(nm <sup>2</sup> xkm) maximum



**Table-2-2**  
**Optical Fibre Characteristics**

<b>Polarization mode dispersion coefficient</b>	$\leq 0.2 \text{ ps/km}^{1/2}$
<b>Temperature Dependence:</b>	Induced attenuation $\leq 0.05 \text{ dB}$ (-60 deg C - +85 deg C)
<b>Bend performance:</b>	@1310nm (75 $\pm$ 2 mm dia Mandrel), 100 turns; Attenuation rise $\leq 0.05 \text{ dB}$ @1550nm (30 $\pm$ 1 mm dia Mandrel), 100 turns; Attenuation rise $\leq 0.10 \text{ dB}$ @1550nm (32 $\pm$ 0.5 mm dia Mandrel), 1 turn; Attenuation rise $\leq 0.50 \text{ dB}$

### 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-4 (upto 3 MSP protected directions) and equipped with 1 nos. of minimum 16 port E1 interface(G.703) card, two 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 BOQ 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, main and protection channel shall be terminated on separate cards and there shall not be single point of failure.

The equipment shall be configurable either as Terminal Multiplexer (TM) as well as ADM with software settings only.

#### SDH ADM

The aggregate interfaces shall be (at least) STM-4 towards at least two protected directions (Protected as specified in this specifications). At present the equipment shall be equipped with a 1 nos., min.16 E-1 port electrical tributary cards & two no., min.4 port Ethernet interface card as tributaries. The equipment shall provide access to full STM-4 payload.

The offered STM-4 SDH equipment shall be upgradeable to STM-4 by changing optical line cards only. Cross connection (VC4) capability of offered SDH equipment shall be provided according to STM-4 equipment. The contractor shall demonstrate the STM-4 capability during FAT.

### 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 Modems 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 2-3. One 2MHz synchronisation output from each equipment shall be provided.

### 2.3.1.6 Electrical and Optical I/O Characteristics and General Parameters

Table 2-3 provides the electrical and optical characteristics as well as other general parameters for SDH equipment.

<b>Table 2-3</b> <b>Electrical and Optical I/O Characteristics and General Parameters</b>	
<b>Optical Wavelength</b> <sup>NOTE (1)</sup>	1310/1550nm
<b>Optical Source</b> <sup>NOTE (2)</sup>	Laser
<b>Optical Source Lifespan</b>	Better than 5 X10 <sup>5</sup> hours
<b>Optical Fibre Type</b>	G.652 D
<b>Optical Connectors</b>	Type FC-PC
<b>Transmission Quality</b>	Per ITU-T G.821, G.823, G.826
<b>Source Primary Power</b>	-48 Vdc
<b>Equipment Specifications</b>	Per ITU-T G.783
<b>Tributary, Electrical Interface</b>	Per ITU-T G.703, 75 Ω
<b>Ethernet Interface</b>	10/100 Mbps
<b>SDH Bit Rates</b>	Per ITU-T G.703
<b>Optical Interfaces</b>	Per ITU-T G.957, G.958
<b>Frame and Multiplexing Structure for SDH</b>	Per ITU-T G.707
<b>Synchronization</b>	Per ITU-T G.813
<b>Management Functions</b>	Per ITU-T G.774, G.784
<b>Protection Architectures</b>	Per ITU-T G.841
<b>Built In Testing and Alarms</b>	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.

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- 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 2-4.

#### 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.

**Table 2-4**  
**CEPT E-1 Standard First Order Multiplexing**  
**Electrical Input/Output Characteristics**

<b>Applicable Standards:</b>	CEPT per CCITT Recommendation G.702, G.703, G.711 and G.712
<b>Number of Tributaries:</b>	30 X 64 Kbps
<b>Alternative Sub-rate Tributaries:</b>	n X 64 Kbps V.36 64Kb/s V.11/V.36
<b>Output Aggregate Rate:</b>	2.048 Mb/s $\pm$ 50 ppm
<b>Interface Code:</b>	HDB3
<b>Impedance:</b>	75 ohm unbalanced
<b>Peak Level @ 120 ohm:</b>	3.0 volts $\pm$ 10%
<b>Peak Level @ 75 ohm:</b>	2.37 volts $\pm$ 10%
<b>Maximum Insertion Loss:</b>	6 dB
<b>Signal Waveform:</b>	Per CCITT G.703
<b>Frame Structure:</b>	Per CCITT G.742
<b>Jitter Performance:</b>	Per CCITT G.823
<b>Power Supply Voltage:</b>	-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 PABX trunks & 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/2Mbps (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.

#### **2.11.6 Help**

All applications shall be supported by USER accessible HELP commands that shall assist the user in the performance of its tasks. HELP commands for an application shall be available to the user from within the active application and shall not interfere with the activities of the application.

-----End of the Section-----



### Section – 3

#### Environment, EMI, Power Supply, Cabling and Earthing

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## Section - 3

### Environment, EMI, Power Supply, Cabling and Earthing

The purpose of this section is to describe the minimum general equipment characteristics and specifications for environmental conditions, source power conditioning and backup, equipment construction, and installation. The section also highlights the stringent Electro Magnetic Compatibility (EMC) guidelines for equipment that will be operated under the severest Electro Magnetic Interference (EMI) and Electro Static Discharge (ESD) conditions expected in an Extra High Voltage (EHV) power system environment.

#### 3.1 Environmental Requirements

Equipment and their components provided under this specification shall operate reliably under the following environmental conditions.

##### 3.1.1 Temperature and Humidity

Most of the equipment will not be installed in environmentally controlled shelters. Therefore, equipment shall operate in accordance with the limits shown in Table 4-1.

**Table 4-1**  
**Environmental Operating Limits**

<b>Temperature Range:</b>	(Un Controlled Environment)
<b>Specification</b>	0 to 45°C
<b>Operation without damage</b>	-10 to 55°C
<b>Shipping/storage</b>	-40 to 60°C
<b>Relative Humidity, non-condensing</b>	Upto 90%
<b>Elevation:</b>	
<b>Operating</b>	to 3,000 m
<b>Non-operating</b>	to 10,000 m

For each location, the Contractor is required to assess the environmental conditions for the equipment to be installed under this specification. The Contractor is responsible for all necessary enclosure, rack or equipment upgrades to ensure the proper operation of the installed equipment.

##### 3.1.2 EMI and Electrostatic Interference

At each location, the Contractor shall assess the need for shielding against radiated emissions and shall provide recommended solutions for any EMI problem found at each location. Specifications provides the type of immunity tests for which the equipment shall be required to pass without failure. For the individual tests to be carried out at the different interfaces, references are made to the relevant IEC and ITU-T recommendations.

### **3.1.3 Vibration and Shock Resistance**

As per testing requirements indicated in this specification.

### **3.1.4 Tropicalization**

Communications equipment will often be stored and operated in uncontrolled environment areas and will be subject to mould, growth of fungus, corrosion and oxidation. The equipment and components shall be suitably tropicalized during manufacture through commissioning, as necessary.

### **3.1.5 Contaminants**

Communications equipment may be located in areas of poor air quality with the main contaminant being dust. Cabinets shall be tight fitting utilizing filtered ventilation openings only.

## **3.2 Primary Source AC/DC Power Requirements**

Facilities will be required to support both AC and DC power load requirements of telecommunications equipment as specified below:

### **3.2.1 Primary Source AC Power**

It will be the Employer's responsibility to provide required Primary AC source Power for communications equipment installed under this specification. The Primary AC Power supplied will be 240 VAC  $\pm$  10%, 50Hz with a frequency variance between 46 and 55 Hz. Harmonic distortion will not exceed five (5) percent.

All equipment and components provided under this specification requiring Primary AC Power, shall be designed for normal operation under the above stated tolerances for 240 VAC supply.

The Contractor shall provide in their Bid as well as in the survey report to the Employer the projected 240 VAC Primary Power load requirement per equipment and totals, by location, for equipment provided under this specification. The Contractor shall provide suitable UPS for communication equipment/module etc. requiring AC power supply at locations other than control centre.

### **3.2.2 -48V DC Power**

Power supplies/converters for communications equipment (except computer system supplied as part of NMS which shall use 240 VAC) provided under this specification, shall use -48Vdc uninterrupted primary source power. The power supply may vary normally within the voltage range -42 to -58 Vdc and the supplied equipment shall operate satisfactorily within this range.

### **3.2.3 Power Distribution and Protection**

The Employer will furnish only one source primary 240 VAC and/or -48 VDC power. It shall be

the Contractor's responsibility for the connection and distribution of all Primary AC and -48V dc source power, in full compliance with all local and national electrical codes.

The Employer shall indicate during the survey by Contractor, on the primary source, the feeders/points that can be used by the Contractor. The Contractor shall supply & install Primary AC and -48Vdc feeder cables to Contractor-furnished distribution panels.

The Contractor shall provide required distribution panels, circuit breakers and appropriate Panel Disconnects. Distribution Panel feeders, Panel Disconnects, distribution panels and circuit breakers shall be sized and equipped to support at least 100% expanded load requirements.

The Contractor shall provide and install all required primary power distribution sourced from the distribution panels. The Contractor shall also be responsible for Load Balancing.

The Contractor is responsible for all inter-rack (enclosure) and intra-rack (enclosure) power distribution required to support equipment supplied under this specification. The Contractor shall provide all cabling, fusing, switching and circuit breaker and surge protection required.

Partially equipped subsystems shall be installed with provision for expansion. Equipment power supplies provided under this specification, shall be sized to support fully equipped subsystems. Primary power distribution protection shall be sized to support and protect maximum operating load potential whether or not the actual projected load shall meet that maximum load potential.

The Contractor shall provide equipment and rack safety earthing in compliance with this specification.

### **3.3 Equipment Construction, Assembly and Installation**

All equipment supplied under this specification shall be constructed, assembled and installed in accordance with the following requirements:

#### **3.3.1 Identification**

All cabling, racks/enclosures, equipment, modules and materials shall be uniquely identifiable as per the following:

##### **3.3.1.1 Equipment**

Each equipment component to the level of printed circuit card, shall be clearly marked with the manufacturer's part number, serial number, month/year of manufacture and revision level. Changes to components shall be identified by an unambiguous change to the marked revision level. The Contractor shall be responsible for maintaining the master revision level list until the Contractor has complied with all requirements of this specification.

Where custom components and parts are provided, each component/part shall be marked to specifically identify that component/part. Printed circuit card cages are defined as an equipment component and as such, shall be clearly identified as stated within this specification.

Equipment chassis and printed circuit card cages having wired backplanes, shall be clearly marked with the manufacturer's part number, serial number, month/year of manufacture, revision level and an additional identifier corresponding directly to the applicable backplane wiring diagram/list.

### **3.3.1.2 Power Distribution**

Power distribution panels shall be clearly marked with their unique identifier, source feed information, and remote source feed emergency disconnect location and identity.

Power distribution panel "Main Disconnect" and circuit breakers shall be clearly marked with a unique identifier. Circuit breaker feed lists shall be clear, accurate and the feed list information shall be posted inside each distribution panel door.

Inter-rack and intra-rack (enclosure) power distribution shall be clearly identified with source feed, voltage and power rating information. All power feed cabling shall be clearly identified near the point of termination.

All power distribution identification shall utilize heat-resistant permanent marking techniques such as stamped non-metallic tags, embossed labels, etc. Marking techniques are subject to approval by the Employer. Power distribution identifiers and information shall agree with the Contractor's power cable plant drawings.

### **3.3.1.3 Signal Cabling**

Connectorised signal cabling/wiring requires marking with a unique identifier at each connectorised end. The signal cable/wire identifier shall include a cable identifier and the location of both terminations.

Signal cable/wiring installed on terminal blocks requires marking with the cable identifier and distant end location. The cable tag shall be clearly visible at the cable fan-out point.

All signal cable, wiring and terminations shall be clearly labeled/tagged with identifiers consistent with Contractor supplied cable plant records. Marking techniques are subject to approval by the Employer.

### **3.3.1.4 Equipment Racks and Enclosures**

All equipment racks, enclosures and equipment, including distribution frames, shall be clearly labeled with unique identifiers consistent with Contractor supplied floor plans and rack elevations.

## **3.3.2 Installation Hardware**

Equipment racks, enclosures, cable raceways and installation hardware shall, at a minimum, comply with the following requirements:

### **3.3.2.1 Equipment Sub-Racks and Cabinets (Enclosures)**

All equipment provided under this specification, shall be physically mounted in sub-racks and cabinets (enclosures). The Contractor shall determine and propose for the Employer approval, the type, size, weight and manner of installation for each location.

Selection of equipment sub-racks and cabinets (enclosures) shall meet the following requirements:

#### **(A) Equipment SubRack Construction**

Equipment Sub Racks provided for installation in environmentally controlled facilities, shall meet the following minimum requirements:

- (1) Equipment Sub Racks shall be steel/aluminum fabricated and finished on all surfaces. All metal and welds shall be thoroughly cleaned and sanded to obtain a smooth finish. All surfaces shall be treated for rust and primed to form a bond between metal and the finish coats of paint.
- (2) Equipment covers shall be provided for exposed components mounted in equipment sub Racks.
- (3) Dust and moisture protection shall meet or exceed IP20 standards.

#### **(B) Equipment Cabinet (Enclosure) Construction**

- (1) Equipment cabinets (enclosures) shall be steel/ steel & Aluminium extrusion fabricated and finished on all surfaces. All metal and welds shall be thoroughly cleaned and sanded to obtain a smooth finish. All surfaces shall be treated for rust and primed to form a bond between metal and the finish coats of paint.
- (2) Equipment cabinets (enclosures) shall be designed free-standing but shall be mounted to the floor. Cabinets (enclosures) shall have secure fitting, lockable, full-length front doors for access to hardware and wiring. Equipment covers for exposed components mounted inside cabinets are not required unless specifically recommended.
- (3) All doors and removable panels shall be fitted with long life rubber beading. All panels shall be fabricated from minimum 2.0mm thickness steel sheet. However, for racks with load bearing Aluminium extrusion frame, door panels and side panels may be fabricated from minimum 1.6mm thickness steel sheet and the top & bottom panels shall be fabricated from minimum 2.0mm thickness steel sheet.
- (4) Equipment cabinets (enclosures) shall be dust and moisture-proof as per IP41 specification, or better.

### **3.3.2.2 Cable Raceways**

The Contractor is required to provide and install all additional necessary indoor and outdoor cable raceways. The cable raceways shall be in conformance with the following:

- (1) Signal cabling and power cabling shall require separate cable raceways. Signal and power cabling shall not share the same raceways and shall be installed as far apart as is practical. Adequate shielding shall be provided as required.
- (2) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.
- (3) Outdoor cable raceways shall be of corrugated construction and shall be fitted with solid covers overlapping all sides of the cable raceways.
- (4) Outdoor cable raceways shall be fabricated from construction grade aluminum, galvanized iron or anodized sheet metal or any other suitable material approved by the Employer. Suitable anti-corrosion measures shall be taken. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to-paint bond.
- (5) Indoor cable raceways fabricated of aluminum or galvanized iron, shall not normally need special finishing or painting, unless otherwise stipulated by the Employer. Steel fabricated raceways shall require a red oxide primer coat at a minimum.

### **3.3.3 Signaling Distribution**

The Contractor shall be responsible for all signal wiring associated with furnished equipment in accordance with the following:

- (1) All signal wiring connections to the communications equipment shall be via Krone type or equivalent terminal blocks.
- (2) The Contractor shall provide subscriber level wiring and patching wherever required.

### **3.3.4 Lightning and Transient Voltage Protection**

The Contractor shall be required to provide protection from lightning and transient voltages for all wideband communications equipment, in accordance with the following:

- (1) At the outside cable plant point-of-entry of all cabling penetrations for all cabling installed by the Contractor, the Contractor shall provide lightning and transient voltage isolation for the inside plants cabling, wiring, and all terminations and equipment.
- (2) All equipment installed under this specification that requires 240VAC primary power, shall be surge protected.

### **3.3.5 Station Safety Earthing and Signal Grounding**

For each facility, the Contractor is responsible for meeting the following station and equipment earthing requirements:

- (1) All safety earthing and signal grounding shall be in full compliance with EMI/EMC requirements as per relevant international standards
- (2) Each cabinet (enclosure) or cabinet (enclosure) group shall include suitable signal ground and safety earth networks. The signal ground network shall terminate at a separate signal ground stud connection isolated from safety earth.
- (3) Each earth/ground network shall utilize copper bus bars, copper braids and/or 16 sqmm or bigger earth cable. All equipment earth/ground connections shall be made directly to the equipment chassis utilizing grounding lugs and secured metal-to-metal with star washers. Use of the enclosure frame, skin or chassis mounting hardware as part of the earthing/grounding networks, is not acceptable.
- (4) The safety earth network shall be connected to "earth ground" at the safety earth stud. The earth stud connection shall be sized for an external earthing cable equipped with a 2/0 solid copper lug secured metal-to-metal with star washers. Primary AC feeds and distribution within enclosures requires earthing wire connection to the safety earth stud.
- (5) The safety earth and signal ground networks shall be inter-connected only at the safety earth stud and signal ground stud.

The Contractor shall extend the existing station earth to the equipment room using suitable G.I. earthing strip (50 x 6 mm), wherever required. .

The Contractor is responsible for providing all required earthing/grounding cable and installation. Cabinet (Enclosure) and equipment safety earthing and signal grounding shall be subject to the Employer's approval.

The Contractor shall be responsible for determining the suitability of existing station earth for the equipment to be supplied under this contract. In case existing earthing arrangement at the site is not adequate, the Contractor shall either make improvement in the existing earthing arrangement or make new earthing as per requirement.

### **3.3.6 Interconnections**

All power and signal cabling between component units of the communications systems shall be supplied and installed by the Contractor and shall be shown on contractor-supplied as-built drawings.

The Contractor shall supply and install all primary power cords, powerstrips, receptacles, circuit breakers, fuse panels, switches, earth fault detectors, surge protectors, distribution cabling, and



power connectors required to support all equipment enclosures and system components furnished and installed under this specification, except as specifically excluded.

Plug-type power connectors with captive fastening (such as "Twist-Lock") shall be used for interconnection of source power to the equipment enclosures or racks.

Plug-type connectors with captive fasteners (ie. DB-25, etc) shall be used for the interconnection of all inter and intra-enclosure signalling cable.

### **3.3.7 Finish Colors**

Unless otherwise specified, finish colors for enclosures shall be gloss white enamel on the inside, and semi-gloss medium grey enamel on the outside. Only brushed aluminum trim shall be used. Employer reserves the right to approve the proposed color scheme.

## **3.4 Location of Equipment, Cable Routes and Associated Civil Works**

During the Site Surveys, the Contractor shall determine and propose locations for all equipment to be supplied under this contract. Further, the Contractor shall locate and identify proposed routing for all cabling between all equipment locations including existing and planned equipment not provided under this contract, but required to be connected under the scope of this contract. This subsection defines the requirements and clarifies the responsibilities of the Employer and the Contractor regarding equipment siting, intra and inter facility interconnectivity and necessary associated civil works.

### **3.4.1 Locations for Supplied Equipment**

All transmission equipment and associated DDFs and MDFs, shall generally be colocated in the same communications room located in the Control Building whenever possible.

### **3.4.2 Associated Civil Works**

The Contractor shall provide all required minor civil works necessary for full connectivity as required in the Contractor's scope of work as follows:

- (1) All wall and floor penetrations necessary for the installation of all cabling to be performed in accordance with the requirements of this specification.
- (2) Installation of racks, cabinets, cable raceways, and cabling supplied as part of this contract.

### **3.4.3 Cable Trenches**

A network of cable trenches and/or ducts may exist at some sites but shall require expansion and/or new construction at some stations. It shall be a responsibility of the contractor to cooperate fully with the Employer and all other on-going project contractors in the planning and efficient use of existing and new cable trenches. The existing cable trenches/ cable raceways proposed to be used shall be identified in the survey report. The contractor shall make its best effort to route

the cable through the existing available cable trenches. Where suitable existing cable trenches are not available, suitable alternatives shall be proposed for Employer approval. The Employer shall provide any additional cable trenches required for such approved alternatives.

It may be noted that in order to utilise the existing trenches, the Contractor supplied cables may be required to be co-located with LV cables. Accordingly, the contractor shall ensure that selection and installation of cables is suitable for the purpose. The contractor shall be responsible for new building penetrations required for supplied cabling. Caution shall be taken to ensure existing equipment and site personnel are protected from dust and debris incident to the cable penetration work. Penetration shall be neatly formed and sealed for protection from moisture, dust wind and vermin intrusion.

All required fitting, supports, accessories, ducts, inner ducts, conduits, riser and any item not specially mentioned but required for lay and installation of cables in trenches shall be supplied and installed by the Contractor.

-----**End of this Section**-----

## Section - 04

### Inspection, Test and Availability

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## **Section - 04**

### **Inspection, Test and Availability**

All materials furnished and all work performed under this Contract shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, and all deficiencies have been corrected to comply with this Specification and approved for shipment by the Employer.

Except where otherwise specified, the Contractor shall provide all manpower and materials for tests, including testing facilities, logistics, power and instrumentation, and replacement of damaged parts. The costs shall be borne by the Contractor and shall be deemed to be included in the contract price.

The entire cost of testing for factory & site acceptance, routine tests, production tests and other test during manufacture & site activities specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector/Employer's representative.

Acceptance or waiver of tests shall not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

All tests shall be witnessed by the Employer and/or its authorized representative (hereinafter referred to as the Employer) unless the Employer authorizes testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.

Should any inspections or tests indicate that specific item does not meet Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies at no cost to the Employer. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

The Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified Type, Acceptance, Routine, or Manufacturing tests to assure the Employer of specification compliance.

All security related features shall be demonstrated during FAT/SAT as required by the Employer.

#### **4.1 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.

## 4.2 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.

#### 4.2.1 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 4-1.

**Table 4-1**  
**Factory & field Test Plan Requirements**

<b>Item:</b>	<b>Description:</b>
<b>1.</b>	Test schedule
<b>2.</b>	Record-keeping assignments, procedures and forms
<b>3.</b>	Procedures for monitoring, correcting and retesting variances
<b>4.</b>	Procedures for controlling and documenting all changes made to the communications equipment after the start of testing

#### 4.2.2 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 4-2.

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.

**Table 4-2**  
**Test Procedure Requirements**

<b>Item:</b>	<b>Description:</b>
<b>1.</b>	Test Title and Revision Level, if applicable
<b>2.</b>	List of Standard(s) complied with
<b>3.</b>	Function(s) / parameter(s) to be tested
<b>4.</b>	Purpose of each test segment
<b>5.</b>	List of required test equipment
<b>6.</b>	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.
<b>7.</b>	Test setup including test configuration block diagrams and/or illustrations.
<b>8.</b>	Test procedures to be followed.
<b>9.</b>	Required inputs and expected outputs for each test segment
<b>10.</b>	Acceptance criteria for each test segment.
<b>11.</b>	List of test data to be supplied by the Contractor(s) and copies of any certified data to be used
<b>12.</b>	Format of test reports.

#### 4.2.3 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 4-3.

**Table 4-3**  
**Test Record Requirements**

<b>Item:</b>	<b>Description:</b>
<b>1.</b>	Test Title and Revision Level, if applicable; contract references
<b>2.</b>	Date and time for test start and test completed
<b>3.</b>	Test title and reference to the appropriate section of the test procedures
<b>4.</b>	Description of any special test conditions or special actions taken (Includes test-case data).
<b>5.</b>	Test results for each test segment including an indication of Passed, Conditional Pass, Incomplete or Failed.
<b>6.</b>	Test procedure modifications made during testing.
<b>7.</b>	Variance Report(s) tracking information and copies (if variance(s) was detected).
<b>8.</b>	Contractor's test engineer(s) identification, signature and remarks
<b>9.</b>	Employer's test witness identification, signature and remarks
<b>10.</b>	List of all attachments

**Table 4-3**  
**Test Record Requirements**

<b>Item:</b>	<b>Description:</b>
<b>11.</b>	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.

#### **4.2.4 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.

#### **4.2.5 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

### **4.3 Type Testing**

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the following:

- (a) All equipment being supplied shall conform to type tests as per technical specification.



- (b) The test reports submitted shall be of the tests conducted within last five (5) years prior to the date of bid opening. In case the test reports are older than five years (5) ago on the date of bid opening, the Contractor shall repeat these tests at no extra cost to the purchaser.
- (c) The Contractor shall submit, within 30 days of Contract Award, copies of test reports for all of the Type Tests that are specified in the specifications and that have previously ( before Contract award) been performed. These reports may be accepted by the Employer only if they apply to materials and equipment that are essentially identical to those due to be delivered under the Contract and only if test procedures and parameter values are identical to those specified in this specifications carried out at accredited labs and witnessed by third party / customer's representatives.

In the event of any discrepancy in the test reports or any type tests not carried out, same shall be carried out by Contractor without any additional cost implication to the Employer.

- (d) Type Tests shall be certified or performed by reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer. The test procedures shall be formatted as defined in the technical specifications and shall include a complete list of the applicable reference standards and submitted for Employer approval at least four (4) weeks before commencement of test(s). The Contractor shall provide the Employer at least 30 days written notice of the planned commencement of each type test.
- (e) The Contractor shall provide a detailed schedule for performing all specified type tests. These tests shall be performed in the presence of a representative of the Employer.
- (f) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.
- (h) In case of failure during any type test, the Supplier is either required to manufacture a fresh sample lot and repeat all type tests successfully or repeat that particular type test(s) at least three times successfully on the samples selected from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

#### **4.3.1 Type Test Samples**

The Contractor shall supply equipment/material for sample selection only after the Quality Assurance Plan has been approved by the Employer. The sample material shall be manufactured strictly in accordance with the approved Quality Assurance Plan. The Contractor shall submit for Employer approval, the type test sample selection procedure. The selection process for conducting the type tests shall ensure that samples are selected at

random. At least three samples of each of the proposed equipment shall be offered for selection, out of which one sample for each equipment shall be selected.

#### **4.3.2 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

##### **4.3.2.1 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:

##### **4.3.2.1.1 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 table 5-1: 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 55°C.
- (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 table 5-1 (Operation to specification range)
- (3) Cycle duration for each temperature is three (3) hours.
- (4) Ramp : 1 °C/minute.
- (5) Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

**4.3.2.1.2 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 4-4:

**Table 4-4: 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 - <b>Level : 1</b>
2	Voltage dips and Interruptions	Yes	Yes	N/A	N/A	
3	1.2/50 - 8/20 $\mu$ s surges	Yes	Yes	Yes	N/A	Table 12 of IEC 60870-2-1: 1995 - <b>Level : 4</b>
4	Fast transient bursts	Yes	Yes	Yes	Yes	
5	Damped oscillatory waves	Yes	Yes	Yes	Yes	

**Table 4-4: Recommended Immunity Tests**

S. No.	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Para-metres
6	10/700 μs surges	N/A	N/A	N/A	Yes	
7	Electrostatic discharge	Yes				Table 13 of IEC 60870-2-1: 1995 - <b>Level : 4</b>
8	Power frequency magnetic field	Yes				Table 14 of IEC 60870-2-1: 1995 - <b>Level : 4</b>
9	Damped oscillatory magnetic field	Yes				
10	Radiated electromagnetic field	Yes				Table 15 of IEC 60870-2-1: 1995 - <b>Level : 4</b>
11	Power Frequency voltage on control and signal lines	N/A	N/A	Yes	Yes	IEC 61000-4-16 : 2002-07 <b>Level : 4</b>
12	DC voltage on control and signal lines	N/A	N/A	Yes	N/A	IEC 61000-4-16 : 2002-07 <b>Level : 4</b>
<b>-End of Table-</b>						

**(b) Emission Tests**

The list of Emission tests are specified below in Table 4-5

**Table 4-5:  
Recommended Emission Tests**

S. NO.	Emission test	AC Power Supply	DC Power Supply	Contr ol & 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>B</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				
<b>-End Of Table-</b>						

**(c) Insulation Withstand Voltages**

As per section 6 of IEC 870-2-1. Recommended class : VW1 of Table 18.

**4.3.2.1.3 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  $A = 294 \text{ m/s}^2$ ,  $D = 18 \text{ ms}$ . 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.

### **4.4 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.

#### **4.4.1 Sampling for FAT**

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, all required FAT tests in the approved FAT procedures, shall be performed on all samples. The Sampling rate for the Factory acceptance tests shall be minimum 10% of the batch size (minimum 1) for all items. The physical verification shall be carried out on 100% of the offered quantities as per the approved FAT procedure. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected. In case a number of equipments are required for demonstration of the performance of any equipment during FAT, the sample size shall be taken as that number of equipments which are necessary to demonstrate the performance, irrespective of the percentage.

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/ approvals until such a report is made and remedial actions taken, as applicable.

#### **4.4.2 Production Testing**

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



**Table 4-6:  
Factory Acceptance Testing for Fibre Optic Transmission System**

<b>Item:</b>	<b>Description:</b>
<b>1.</b>	Physical inspection for conformance to DRS, BOQ, drawings and appearance of equipment
<b>2.</b>	Optical output power
<b>3.</b>	Transmitter lightwave spectral analysis
<b>4.</b>	Low receive level threshold
<b>5.</b>	Generation of bit error rate curve
<b>6.</b>	Measurement of analog and digital service channel parameters as well as service channel functionality
<b>7.</b>	Performance of supervision, alarm, Craftsperson interface, diagnostics, loop backs etc.
<b>8.</b>	Electrical interface tests which include: output and input jitter, bit error rate, pulse shape, cable compensation, and line rate tolerance for multiplexers
<b>9.</b>	At a minimum tests on Ethernet interface shall include demonstration of ping test, throughput test, Latency test, Packet Loss test as per RFC 2544
<b>11.</b>	Simulation of failure conditions and failover of each redundant unit.
<b>12.</b>	Test of spare card slots
<b>13.</b>	Checks of power supply/converter voltage margins
<b>14.</b>	Random inspections to verify the accuracy of documentation
<b>15.</b>	Test of spare parts/modules/cards as per applicable tests

**Table 4-7  
Factory Acceptance Testing Requirements for Termination Equipment  
(MUX)**

<b>Item</b>	<b>Description:</b>
<b>1.</b>	Physical Inspection for conformance to DRS, BOQ, drawings and appearance of equipment
<b>2.</b>	Performance of supervision, alarm, control and switching systems, diagnostics, loopbacks, Craftsperson interface etc.
	Electrical interface tests which include: output and input jitter, bit error rate, pulse

**Table 4-7**  
**Factory Acceptance Testing Requirements for Termination Equipment (MUX)**

<b>Item</b>	<b>Description:</b>
<b>3.</b>	shape, cable compensation, and line rate tolerance for the channel banks/low-level multiplexers
<b>4.</b>	Framing, signaling, and operational and maintenance tests consistent with applicable ITU-T requirements
<b>5.</b>	Simulation of failure conditions and failover of each redundant unit
<b>6.</b>	Test of spare card slots and test of spare parts/modules/cards as per applicable tests
<b>7.</b>	Checks of power supply/converter voltage margins and short circuit and overvoltage protection
<b>8.</b>	Random inspections to verify the accuracy of documentation

**Table 4-8**  
**FAT on Craft Terminal**

<b>1</b>	Physical inspection of Craft Terminal hardware for conformance to approved BoQ, DRS & drawing
<b>2</b>	Testing of Craft Terminal to demonstrate proper operation of all functions

#### **4.5 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.

#### **4.5.1 Phases for Site Acceptance Testing**

The SAT shall be completed in following phases:

##### **4.5.1.1 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.

##### **4.5.1.2 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.

### 4.5.1.3 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.

**Table 4-9**  
**Fibre Optic Transmission system Installation Testing**

<b>Item:</b>	<b>Description:</b>
<b>1.</b>	Physical Inspection for conformance to drawings, rack elevations and appearance of equipment and cabling
<b>2.</b>	Station power supply input and equipment power supply (DC-DC converter) output voltage measurements
<b>3.</b>	Terminal transceiver performance testing (Tx power, Tx spectrum, receive signal strength, connector losses etc.)
<b>4.</b>	Service channel performance
<b>5.</b>	Craftsperson interface, alarm and control functional performance
<b>6.</b>	Rack and local alarms: No alarms shall be present and all alarms shall be demonstrated to be functional
<b>7.</b>	Network management interface and supervision performance
<b>8.</b>	Correct configuration, level setting & adjustments and termination of Input/output interfaces
<b>9.</b>	Proper establishment of Safety and signalling earthing system and resistance to ground to be checked.
<b>10.</b>	Simulation of failure conditions and failover of protected components.

**Table 4-10**

**Termination Equipment Sub-system Installation Testing**

<b>Item:</b>	<b>Description:</b>
<b>1.</b>	Physical Inspection for conformance to drawings, rack elevations and appearance of equipment and cabling
<b>2.</b>	Power supply/converter voltage measurements
<b>3.</b>	Muldem performance testing
<b>4.</b>	Craftsperson interface, alarm and control functional performance
<b>5.</b>	Rack and Local alarms
<b>6.</b>	Network management interface and supervision performance
<b>7.</b>	Channel performance
<b>8.</b>	Safety and signalling earthing system
<b>9.</b>	Simulation of failure conditions and failover of protected components.

**Table 4-11**

**NMS Installation Testing (if Applicable)**

<b>Item:</b>	<b>Description:</b>
<b>1.</b>	Physical inspection for conformance to drawings, rack elevations and appearance of equipment and cabling
<b>2.</b>	Workstation hardware inventory, configuration and characteristics
<b>3.</b>	Demonstration of proper operation of all hardware, including workstations peripherals

-----**End of this Section**-----

## Section-5

### Training and Support Services

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## **Section-5**

### **Training and Support Services**

This section describes the requirements for Contractor-supplied training, support services, and maintenance of the FOTS, Terminations equipments sub-systems, etc. The intent of the training and support program is to ensure a smooth transfer of systems and technologies from the Contractor to the Employer, and to ensure that Employer staff is fully trained to operate, maintain and expand the integrated telecommunication network.

#### **5.1 Training**

The Contractor shall provide a comprehensive training program that prepares the Employer's personnel for on-site installation support, operation, and maintenance of the telecommunication network.

Training may be conducted by the Contractor, the Contractor's subcontractors, and/or original equipment manufacturers (OEMs). The training requirements of this Specification shall apply to all such courses.

Training courses shall be conducted by personnel who speak understandable English and who are experienced in instruction. All necessary training material shall be provided by the Contractor. The training charges quoted by the Contractor shall include training materials and all associated expenses. However, for all training courses in India or abroad, the travel (e.g., airfare) and per diem expenses of the participants will be borne by the Employer. For courses conducted abroad, however, the Contractor shall extend all necessary assistance for making appropriate lodging arrangement.

Hands-on training shall be provided with equipment identical to that being supplied to the Employer.

The schedule, location and detailed training contents shall be submitted by the Contractor to the Employer for approval.

##### **5.1.1 System Design & Overview Training**

This training shall provide a functional description of the telecommunication subsystems for both fibre optic transmission system and Termination equipment system and a discussion of the failover and alternate routing schemes inherent in the configuration. The training shall include an overview of the network configuration and indicate the functional responsibilities of all major subsystems including the network monitoring system hardware and software. The training shall highlight all significant methodologies or concepts utilized by the hardware and software to perform the required functions. High-level hardware configuration block diagrams and network/sub-network block/flow diagrams shall be included to enhance the understanding of the overall capability incorporated into all network and sub-network equipment.

The training shall be oriented to a user's point of view. The Employer/Owner users will include

managers, design & planning personnel, communication support staff and maintenance personnel. As part of the proposal, the Contractor shall identify the number of days deemed appropriate for this training.

The overview training shall be customized for the specific functions, features, and equipment purchased by the Employer; it shall not be a general presentation of the Contractor's standard equipment repertoire. Personnel assigned by the Contractor to implement the Employer's system shall conduct this overview training. The Employer shall review and approve the contents of the overview training at least four (4) weeks prior to the course.

### **5.1.2 Installation & Maintenance Training**

There shall be separate modules of the installation & maintenance training for the following systems:

- (1) FO Transmission System Training
- (2) Termination Equipment System Training

The installation & maintenance trainings shall enable the Employer to be self-sufficient in preventive & restorative maintenance of the respective communications subsystems purchased by the Employer.

### **5.1.3 Training Course Requirements**

This section describes general requirements that apply to all training courses.

#### **5.1.3.1 Class Size**

The Employer plans to send a number of participants to the training courses for a specified duration as described in Appendices.

#### **5.1.3.2 Training Schedule**

The Contractor shall provide training in a timely manner that is appropriate to the overall project schedule. All training courses shall be available to the Employer for a minimum of five years after final acceptance of the communication system.

The training courses shall be offered in one cycle, such that none of the courses within the cycle overlap. The Contractor shall take the above requirements into account in developing the preliminary training schedule. Contractor shall develop a final training schedule in consultation with the Employer after contract award.

#### **5.1.3.3 Manuals and Equipment**

The Contractor, subcontractor, or OEM shall prepare training manuals and submit them to the Employer for review at least one month prior to the start of classroom instruction. The training manuals shall be prepared specifically for use as training aids; reference manuals,



maintenance manuals, and user's manuals may be used as supplementary training material. Principal documents used for training shall be tailored to reflect all the Employer requirements specified.

Each course participant shall receive individual copies of training manuals and other pertinent material at least two weeks prior to the start of each course. The Employer shall retain the master and two additional copies of all training manuals and materials as reference documentation. A complete set of instructor's manuals and training aids shall also be provided.

Upon completion of each course, instructor's manuals, training manuals, and training aids shall become the property of the Employer. As part of the delivered system documentation and the final documentation, the Contractor shall supply the Employer with all changes and revisions to the training manuals and other training documentation. The Employer reserves the right to copy all training manuals and aids for use in the Employer-conducted training courses. The Contractor shall furnish for use during training courses all special tools, equipment, training aids, and any other materials required to train course participants.

## **5.2 Support Services**

Throughout design, implementation, factory testing, and field installation and testing, the Contractor shall supply consulting assistance, as required by the Employer for site preparation, field installation, and other areas where technical support may be required.

The Contractor shall be responsible for minor facility renovation, and maintenance of the supplied system up to and including successful completion of the Site Acceptance Test.

After final acceptance of the communications equipment, the Contractor shall offer continuing technical support and spare parts for the designed life of the equipment or 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. Some locations have existing SDH & MUX equipment. The traffic may be switched over to new fibre optic communication equipment in phase manner. The Contractor shall review the Employer existing equipment make, integration & switch over recommendation and prepare a detailed field implementation plan.

### **5.2.1 Technical Support**

Consultation with Contractor's technical support personnel and trained field service personnel shall be readily available on a short-term/long-term basis to assist the Employer personnel in maintaining, expanding, and enhancing the telecommunication network upon expiration of the warranty period. The Contractor shall include in their offer(s), a proposal for ensuring continued technical support as stated above.

### **5.2.2 Contractor's Future Hardware/Software Changes**

The Employer shall be informed of all alterations or improvements to the hardware supplied under this Specification. The Employer shall be placed on the Contractor's mailing list to

receive announcements of the discovery, documentation, and solution of hardware/software problems as well as other improvements that could be made to supply equipment. The service shall begin at the time of contract award, and shall continue for 10 years. The Contractor shall also include a subscription to the hardware subcontractors' change notification service from the time of contract award through the warranty period, with a Employer renewable option for extended periods.

### **5.3 Spare Parts and Test Equipment**

The spare parts and test equipment shall be provided for each subsystem as described below.

#### **5.3.1 Mandatory Spare Parts**

Appendices provides the Mandatory Spare Parts Requirements described in **subsystem sets**. The mandatory spare parts table represents the minimum spares the Contractor shall be required to supply. The **subsystem set** of spare parts is defined to include all equipment modules, subunits and parts required to effect replacement, repair and restoration to full operational status of a defined unit of a subsystem (i.e. SDH equipment, Primary Mux, Drop/Insert etc.)

### **5.4 System Maintenance**

The contractor shall be responsible to maintain the confidentiality of the Employer's System Information that Employer shares with the contractor for maintenance period.

#### **5.4.1 Warranty Period**

The one year period commencing immediately after the operational acceptance is called the Warranty Period/Defect liability Period. In addition to the responsibilities covered under contract during Defect Liability Period, the Contractor shall also be responsible for maintenance of the Fibre Optic Transmission System, Termination Equipment, etc. supplied under this Package.

#### **5.4.2 Contractor's Maintenance Responsibility**

The Contractor shall be responsible for carrying out "Comprehensive Maintenance" of the Communication System for a period of six years after warranty period for ensuring the successful operation of the system. The Contractor shall be responsible for achieving the system availability and the response time mentioned in technical specifications. The bidder shall quote the Annual Maintenance Charges for six years after Warranty Period which shall be considered in the bid evaluation. Bidder shall submit the detailed procedure for achieving above in the bid. Upon expiry of the six years AMC period Employer may, at its discretion, extend this Maintenance for additional one year at the same price & terms and conditions.

### **5.5 Miscellaneous Supplies**

The Contractor shall provide all required consumable and non-consumable supplies necessary to support all installation and test activities through final operational acceptance. However, if there

are any problems in the SAT and additional consumables are required, the same shall also be supplied by the Contractor at no additional cost.

## **5.6 Documentation**

The Contractor shall submit following documents during detailed engineering:

- (a) Data Requirement sheets
- (b) Link Budget calculations
- (c) MQP, FQP
- (d) Bill of Quantity including mandatory spares
- (e) Previous Type test reports
- (f) Factory Test report
- (g) Manuals for each equipment
- (h) Schematic drawing
- (i) Numbering, Marking, labelling document
- (j) Synchronization plan
- (k) Test schedule
- (l) Training manual
- (m) Configuration diagram
- (n) Transportation & handling Procedure
- (o) Installation Manuals
- (p) Maintenance Manuals

**Appendix - A**

**Bill of Quantities**  
**(BOQ)**  
**for**  
**Communication Equipment for Marsyangdi – Kathmandu 220kV Transmission Line Project**  
**associated with**  
**M/s Nepal Electricity Authority (NEA)**

S.No.	Item Description	Unit	220/132 KV Matatrirtha S/S	220/132 KV Marsaindi( Markichowk ) S/S	Kathman du LDC	Total Quantity
<b>1.0</b>	<b>Transmission Equipment</b>					
<b>A</b>	<b>SDH Equipment ( STM- 4 MADM, upto 3 MSP protected directions)</b>					
<b>(I)</b>	Base Equipment (Common cards, Cross-connect/control cards, Optical base cards, Power supply cards, power cabling, other hardware & accessories including sub-racks, patch cords, DDF etc. fully equipped excluding (II) and (III) below)	No.	2	2	1	5
<b>(II)</b>	<b>Optical Interface/SFP<sup>#</sup> for</b>					
<b>(a)</b>	<b>L4.2</b>	<b>No.</b>	<b>4</b>	<b>6</b>	<b>2</b>	<b>12</b>
<b>(b)</b>	L4.1	No.	6	6	2	12
<b>(c)</b>	S4.1		2	0	2	4
<b>(III)</b>	<b>Tributary Cards</b>					
<b>(a)</b>	E1 Interface card (Minimum 16 interfaces per card )	No.	2	2	1	5
<b>(b)</b>	Ethernet interfaces 10/100 Mbps with Layer-2 switching (Minimum 4 interfaces per card.)	No.	4	4	2	10
<b>2.0</b>	<b>Equipment Cabinets</b>					
<b>a)</b>	<b>For SDH Equipment</b>	No.	2	2	1	5
<b>3.0</b>	<b>TMN – Craft Terminal for SDH &amp; PDH Equipments</b>					
<b>(a)</b>	Hardware	Set*	1	0	0	1
<b>(b)</b>	Software	Set*	1	0	0	1
<b>4.0</b>	<b>Main Distribution Frame</b>	No.	1	1	1	3

S.No.	Item Description	Unit	220/132 KV Matatrirtha S/S	220/132 KV Marsaindi( Markichowk ) S/S	Kathman du LDC	Total Quantity
	(100 pairs)					

Note# :Optical interface/SFP can be provided with Optical base card or Control card with the condition that control card shall not be equipped with more than one Optical interface/SFP and optical card with not more than two Optical interface/SFP. However main and protection channel shall be terminated on separate cards

Note\*: Set shall include all required hardware/software for complete TMN –Craft Terminal system as specified in technical specifications.

Note\*\* : Consider for existing equipment installed at Matatitha (Existing) and Optical Interface Card(s)/SFP shall be suitable to integrate with equipment installed Matatirtha (Existing).

Note\*\*\* : Consider for existing equipment installed at Markichock (Existing) and Optical Interface Card(s)/SFP shall be suitable to integrate with equipment installed Markichock (Existing).

<b>Table - 2</b> <b>BOQ for Mandatory Spares of Communication Equipments</b>			
S.No.	Item Description	Unit	Quantity
<b>1.0</b>	<b>Transmission Equipment</b>		
<b>A</b>	<b>SDH Equipment ( STM- 4 MADM, upto 3 MSP protected directions)</b>		
(I)	Common cards, Power supply cards, power cabling, other hardware & accessories (each)	Set <sup>\$\$</sup>	<b>1</b>
(II)	<b>Optical Interface/SFP for</b>		
(a)	<b>S4.1</b>	No.	<b>1</b>
(b)	<b>L4.2</b>	No.	<b>2</b>

<b>Table - 2</b> <b>BOQ for Mandatory Spares of Communication Equipments</b>			
<b>S.No.</b>	<b>Item Description</b>	<b>Unit</b>	<b>Quantity</b>
(c')	L4.1	No	<b>3</b>
<b>(III)</b>	<b>Tributary Cards</b>		
(a)	E1 Interface card (Minimum 16 interfaces per card)	No.	<b>1</b>
(b)	Ethernet interfaces 10/100 Mbps with Layer-2 switching (Minimum 4 interfaces per card.)	No.	<b>1</b>
<b>3.0</b>	<b>Pre Connectorized Optical Fiber Patch Cords (10 Mtrs) – Pack of Six Patch Cords</b>	Set	<b>1</b>

Note\$\$: One Set means one of each type of module/unit card etc

**Table-3**  
**BOQ for Auxiliary Power Supply Equipments**

S. No.	Item description	Unit	Ratings (DCPS & Battery)		Total Qty.
			15 A		
			200 AH		
A.	Main Equipments		220/132 KV Matatrirtha S/S	220/132 KV Marsaindi(Markichowk) S/S	
1	SMPS based 48V DC Power Supply (DCPS) system	Nos.	01	01	02
2	VRLA type Battery bank for above DCPS system	Nos.	01	01	02
B.	Mandatory Spares for DCPS				
1	MCCB/MCB-2P/ Contactor/ Timer/ Relay of each type & rating (as applicable)	Set	01	00	01
2	Single Pole MCBs (for outgoing DC Feeders)	Nos.	05	00	05
3	Electronic Printed Circuit Board / Card of each type (all cards/module including SMPS Module, DC Power Supply Controller, various interface cards etc.)	Set	01	00	01



**Table: - 4**

<b>Sl. No.</b>	<b>Item Description</b>	<b>Location</b>	<b>No. of Trainees</b>	<b>Duration in working days</b>
1	Training on SDH MUX and NMS (Craft Terminal and PLCC equipments	Manufacturer works/Training centre	4	2
		On Job Training Nepal	4	5

**Table -5  
Maintenance Charges**

<b>S. No.</b>	<b>Items Description</b>	<b>Unit</b>	<b>Qty</b>
1	Maintenance Charges for Communication System for One (1) year during Warranty period	Year	1
2	Maintenance Charges for Communication System for 6 year after Warranty period	Year	1x6

## **Appendix B**

### **Data Requirement Sheets**

## **Appendix-B**

### **Data Requirement Sheets**

The following sets of Data Requirement Sheets are required to be filled up by the bidders to aid in the evaluation process. The response shall be brief and to the point and shall be supported by the printed product description and other literature. The DRS duly filled and the relevant drawings shall also be submitted during the detailed engineering along with the relevant technical brochures.

DRS Form 01

**DATA REQUIREMENTS SHEETS for  
OPTICAL LINE TERMINATION EQUIPMENT (OLTE)**

Manufacturer: \_\_\_\_\_

Model #: \_\_\_\_\_

**GENERAL OLTE FEATURES**

<b>Seq</b>	<b>Parameter:</b>	<b>As per Technical Specification</b>	<b>As per Bidder Offering</b>
<b>1.</b>	SDH hierarchy level:	STM-4	
	Capacity Aggregate Bit-rate:	155 Mbps	
	CEPT E-1 Ports:	63 x E1	
<b>2.</b>	Minimum No. of protected (MSP) directions	Two	
<b>3.</b>	No. of E1 ports in E1 tributary cards	minimum 16	
<b>4.</b>	No. of Ethernet ports in Ethernet interface tributary cards	minimum 4	
<b>5.</b>	Service Channel provision a) Voice Channel b) Data Channel	Yes Minimum 1 Minimum 1	
<b>6.</b>	Power Supply cards of SDH equipment	1:1 APS or distributed power supply	
	Common Control* Card of SDH equipment	1:1 APS	

\* = Common Control Cards which are essentially required for the operation of the equipment

DRS Form 02

**DATA REQUIREMENTS SHEETS for  
Primary Multiplexer/Drop & Insert Multiplexer**

Manufacturer:

\_\_\_\_\_

Model #:

\_\_\_\_\_

Configuration:

Seq.	Parameter	As per Technical Specification	As per Bidder Offering
1.	Output Aggregate Rate	2.048 Mbps +/- 50 ppm	
2.	Interface Code	HDB3	
3.	Impedance	75 ohm unbalanced	
4.	Maximum Insertion Loss	6 dB	
5.	Power Supply card of multiplexer	1:1 APS or distributed power supply	

The detailed DRS for all equipments/items are required to be submitted along with brochures during detailed engineering.

-----End of the Appendix-----

## **CHAPTER 19-GENERAL TECHNICAL REQUIREMENT (GTR)-TRANSFORMER & REACTOR**

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## **CHAPTER 19-GENERAL TECHNICAL REQUIREMENT (GTR)-TRANSFORMER & REACTOR**

### **1.0 FOREWORD**

- 1.1 The provisions under this Chapter are intended to supplement general requirements for the materials, equipments and services covered under other Chapters of tender documents and is not exclusive. However in case of conflict between the requirements specified in this Chapter and requirements specified under other Chapters, the requirements specified under respective Chapters shall prevail.

### **2.0 GENERAL REQUIREMENT**

- 2.1 The bidders shall submit the technical requirements, data and information as per the technical data sheets provided in the bid documents.
- 2.2 The bidders shall furnish catalogues, engineering data, technical information, design documents, drawings etc., fully in conformity with the technical specification. An indicative list of such drawings and documents for transformer and reactor are enclosed in Annexure-A.
- 2.3 It is recognised that the Contractor may have standardised on the use of certain components, materials, processes or procedures different from those specified herein. Alternate proposals offering similar equipment based on the manufacturer's standard practice will also be considered provided such proposals meet the specified designs, standard and performance requirements and are acceptable to the Purchaser. Unless brought out clearly, the Bidder shall be deemed to conform to this specification scrupulously. All deviations from the specification shall be clearly brought out in the respective schedule of deviations. Any discrepancy between the specification and the catalogues or the bid, if not clearly brought out in the specific requisite schedule, will not be considered as valid deviation.
- 2.4 Wherever a material or article is specified or defined by the name of a particular brand, Manufacturer or Vendor, the specific name mentioned shall be understood as establishing type, function and quality and not as limiting competition.
- 2.5 Equipment furnished shall be complete in every respect with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or needed for erection, completion and safe operation of the equipment as required by applicable codes though they may not have been specifically detailed in the Technical Specifications unless included in the list of exclusions. Materials and components not specifically stated in the specification but which are necessary for commissioning and satisfactory operation of the equipment unless specifically excluded shall be deemed to be included in the scope of the specification and shall be supplied without any extra cost. All similar standard components/parts of similar standard equipment provided, shall be inter-changeable with one another.

### **3.0 STANDARDS**

- 3.1 The works covered by the specification shall be designed, engineered, manufactured, built, tested and commissioned in accordance with the Acts, Rules, Laws and Regulations of Nepal.
- 3.2 The equipment to be furnished under this specification shall conform to latest issue with all amendments (as on the date of bid opening) of standard specified under Annexure-B of this Chapter, unless specifically mentioned in the specification.
- 3.3 The Bidder shall note that standards mentioned in the specification are not mutually exclusive or complete in themselves, but intended to compliment each other.

## **CHAPTER 19-GENERAL TECHNICAL REQUIREMENT (GTR)-TRANSFORMER & REACTOR**

- 3.4 The Contractor shall also note that list of standards presented in this specification is not complete. Whenever necessary the list of standards shall be considered in conjunction with specific IEC/CIGRE/IEEE/NEMA.
- 3.5 When the specific requirements stipulated in the specifications exceed or differ than those required by the applicable standards, the stipulation of the specification shall take precedence.
- 3.6 Other internationally accepted standards which ensure equivalent or better performance than that specified in the standards specified under Annexure B / individual Chapters for various equipments shall also, be accepted, however the salient points of difference shall be clearly brought out in additional information schedule along with English language version of such standard. The equipment conforming to standards other than specified under Annexure B / individual Chapters for various equipments shall be subject to Purchaser's approval.
- 3.7 The bidder shall clearly indicate in his bid the specific standards in accordance with which the works will be carried out.

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

- 4.1 All equipment shall perform satisfactorily under various electrical, electromechanical and meteorological conditions of the site of installation.
- 4.2 All equipment shall be able to withstand all external and internal mechanical, thermal and electromechanical forces due to various factors like wind load, temperature variation, ice & snow, (wherever applicable) short circuit etc for the equipment.
- 4.3 The equipment shall also comply to the following:
- To facilitate erection of equipment, all items to be assembled at site shall be "match marked".
  - All piping, if any between equipment control cabinet/ operating mechanism to marshalling box of the equipment, shall bear proper identification to facilitate the connection at site.
- 4.4 EHV equipments and system shall be designed to meet the following major technical parameters as brought out hereunder.

#### **4.4.1 System Parameter**

Sl. No.	Description of parameters	220 KV System	132 KV System	33 KV System
1.	System operating voltage	220KV	132KV	33KV
2.	Maximum system operating voltage (rms),Um	245KV	145KV	36KV
3.	Rated frequency	50Hz	50Hz	50Hz
4.	No. of phase	3	3	3
5.	Rated Insulation levels			
i)	Full wave impulse withstand voltage(1.2/50 micro sec.)	1050KVp	650KVp	170KVp



## **CHAPTER 19-GENERAL TECHNICAL REQUIREMENT (GTR)-TRANSFORMER & REACTOR**

ii)	Switching impulse withstand voltage (250/2500 micro sec.) dry and wet	-	-	-
iii)	One minute power frequency dry and wet withstand voltage (rms)	460KV	275KV	70KV
6.	Corona extinction voltage	156KV	105KV	-
7.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 508kV rms for 765kV, 320KV rms for 400KV system and 156KV rms for 220KV system & 92 KV rms for 132KV system	1000 micro-volt	500 micro-volt	-
8.	Minimum creepage distance	25 mm/KV (6125 mm)	25 mm/KV (3625 mm)	25 mm/KV (900 mm)
9.a	Min. clearances in air for Transformer & Reactor			
i.	Phase to phase	2300 mm (for BIL- 950 kVp)	1220 mm (for BIL- 550 kVp)	350 mm (for BIL- 170 kVp)
ii.	Phase to earth	1800 mm (for BIL- 950 kVp)	1050 mm (for BIL- 550 kVp)	320mm (for BIL- 170 kVp)
9.b	Min. clearances in air for other switchyard equipments			
i)	Phase to phase	2100 mm	1300 mm	320 mm
ii)	Phase to earth	2100 mm	1300 mm	320 mm
iii)	Sectional clearances	5000 mm	4000 mm	3000 mm
10.	Rated short circuit current for 1 sec. duration	40 kA	31.5 kA	25 kA
11.	System neutral earthing	Effectively earthed	Effectively earthed	Effectively earthed

Note : The insulation and RIV levels of the equipments shall be as per values given in the respective chapter of the equipments.

### **5.0 ENGINEERING DATA AND DRAWINGS**

5.1 The engineering data shall be furnished by the Contractor in accordance with the Schedule for each set of equipment as specified in the Technical Specifications.

## **CHAPTER 19-GENERAL TECHNICAL REQUIREMENT (GTR)-TRANSFORMER & REACTOR**

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

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

### **5.3 Drawings**

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

- 5.3.2 Each drawing submitted by the Contractor shall be clearly marked with the name of the Purchaser, the unit designation, the specifications title, the specification number and the name of the Project. If standard catalogue pages are submitted, the applicable items shall be indicated therein. All titles, noting, markings and writings on the drawing shall be in English. All the dimensions should be in metric units.

- 5.3.3 Further work by the Contractor shall be in strict accordance with these drawings and no deviation shall be permitted without the written approval of the Purchaser, if so required.

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

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

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

### **5.7 Approval Procedure**

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

- |    |   |                           |
|----|---|---------------------------|
| i) | Approval/comments/<br>by Purchaser on initial<br>submission | As per agreed<br>schedule |
|----|---|---------------------------|

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ii)	Resubmission (whenever required) time).	Within 4 (four) weeks from date of comments including both ways postal
iii)	Approval or comments of resubmission.	Within 4 weeks of receipt
iv)	Furnishing of distribution copies in bound volume (5 copies per substation and one copy for Corporate office of Owner)	3 weeks from the date of final approval
v)	Furnishing of distribution copies of test reports	
	(a) Type test reports (one copy per substation plus one copy for corporate office of Owner)	3 weeks from the date of final approval
	(b) Routine Test Reports (one copy for each substation)	-do-
vi)	Furnishing of instruction/ operation manuals (4 copies per substation and two copies for corporate office of Owner)	As per agreed schedule
(vii)	Visual Compact Disk (VCD) highlighting installation and maintenance techniques/ requirements of transformer & reactor  (one per substation plus one for corporate office of Owner)	-do-
(viii)	As built drawings on CD/optical Disc (Two sets per substation plus one set for corporate office of Owner)	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) The drawings which are required to be referred frequently during execution should be submitted on cloth lined paper or Laminated Sheets. The list of such drawings shall be finalised with the Contractor at the time of Award.
- (3) All major drawings should be submitted in Auto Cad Version 2000 or better.

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- (4) The instruction Manuals shall contain full details of drawings of all equipment being supplied under this contract, their exploded diagrams with complete instructions for storage, handling, erection, commissioning, testing, operation, trouble shooting, servicing and overhauling procedures.
- (5) If after the commissioning and initial operation of the substation, the instruction manuals require any modifications/ additions/changes, the same shall be incorporated and the updated final instruction manuals shall be submitted by the Contractor to the Purchaser.
- (6) The Contractor shall furnish to the Purchaser catalogues of spare parts.

### **6.0 MATERIAL/ WORKMANSHIP**

#### **6.1 General Requirement**

- 6.1.1 Where the specification does not contain references to workmanship, equipment, materials and components of the covered equipment, it is essential that the same must be new, of highest grade of the best quality of their kind, conforming to best engineering practice and suitable for the purpose for which they are intended.
- 6.1.2 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, leveling, aligning, coupling of or bolting down to previously installed equipment bases/foundations, performing the alignment check and final adjustment prior to initial operation, testing and commissioning in accordance with the manufacturer's tolerances, instructions and the Specification. All factory assembled rotating

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machinery shall be checked for alignment and adjustments made as necessary to re-establish the manufacturer's limits suitable guards shall be provided for the protection of personnel on all exposed rotating and / or moving machine parts and shall be designed for easy installation and removal for maintenance purposes. The spare equipment(s) shall be installed at designated locations and tested for healthiness.

- 6.1.6 The Contractor shall apply oil and grease of the proper specification to suit the machinery, as is necessary for the installation of the equipment. Lubricants used for installation purposes shall be drained out and the system flushed through where necessary for applying the lubricant required for operation. The Contractor shall apply all operational lubricants to the equipment installed by him.
- 6.1.7 All oil, grease and other consumables used in the Works/ Equipment shall be purchased in Nepal unless the Contractor has any special requirement for the specific application of a type of oil or grease not available in Nepal. In such is the case he shall declare in the proposal, where such oil or grease is available. He shall help Purchaser in establishing equivalent Nepal make and Nepal Contractor. The same shall be applicable to other consumables too.
- 6.1.8 A cast iron or welded steel base plate shall be provided for all rotating equipment which are to be installed on a concrete base unless otherwise agreed to by the Purchaser. Each base plate shall support the unit and its drive assembly, shall be of design with pads for anchoring the units, shall have a raised up all around and shall have threaded in air connections, if so required.

### **6.2 Provisions for Exposure to Hot and Humid climate**

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

#### **6.2.1 Space Heaters**

- 6.2.1.1 The heaters shall be suitable for continuous operation at 230 V AC supply voltage. On-off switch and fuse shall be provided.
- 6.2.1.2 One or more adequately rated thermostatically connected heaters shall be supplied to prevent condensation in any compartment. The heaters shall be installed in the compartment and electrical connections shall be made sufficiently away from below the heaters to minimize deterioration of supply wire insulation. The heaters shall be suitable to maintain the compartment temperature to prevent condensation.
- 6.2.1.3 Suitable anti condensation heaters with the provision of thermostat shall be provided.

#### **6.2.2 FUNGI STATIC VARNISH**

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

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### **6.2.3 Ventilation opening**

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

### **6.2.4 Degree of Protection**

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

- a) Installed out door: IP- 55
- b) Installed indoor in air conditioned area: IP-31
- c) Installed in covered area: IP-52
- d) Installed indoor in non air conditioned area where possibility of entry of water is limited: IP-41.

The degree of protection shall be in accordance with IEC-947 (Part-I)/ IEC 529. Type test report for degree of protection test, on each type of the box shall be submitted for approval.

### **6.3 RATING PLATES, NAME PLATES AND LABELS**

6.3.1 Each main and auxiliary item of substation is to have permanently attached to it in a conspicuous position a rating plate of non-corrosive material upon which is to be engraved manufacturer's name, year of manufacture, equipment name, type or serial number together with details of the loading conditions under which the item of substation in question has been designed to operate, and such diagram plates as may be required by the 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 shall be bilingual with Hindi inscription first followed by English. Alternatively two separate plates one with Hindi and the other with English inscriptions may be provided.

### **6.4 FIRST FILL OF CONSUMABLES, OIL AND LUBRICANTS**

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

### **7.0 DESIGN IMPROVEMENTS / COORDINATION**

7.1 The bidder shall note that the equipment offered by him in the bid only shall be accepted for supply. However, the 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.

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- 7.2 If any such agreed upon change is such that it affects the price and schedule of completion, the parties shall agree in writing as to the extent of any change in the price and/or schedule of completion before the Contractor proceeds with the change. Following such agreement, the provision thereof, shall be deemed to have been amended accordingly.
- 7.3 The Contractor shall be responsible for the selection and design of appropriate equipments to provide the best coordinated performance of the entire system. The basic design requirements are detailed out in this Specification. The design of various components, sub-assemblies and assemblies shall be so done that it facilitates easy field assembly and maintenance.
- 7.4 The Contractor has to coordinate designs and terminations with the agencies (if any) who are Consultants/Contractor for the Purchaser. The names of agencies shall be intimated to the successful bidders.
- 7.5 The Contractor will be called upon to attend design co-ordination meetings with the Engineer, other Contractor's and the Consultants of the Purchaser (if any) during the period of Contract. The Contractor shall attend such meetings at his own cost at Corporate Office of Owner, Nepal or at mutually agreed venue as and when required and fully cooperate with such persons and agencies involved during those discussions.

### **8.0 QUALITY ASSURANCE PROGRAMME**

- 8.1 To ensure that the equipment and services under the scope of this Contract whether manufactured or performed within the Contractor's Works or at his Sub-contractor's premises or at the Purchaser's site or at any other place of Work are in accordance with the specifications, the Contractor shall adopt suitable quality assurance programme to control such activities at all points necessary. Such programme shall be broadly outlined by the contractor and finalised after discussions before the award of contract. The detailed programme shall be submitted by the contractor after the award of contract and finally accepted by **OWNER** after discussion. However, in case detailed valid programme approved by OWNER for the equipment already exist, same would be followed till its validity. A quality assurance programme of the contractor shall generally cover the following:
- (a) His organisation structure for the management and implementation of the proposed quality assurance programme;
  - (b) Documentation control system;
  - (c) Qualification data for bidder's key personnel;
  - (d) The procedure for purchases of materials, parts components and selection of sub-Contractor's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.
  - (e) System for shop manufacturing and site erection controls including process controls and fabrication and assembly control;
  - (f) Control of non-conforming items and system for corrective actions;
  - (g) Inspection and test procedure both for manufacture and field activities.
  - (h) Control of calibration and testing of measuring instruments and field activities;
  - (i) System for indication and appraisal of inspection status;
  - (j) System for quality audits;

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- (k) System for authorising release of manufactured product to the Purchaser.
- (l) System for maintenance of records;
- (m) System for handling storage and delivery; and
- (n) A quality plan detailing out the specific quality control measures and procedures adopted for controlling the quality characteristics relevant to each item of equipment furnished and/or services rendered.

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

### **8.2 Quality Assurance Documents**

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

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

- 9.1 All equipment being supplied shall conform to type tests including additional type tests as per technical specification and shall be subject to routine tests in accordance with requirements stipulated under respective Chapters. Purchaser reserves the right to witness any or all the tests. The Contractor shall intimate the Purchaser the detailed program about the tests atleast three (3) weeks in advance in case of domestic supplies & six (6) weeks in advance in case of foreign supplies.
- 9.2 The reports for all type tests and additional type tests as per technical specification shall be furnished by the Contractor alongwith equipment / material drawings. The type tests conducted earlier should have either been conducted in accredited laboratory (accredited based on ISO / IEC Guide 25 / 17025 or EN 45001 by the national accreditation body of the country where laboratory is located) or witnessed by the representative(s) of OWNER or Utility/third party.

In the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design / manufacturing changes (including substitution of components) or due to non-compliance with the requirement stipulated in the Technical Specification or any/all additional type tests not carried out, same shall be carried out without any additional cost implication to the Purchaser.
- 9.3 The Purchaser intends to repeat the type tests and additional type tests on transformers & reactor for which test charges shall be payable as per provision of contract. The price of conducting type tests and additional type tests shall be included in Bid price and break up of these shall be given in the relevant schedule of Bid Proposal Sheets. These Type test charges would be considered in bid evaluation. In case Bidder does not indicate charges for any of the type tests or does not mention the name of any test in the price schedules, it will be presumed that the particular test has been offered free of charge. Further, in case any Bidder indicates that he shall not carry out a particular test, his offer shall be considered incomplete and shall be liable to be rejected.
- 9.4 The Purchaser, his duly authorised 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



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Engineer and for his duly authorised representative permission to inspect as if the works were manufactured or assembled on the Contractor's own premises or works. Inspection may be made at any stage of manufacture, despatch or at site at the option of the Purchaser and the equipment if found unsatisfactory due to bad workmanship or quality, material is liable to be rejected.

- 9.5 The Contractor shall give the Purchaser /Inspector thirty (30) days written notice of any material being ready for joint testing including contractor and **Owner**. 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 thirty (30) days of the date of which the equipment is notified as being ready for test/inspection, failing which the Contractor may proceed alone with the test which shall be deemed to have been made in the Inspector's presence and he shall forthwith forward to the Inspector duly certified copies of tests in triplicate.
- 9.6 The 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.
- 9.7 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.
- 9.8 In all cases where the Contract provides for tests whether at the premises or at the works of the Contractor or of any Sub-Contractor, the Contractor except where otherwise specified shall provide free of charge such items as labour, materials, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Purchaser /Inspector or his authorised representative to carry out effectively such tests of the equipment in accordance with the Contract and shall give facilities to the Purchaser /Inspector or to his authorised representative to accomplish testing.
- 9.9 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.
- 9.10 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.
- 9.11 The Purchaser reserves the right for getting any field tests not specified in respective Chapters of the technical specification conducted on the completely

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assembled equipment at site. The testing equipments for these tests shall be provided by the Purchaser.

### **10. TESTS**

#### **10.1 Pre-commissioning Tests**

On completion of erection of the equipment and before charging, each item of the equipment shall be thoroughly cleaned and then inspected jointly by the 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. However necessary fee shall be reimbursed by **Owner** 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, discolouration and any other damages. All exposed threaded portions shall be suitably protected with either a metallic or a non-metallic protecting device. All ends of all valves and pipings and conduit equipment connections shall be properly sealed with suitable devices to protect them from damage.

### **12.0 FINISHING OF METAL SURFACES**

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

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ground level) shall also be galvanized according to equivalent international standards.

### **13.0 HANDLING, STORING AND INSTALLATION**

- 13.1 In accordance with the specific installation instructions as shown on manufacturer's drawings or as directed by the Purchaser or his representative, the Contractor shall unload, store, erect, install, wire, test and place into commercial use all the equipment included in the contract. Equipment shall be installed in a neat, workmanlike manner so that it is level, plumb, square and properly aligned and oriented. Commercial use of switchyard equipment means completion of all site tests specified and energisation at rated voltage.
- 13.2 Contractor may engage manufacturer's Engineers to supervise the unloading, transportation to site, storing, testing and commissioning of the various equipment being procured by them separately. Contractor shall unload, transport, store, erect, test and commission the equipment as per instructions of the manufacturer's supervisory Engineer(s) and shall extend full cooperation to them.
- 13.3 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.
- 13.4 Where assemblies are supplied in more than one section, Contractor shall make all necessary mechanical and electrical connections between sections including the connection between buses. Contractor shall also do necessary adjustments/alignments necessary for proper operation of circuit breakers, isolators and their operating mechanisms. All components shall be protected against damage during unloading, transportation, storage, installation, testing and commissioning. Any equipment damaged due to negligence or carelessness or otherwise shall be replaced by the Contractor at his own expense.
- 13.5 Contractor shall be responsible for examining all the shipment and notify the 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, wharf age and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor.
- 13.6 The Contractor shall be fully responsible for the equipment/material until the same is handed over to the 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.
- 13.7 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.
- 13.8 The Contractor shall be responsible for making suitable indoor storage facilities, to store all equipment which require indoor storage.
- 13.9 The words 'erection' and 'installation' used in the specification are synonymous.

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

13.11 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life. If at any stage during the execution of the Contract, it is observed that the erected equipment(s) do not meet the above minimum clearances as given in clause 4.4.1 the Contractor shall immediately proceed to correct the discrepancy at his risks and cost.

### **13.12 Equipment Bases**

A cast iron or welded steel base plate shall be provided for all rotating equipment which is to be installed on a concrete base unless otherwise agreed to by the 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 SPECIAL TOOLS AND TACKLES**

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

### **15.0 AUXILIARY SUPPLY**

15.1 The sub-station auxiliary supply is normally met through a system having the following parameters. The auxiliary power for station supply, including the equipment drive, cooling system of any equipment, air-conditioning, lighting etc shall be designed for the specified Parameters as under.

Normal Voltage	Variation in Voltage	Frequency in HZ	Phase /Wire	Neutral connection
400V	+/- 10%	50 +/- 5%	3/	Solidly 4 WireEarthed.
230V	+/- 10%	50 +/- 5%	1/	Solidly 2 WireEarthed.

Combined variation of voltage and frequency shall be limited to +/- 10%.

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

16.1 All types of boxes, cabinets etc. shall generally conform to & be tested in accordance with IEC-439 and the clauses given below:

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

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- 16.3 Cabinet/boxes shall be free standing floor mounting type, wall mounting type or pedestal mounting type as per requirements. A canopy and sealing arrangements for operating rods shall be provided in marshalling boxes / Control cabinets to prevent ingress of rain water.
- 16.4 Cabinet/boxes shall be provided with double hinged doors with padlocking arrangements. The distance between two hinges shall be adequate to ensure uniform sealing pressure against atmosphere. The quality of the gasket shall be such that it does not get damaged/ cracked during the operation of the equipment.
- 16.5 All doors, removable covers and plates shall be gasketed all around with suitably profiled EPDM gaskets. The gasket shall be tested in accordance with approved quality plan. The quality of gasket shall be such that it does not get damaged/ cracked during the ten years of operation of the equipment or its major overhaul whichever is earlier. All gasketed surfaces shall be smooth straight and reinforced if necessary to minimize distortion and to make a tight seal. Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh made of brass.
- 16.6 All boxes/cabinets shall be designed for the entry of cables from bottom by means of weather proof and dust-proof connections. Boxes and cabinets shall be designed with generous clearances to avoid interference between the wiring entering from below and any terminal blocks or accessories mounted within the box or cabinet. Suitable cable gland plate projecting at least 150 mm above the base of the marshalling kiosk/box shall be provided for this purpose along with the proper blanking plates. Necessary number of cable glands shall be supplied and fitted on this gland plate. The gland shall project at least 25mm above gland plate to prevent entry of moisture in cable crutch. Gland plate shall have provision for some future glands to be provided later, if required. The Nickel plated glands shall be dust proof, screw on & double compression type and made of brass. The gland shall have provision for securing armour of the cable separately and shall be provided with earthing tag. The glands shall conform to BS:6121.
- 16.7 A 230V, single phase, 50 Hz, 15 amp AC plug and socket shall be provided in the cabinet with ON-OFF switch for connection of hand lamps. Plug and socket shall be of industrial grade.
- 16.8 For illumination of a 20 Watts fluorescent tube or 15 watts CFL shall be provided. The switching of the fittings shall be controlled by the door switch.
- 16.9 All control switches shall be of rotary switch type and Toggle/piano switches shall not be accepted.
- 16.10 Positive earthing of the cabinet shall be ensured by providing two separate earthing pads. The earth wire shall be terminated on to the earthing pad and secured by the use of self etching washer. Earthing of hinged door shall be done by using a separate earth wire.
- 16.11 The bay marshalling kiosks shall be provided with danger plate and a diagram showing the numbering/connection/feruling by pasting the same on the inside of the door.
- 16.12 a) The following routine tests alongwith the routine tests shall also be conducted:
- i) Check for wiring
  - ii) Visual and dimension check

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b) The enclosure of bay marshalling kiosk, junction box, terminal box shall conform to IP-55 including application of, 2.5 KV rms for 1 (one) minute, insulation resistance and functional test after IP-55 test.

### **17.0 SUPPORT STRUCTURE**

17.1 The support structures to be supplied by the contractor for the tertiary arrangement should be hot dip galvanised with minimum 610 gram/sq.m net of zinc.

17.2 Support structure shall meet the following mandatory requirements:

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

### **18.0 TERMINAL BLOCKS AND WIRING**

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

18.2 Terminal blocks shall be 650 V grade and have continuous rating to carry the maximum expected current on the terminals. These shall be of moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Screw clamp, overall insulated, insertion type, rail mounted terminals can be used in place of stud type terminals. The terminal blocks shall be non-disconnecting stud type equivalent to Elmex type CATM4, Phoenix (cage clamp type), Wago or equivalent.

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

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

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

18.6 The terminal blocks shall be of extensible design.

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

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

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

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

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- 18.10 The arrangements shall be in such a manner so that it is possible to safely connect or disconnect terminals on live circuits and replace fuse links when the cabinet is live.
- 18.11 The Contractor shall furnish all wire, conduits and terminals for the necessary interphase electrical connections (where applicable) as well as between phases and common terminal boxes or control cabinets. For equipments rated for 400 kV and above the wiring required in these items shall be run in metallic ducts or shielded cables in order to avoid surge overvoltages either transferred through the equipment or due to transients induced from the EHV circuits.
- 18.12 All input and output terminals of each control cubicle shall be tested for surge withstand capability in accordance with the relevant IEC Publications, in both longitudinal and transverse modes. The Contractor shall also provide all necessary filtering, surge protection, interface relays and any other measures necessary to achieve an impulse withstand level at the cable interfaces of the equipment

### **19.0 LAMPS AND SOCKETS**

#### **19.1 Lamps**

All incandescent lamps shall use a socket base as per IEC, except in the case of signal lamps.

#### **19.2 Sockets**

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

#### **19.3 Hand Lamp:**

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

#### **19.4 Switches and Fuses:**

- 19.4.1 Each panel shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of DC and AC supplies for various control, signalling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with switchfuse units. Selection of the main and Sub-circuit fuse ratings shall be such as to ensure selective clearance of sub-circuit faults. Potential circuits for relaying and metering shall be protected by HRC fuses.
- 19.4.2 All fuses shall be of HRC cartridge type mounted on plug-in type fuse bases. Miniature circuit breakers with thermal protection and alarm contacts will also be accepted. All accessible live connection to fuse bases shall be adequately shrouded. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage.

### **20.0 Bushings, Hollow Column Insulators, Support Insulators:**

- 20.1 Bushings shall be manufactured and tested in accordance with IEC: 60137 while hollow column insulators shall be manufactured and tested in accordance with IEC 233. The support insulators shall be manufactured and tested as per IEC 168 and IEC 273. The insulators shall also conform to IEC 815 as applicable.

The bidder may also offer composite silicon rubber insulator, conforming to IEC-1109.

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- 20.2 Support insulators, bushings and hollow column insulators shall be manufactured from high quality porcelain. Porcelain used shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified tough and impervious to moisture.
- 20.3 Glazing of the porcelain shall be uniform brown in colour, free from blisters, burrs and similar other defects.
- 20.4 Support insulators/bushings/hollow column insulators shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which they will be used.
- 20.5 When operating at normal rated voltage there shall be no electric discharge between the conductors and bushing which would cause corrosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action. No radio interference shall be caused by the insulators/bushings when operating at the normal rated voltage.
- 20.6 Bushing porcelain shall be robust and capable of withstanding the internal pressures likely to occur in service. The design and location of clamps and the shape and the strength of the porcelain flange securing the bushing to the tank shall be such that there is no risk of fracture. All portions of the assembled porcelain enclosures and supports other than gaskets, which may in any way be exposed to the atmosphere shall be composed of completely non hygroscopic material such as metal or glazed porcelain.
- 20.7 All iron parts shall be hot dip galvanised and all joints shall be air tight. Surface of joints shall be trued up porcelain parts by grinding and metal parts by machining. Insulator/bushing design shall be such as to ensure a uniform compressive pressure on the joints.
- 20.8 Tests**
- In bushing, hollow column insulators and support insulators shall conform to type tests and shall be subjected to routine tests in accordance with International Standards. The type test reports shall be submitted for approval.



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### **Annexure –A**

#### **INDICATIVE LIST OF DRAWINGS FOR TRANSFORMER & REACTOR**

1. Outline General Arrangement (OGA) drawing of transformer & reactor
  - a) Plan
  - b) Elevation
  - c) End View
  - d) Neutral formation of three phase bankList of all accessories with detailed weights, dimensions, clearances, spacing of wheels in direction, center of gravity, location of cooler etc.
2. Foundation Plan showing reaction at points of support, clamping arrangement & location of jacking pads.
3. Technical Data requirement sheet of transformer & reactor
4. Over fluxing withstand duration curve
5. Schematic wiring and diagram of cooling arrangement along with write up on scheme
6. Schematic wiring and diagram of OLTC along with write up on scheme
7. Mounting Arrangement and wiring diagram of remote WTI along with write up
8. Bushing Drawing showing electrical and mechanical characteristics
  - a) HV Bushing
  - b) LV Bushing
  - c) Neutral bushing
9. Outline and General Arrangement of Cooler Control Cabinet
10. Cooler Control cabinet schematic and wiring diagram
11. Magnetisation Characteristics of bushing CTs
12. Hysteresis Characteristics of iron core
13. Rating and Diagram Plate
14. Overall Transport dimension Drawing of transformer & reactor
15. Drawing showing typical sectional view of the windings with details of insulation, cooling circuit method of cooling and core construction etc.
16. Oil Flow Diagram
17. Valve Schedule Plate drawing
18. Twin Bi-directional Roller
19. Connection Diag.of all protective devices to marshalling box showing physical location
20. List of spares
21. Technical Literature on all fittings and accessories.
22. Calculation to support short circuit withstand capacity of transformer & reactor
23. Calculation of hot spot temperature
24. Value of air core reactance with a typical write-up of calculation
25. Oil sampling Bottle details
26. Typical heating and cooling curves
27. OGA of RTCC panel
28. **RTCC panel schematic and wiring diagram**
29. **Outline and General Arrangement drawing of Common Marshalling Box**
30. **Schematic wiring and diagram of Common Marshalling Box**
31. **OGA of Ladder for transformer & Reactor**
32. **Transformer oil storage tank drawing**
33. **33 KV Neutral CT drawing and technical data sheet**
34. Customer inspection schedule
35. Test procedure of transformer & reactor
36. Type test Reports of transformer & reactor
37. O & M manual of transformer & reactor

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### **ANNEXURE - B**

#### **LIST OF SPECIFICATIONS**

##### **GENERAL STANDARDS AND CODES**

IEC-60 (Part 1 to P4)	-	High Voltage Test Techniques
IEC 66	-	Environmental Test
IEC-117	-	Graphical Symbols
IEC-156,	-	Method for the Determination of the Electrical Strength of Insulation Oils.
IEC-270,	-	Partial Discharge Measurements.
IEC-376 Hexafluoride	-	Specification and Acceptance of New Sulphur
IEC-437	-	Radio Interference Test on High Voltage Insulators.
IEC-506,	-	Switching Impulse Tests on High Voltage Insulators.
IEC-507	-	Artificial Pollution Tests on High Voltage Insulators to be used on AC Systems.
IEC-6094	-	Common Specification for High Voltage Switchgear & Control gear Standards.
IEC-815	-	Guide for the Selection of Insulators in respect of Polluted Conditions.
IEC-865 (P1 & P2)	-	Short Circuit Current - Calculation of effects.
ANSI-C.1/NFPA.70	-	National Electrical Code
ANSI-C37.90A	-	Guide for Surge Withstand Capability (SWC) Tests
ANSI-C63.21,	-	Specification for Electromagnetic Noise and
C63.3	-	Field Strength Instrumentation 10 KHz to 1 GHZ
C36.4ANSI-C68.1	-	Techniques for Dielectric Tests
ANSI-C76.1/EEE21	-	Standard General Requirements and Test Procedure for Outdoor Apparatus Bushings.
ANSI-SI-4	-	Specification for Sound Level Meters
ANSI-Y32-2/C337.2	-	Drawing Symbols
ANSI-Z55.11	-	Gray Finishes for Industrial Apparatus and Equipment No. 61 Light Gray
NEMA-107T	-	Methods of Measurements of RIV of High Voltage Apparatus
NEMA-ICS-II	-	General Standards for Industrial Control and Systems Part ICSI-109
CISPR-1	-	Specification for CISPR Radio Interference Measuring Apparatus for the frequency range 0.15 MHz to 30 MHz
CSA-Z299.1-1978h	-	Quality Assurance Program Requirements
CSA-Z299.2-1979h	-	Quality Control Program Requirements

## **CHAPTER 19-GENERAL TECHNICAL REQUIREMENT (GTR)-TRANSFORMER & REACTOR**

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

### **TRANSFORMERS & REACTORS**

IEC 60076	Power transformers
IEC 60076-1	Part 1: General
IEC 60076-2	Part 2: Temperature rise
IEC 60076-3	Part 3: Insulation levels, dielectric tests and external clearances in air
IEC 60076-4	Part 4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors
IEC 60076-3-1	Part 3-1: Insulation Levels and Dielectric Tests – External Clearances in Air
IEC 60076-5	Part 5: Ability to withstand short circuit
IEC 60076-6	Part 6: Reactors
IEC 60076-7	Part 7: Loading guide for oil-immersed power transformers
IEC 60076-8	Part 8: Application guide
IEC 60076-10	Part 10: Determination of sound levels
IEC 60076-10-1	Part 10-1: Determination of sound levels - Application guide
IEC 60076-11	Part 11: Dry-type transformers
IEC 60076-12	Part 12: Loading guide for dry-type power transformers
IEC 60076-13	Part 13: Self-protected liquid-filled transformers
IEC 60076-14	Part 14: Design and application of liquid-immersed power transformers using high-temperature insulation materials
IEC 60076-15	Part 15: Gas-filled power transformers
IEC 60076-16	Part 16: Transformers for wind turbine applications
IEC 60076-18	Part 18: Measurement of frequency response
IEC 60076-19	Part 19: Rules for the determination of uncertainties in the measurement of losses in power transformers and reactors
IEC 60076-21	Part 21: Standard requirements, terminology, and test code for step-voltage regulators
IEC 60044	Current transformers
IEC 60050	International Electrotechnical Vocabulary
IEC 60050(421)	International Electrotechnical vocabulary- Chapter 421 : Power Transformers and Reactors
IEC 60060	High Voltage test techniques
IEC 60060-1	General definitions and test requirements
IEC 60060-2	Measuring systems
IEC 60071	Insulation co-ordination
IEC 60071-1	Part 1: Definitions, principles and rules
IEC 60071-2	Part 2 : Application guide
IEC 60137	Bushing for alternating voltage above 1000V
IEC 60214	On-Load Tap changers
IEC 255-21-3	Relays vibration
IEC 60270	Partial discharge measurements
IEC 60296	Specification for Unused Mineral Oil for Transformers and Switchgear

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IEC 60422	Supervision and Maintenance guide for Mineral Insulating Oil in Electrical Equipment
IEC 60475	Method of Sampling Liquid dielectrics
IEC 60529	Classification of Degrees of Protection provided by Enclosures
IEC 60542	Application Guide for On-Load Tap-Changers
IEC 60567	Guide for the Sampling of Gases and of Oil from Oil-filled Electrical Equipment for the Analysis of Free and Dissolved Gases
IEC 60651	Sound Level Meters
IEC 61083	Digital Recorders and Software for High Voltage Impulse testing
IEC 61083-1	Part 1: Requirements for digital recorders in high voltage impulse tests
IEC 61083-2	Part 2: Evaluation of software used for the determination of the parameters of impulse waveforms
CISPR 16	Specification for radio disturbance and immunity measuring apparatus
CISPR 16-1	Radio disturbance and immunity measuring apparatus
CISPR-18	Radio Interference Characteristics of Power Lines and High Voltage Equipment
ISO 9001	Quality system-Model for Quality Assurance in Design /development
Cigre Publication 202	Guidelines for conducting design reviews for transformers 100 MVA and 123 kV and above. August 2002-Cigre Working Group 12.22
WG 12-15	Guide for Customers Specifications for Transformers 100 MVA and 123 kV and above
WG 12 19	Short Circuit Performance of Transformers.
BS-4360	Specification for weldable structural steel
BS-5135	Specification for arc welding of carbon and carbon manganese steels
BS-5500	Specification for unfired fusion welded pressure vessels
ISO-8501	Preparation of steel surface before application of Paints and related product
IEC-60599	Mineral oil impregnated electrical equipment in service – guide to the interpretation of dissolved and free gases analysis
IEC-60034-5	Degrees of protection provided by integral design of rotating electrical machines(IP Code) classification
IEC-62271-203	Gas insulated metal enclosed switchgear for rated voltage above 52kV
IEC-61639	Direct connection between power transformers and gas-insulated metal enclosed switchgear for rated voltages of 52.5 kV and above.
IEC 60529 / IP : 55	Degree of protection for cooler control cabinet , MOLG ,Cooling fan , oil pump, Buchholz Relay
IEC 60529 / IP : 56	Degree of protection for Pressure Relief Device
IEC 60529 / IP : 43	Degree of protection for Remote tap Changer cubicle (RTCC)

## **CHAPTER 19-GENERAL TECHNICAL REQUIREMENT (GTR)-TRANSFORMER & REACTOR**

### **Clamps & connectors**

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

### **Wires and cables**

- ASTMD-2863 - Measuring the minimum oxygen concentration to support candle like combustion of plastics (oxygen index)
- IEC-96 (part 0 to p4) - Radio Frequency cables.
- IEC-183 - Guide to the Selection of High Voltage Cables.
- IEC-189 (P1 to P7) - Low frequency cables and wires with PVC insulation and PVC sheath.
- IEC-227 (P1 to P7) - Polyvinyl Chloride insulated cables of rated voltages up to and including 450/750V.
- IEC-228 - Conductors of insulated cables
- IEC-230 - Impulse tests on cables and their accessories.
- IEC-287 (P1 to P3) - Calculation of the continuous current rating of cables (100% load factor).
- IEC-304 - Standard colours for insulation for low-frequency cables and wires.
- IEC-331 - Fire resisting characteristics of Electric cables.
- IEC-332 (P1 to P3) - Tests on electric cables under fire conditions.
- IEC-502 - Extruded solid dielectric insulated power cables for rated voltages from 1 kV upto to 30 kV
- IEC-754 (P1 and P2) - Tests on gases evolved during combustion of electric cables.

### **Galvanizing**

- ASTM-A-123 - Specification for zinc (Hot Galvanizing) Coatings, on products Fabricated from rolled, pressed and forged steel shapes, plates, bars and strips.
- ASTM-A-121-77 - Zinc-coated (Galvanized) steel barbed wire

### **Painting**

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

### **HORIZONTAL CENTRIFUGAL PUMPS**

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

**CHAPTER 20 - 220KV CLASS SPECIFICATIONS FOR TRANSFORMERS**  
**(Transformer up to 220 kV class)**

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**CHAPTER 20 - 220KV CLASS SPECIFICATIONS FOR TRANSFORMERS**  
**(Transformer up to 220 kV class)**

**1.0 General**

- 1.1 This specification covers design, engineering, manufacture, testing at manufacturer's works, delivery at site including all materials, accessories, spares, unloading, handling, proper storage at site, erection, testing and commissioning of the equipment specified.
- 1.2 Transportation
- 1.2.1 The Contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the equipment. The dimension of the equipment shall be such that when packed for transportation, it will comply with the requirements of loading and clearance restrictions for the selected route. It shall be the responsibility of the contractor to coordinate the arrangement for transportation of the transformer for all the stages from the manufacturer's work to site.
- 1.2.2 The contractor shall carry out the route survey along with the transporter and finalise the detail methodology for transportation of transformer and based on route survey; any modification/ extension/ improvement to existing road, bridges, culverts etc. if required, shall be in the scope of the bidder.
- 1.2.3 The Contractor shall dispatch the transformer filled with oil or in an atmosphere of nitrogen or dry air. In the former case the contractor shall take care of the weight limitation on transport and handling facility at site. In the latter case, necessary arrangement shall be ensured by the contractor to take care of pressure drop of nitrogen or dry air during transit and storage till completion of oil filling during erection. A gas pressure testing valve with necessary pressure gauge and adaptor valve shall be provided.
- 1.2.4 Transformer shall also be fitted with at least one Electronic impact recorder (on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. The acceptance criteria and limits of impact in all three directions which can be withstood by the equipment during transportation and handling shall be submitted by the contractor during detailed engineering. The recording shall commence in the factory before dispatch and must continue till the unit is installed on its foundation. The data of electronic impact recorder(s) shall be down loaded at site and a soft copy of it shall be handed over to Engineer-in-charge. Further, within three weeks the contractor shall communicate the interpretation of the data. In the unlikely event of impact recorder output not available at site, the equipment shall be thoroughly internally inspected by the manufacturer's representative before erection at site to ensure healthiness of the equipment. Contractor shall mount Vehicle tracking system (GPRS/ GPS/ GSM based) to track the exact position of the vehicle on which the equipment is being loaded for transportation in order to ensure traceability and safety during transportation.

**2.0 Performance**

- 2.1 The transformers shall be used for bi-directional flow of rated power.
- 2.2 Transformers shall be capable of operating under natural cooled condition up to the full/Specified load. Transformers shall be fitted with coolers, capable of dissipating total losses at continuous maximum rating.
- 2.3 The transformers shall be capable of being operated, without danger, on any tapping at the rated MVA with voltage variation of  $\pm 10\%$  corresponding to the voltage of the tapping.

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- 2.4 The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10 per cent continuous over voltage condition it does not exceed 1.9 Tesla at any tap position.
- 2.5 DGA of oil shall be periodically monitored by the Employer and the interpretation of DGA results will be as per IEC - 60599.
- 2.6 Radio Interference and Noise Level
- 2.6.1 The transformers shall be designed with particular attention to the suppression of maximum harmonic voltage, especially the third and fifth so as to minimize interference with communication circuit.
- 2.6.2 The noise level of transformer, when energized at normal voltage and frequency with cooler equipments in operation shall not exceed, when measured under standard conditions, the values specified at relevant clause.
- 2.7 The transformers shall be capable of being loaded in accordance with IEC-60076-7. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.
- 2.8 The transformer and all its accessories including CTs etc. shall be designed to withstand without injury, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for a period of 3 secs. The short circuit level of the HV & LV System to which the subject transformers will be connected is 40 kA for 1 sec (sym, rms, 3 phase fault) on 220kV, 31.5 kA ( sym, rms,3 phase fault on 132 kV ) & 25kA (sym rms 3 phase fault on 33kV).
- 2.9 Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any winding.
- 2.10 Transformers shall withstand, without injurious heating, combined voltage and frequency fluctuations which produce the following over fluxing conditions:
- 110% for continuous operation
  - 125% for 1 - minute
  - 140% for 5 – seconds

**2.11 Dynamic Short Circuit Test requirement**

**i) For 220 kV Class Transformer:**

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

**ii) For 132 kV Class Transformer:**

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on any rating of 132 kV or above voltage class transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report /



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### **(Transformer up to 220 kV class)**

Certificate along with bid. In case bidder has not successfully tested 132 kV or above voltage class transformer for Dynamic Short Circuit Test, their bid shall be considered technically non-responsive. Further design review of offered 132 kV class transformers shall be carried out based on design of short circuit tested 132 kV or above voltage class transformer.

#### **2.12 Design review**

The transformers shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. Adequate safety margin with respect to thermal, mechanical, dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc so that the transformer provide long life with least maintenance.

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

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

The design review will commence after placement of award with successful bidder and shall be finalised before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the transformer under scope of this specification.

The design review shall be conducted generally following the "Guidelines for conducting design reviews for transformers 100 MVA and 123kV and above" prepared by Cigre SC 12 Working Group 12.22.

The manufacturer shall provide all necessary information and calculations during design review to demonstrate that the transformer meets the requirements for short circuit strength and durability. The latest recommendations of IEC and Cigre SC 12 shall be applied for short circuit withstand evaluation.

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

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

1.	Core and magnetic design
2.	Winding and tapping design
3.	Short-circuit withstand capability
4.	Thermal design including review of localised potentially hot area.
5.	Cooling design
6.	Overload capability
7.	Eddy current losses
8.	Seismic design, as applicable
9.	Insulation co-ordination
10.	Tank and accessories
10.1	Bushings and barrier design
10.2	Tap changers
10.3	Protective devices
10.4	Radiators
10.5	Oil and oil preservation system

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11.	Corrosion protection
12.	Electrical and physical Interfaces with substation
13.	Earthing
14.	Processing and assembly
15.	Testing capabilities
16.	Inspection and test plan
17.	Transport and storage
18.	Sensitivity of design to specified parameters
19.	Acoustic Noise
20.	Spares, inter-changeability and standardization
21.	Maintainability

### **3.0 Construction Details**

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

#### **3.1 Tank and Tank Accessories**

##### **3.1.1 Tank**

- 3.1.1.1 Tank shall preferably be of welded construction and fabricated from tested quality low carbon steel of adequate thickness.
- 3.1.1.2 All seams and those joints not required to be opened at site shall be factory welded, and wherever possible they shall be double welded. After completion of tank and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. The requirement of post weld heat treatment of tank/stress relieving shall be based on recommendation of BS-5500 table 4.4.3.1.
- 3.1.1.3 Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.
- 3.1.1.4 The transformer shall have conventional type tank. In case the joint is welded it shall be provided with flanges suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld splatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise of the joint.
- 3.1.1.5 Each tank shall be provided with:
  - (a) Lifting lugs suitable for lifting the equipment complete with oil.
  - (b) A minimum of four jacking pads in accessible position to enable the transformer complete with oil to be raised or lowered using hydraulic jacks. Each jacking pad shall be designed to support with an adequate factor of safety for at least half of the total mass of the transformer filled with oil allowing in addition for maximum possible misalignment of the jacking force to the centre of the working surface.
  - (c) Suitable haulage holes shall be provided.
- 3.1.1.6 The tank shall be designed in such a way that it can be mounted on the rollers.
- 3.1.1.7 The base of each tank shall be so designed that it shall be possible to move the complete transformer unit by skidding in any direction without injury when using plates or rails.

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**3.1.1.8 Paint system and procedures**

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

	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thickness (DFT)	Colour shade
Main tank, pipes, conservator tank, oil storage tank etc. (external surfaces)	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy high build Micaceous iron oxide (HB MIO) (75µm)	Aliphatic polyurethane (PU) (Minimum 50µm)	Minimum 155µm	RAL 7035
Main tank, pipes (above 80 NB), conservator tank, oil storage tank etc. (Internal surfaces)	Shot Blast cleaning Sa 2 ½*	Hot oil resistant, non-corrosive varnish or paint or epoxy	--	--	Minimum 30µm	Glossy white for paint
Radiator (external surfaces)**	Chemical / Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy base Zinc primer (30-40µm)	PU paint (Minimum 50µm)	Minimum 100µm	Matching shade of tank/ different shade aesthetically matching to tank
Radiator and pipes up to 80 NB (Internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish	--	--	--	--
Control cabinet / marshalling box/RTCC	Seven tank process as per IEC	Zinc chromate primer (two coats)	--	EPOXY paint with PU top coat	Minimum 80µm	RAL 7035 shade for exterior and interior

**Note:** \* Indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

\*\* Radiator hot dip galvanized may also acceptable.

**3.1.2 Tank Cover**

**3.1.2.1** The tank cover shall be designed to prevent retention of rain water and shall not distort when lifted. The internal surface of the top cover shall be shaped to ensure efficient collection and direction of free gas to the buchholz relay.

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- 3.1.2.2 At least one adequately sized inspection openings shall be provided in the transformers for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 kg. Handles shall be provided on the inspection cover to facilitate lifting.
- 3.1.2.3 The tank covers shall be fitted with pockets at the position of maximum oil temperature at maximum continuous rating for bulbs of oil and winding temperature indicators. It shall be possible to remove these bulbs without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.
- 3.1.2.4 Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.
- 3.1.2.5 All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression. All gasketed joints shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. Groove provided to accommodate round nitrile rubber cord for rectangular openings shall be milled.
- 3.1.2.6 Tank hotspot
- The maximum temperature on any metal part shall not exceed 130 deg. Celsius.
- 3.1.2.7 Currents flowing in tank cover and bushing turrets
- To allow for the effect of possible induced and capacitive surge current, good electrical connection shall be maintained between the tank and turrets.
- 3.1.2.8 The transformer shall be provided with pipe flange of suitable diameter with bolted blanking plate, gasket and shall be fitted at the highest point of the transformer tank for maintaining vacuum in the tank.
- 3.1.3 **Axles and Wheels**
- 3.1.3.1 The transformer shall be mounted on rollers, as per manufacturer's standard practice.
- 3.1.3.2 The roller mounted transformers are to be provided with flanged bi-directional wheels and axles. This set of wheels and axles shall be suitable for fixing to the under carriage of transformer to facilitate its movement on rail track. Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of transformer.
- 3.1.3.3 The rail track gauge shall be 1676 mm.
- 3.1.4 **Foundation and Anti Earthquake Clamping Device**
- To prevent transformer movement during earthquake, suitable clamping devices shall be provided for fixing the transformer to the foundation.
- 3.1.5 **Conservator & Oil Preservation System**
- Main conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture, and shall be fitted with magnetic oil level gauge with low oil level potential free contacts.
- 3.1.5.2 OLTC shall have conventional type conservator with prismatic oil level gauge.

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**3.1.5.3 Conservator tank and pipe work**

- 3.1.5.3.1 Conservator tank shall have adequate capacity with highest and lowest visible-levels to meet the requirements of expansion of total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to 100degC. The capacity of the conservator tank shall be such that the transformer shall be able to carry the specified overload without overflowing of oil. The Calculation shall be submitted during design review.
- 3.1.5.3.2 The conservator shall be fitted with integral lifting lugs in such a position so that it can be removed for cleaning purposes. Suitable provision shall be kept to replace air cell and cleaning of the conservator wherever applicable.
- 3.1.5.3.3 Conservator shall be positioned so as not to obstruct any electrical connection to transformer. Pipe work shall neither obstruct the removal of tap changers for maintenance or the opening of inspection or manhole covers.
- 3.1.5.3.4 Pipe work connections shall be of adequate size for their duty and as short and direct as possible. Only radiused elbows shall be used.
- 3.1.5.3.5 The feed pipe to the transformer tank shall enter the transformer cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the transformer side of the Buchholz relay, and straight for not less than three times that diameter on the conservator side of the relay.
- 3.1.5.3.6 This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degree.

**3.1.5.4 Oil Preservation Equipment**

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

- 3.1.5.4.1 Contact of the oil with atmosphere is prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth.
- 3.1.5.4.2 The temperature of oil is likely to rise upto 100 deg C during operation. As such air cell used shall be suitable for operating continuously at 100 deg C.
- 3.1.5.4.3 Air cell of conservator shall be able to withstand the vacuum during installation /maintenance periods. Otherwise provision shall be kept to isolate the conservator from the main tank when the latter is under vacuum by providing a vacuum sealing valve or other suitable means in the pipe connecting main tank with the conservator. The transformer manual shall give full and clear instructions on the operation, maintenance, testing and replacement of the air cell. It shall also indicate shelf life, life expectancy in operation, the recommended replacement intervals and the supplier.
- 3.1.5.4.4 The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator.

**3.1.5.5 Dehydrating Filter Breather**

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

- a) Passage of air is through silicagel.

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

#### **3.1.5.6 Pressure Relief Device**

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

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

#### **3.1.5.7 Buchholz Relay**

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

#### **3.1.5.8 Temperature Indicators**

##### **3.1.5.8.1 Oil Temperature Indicator (OTI)**

All transformers shall be provided with a 150 mm (approx.) dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent ungrounded alarm and trip contacts, maximum reading pointer and resetting device shall be provided in the OTI. A temperature sensing element suitably located in a pocket on top oil shall be furnished. This shall be connected to the OTI by means of capillary tubing. Temperature indicator dials shall have linear gradations to clearly read atleast every 2 deg C. Accuracy of OTI shall be  $\pm 3.0$  deg C or better. The setting of alarm and tripping contacts shall be adjustable at site.

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

- a) Signal transmitter



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

b) Remote oil temperature indicator

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

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

#### **3.1.5.8.2 Winding Temperature Indicator (WTI)**

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

- i) Temperature sensing element.
- ii) Image coil.
- iii) Auxiliary CTs, if required to match the image coil, shall be furnished and mounted in the cooler control cabinet.
- iv) 150 mm (approx) dia local indicating instrument with maximum reading pointer and two adjustable electrically independent, ungrounded contacts; besides that required for control of cooling equipment if any, one for high winding temperature alarm and one for trip. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C.
- v) Calibration device.
- vi) Accuracy of WTI shall be  $\pm 3.0$  deg C or better.  
The setting of alarm and tripping contacts shall be adjustable at site and typical values are as given below which will be reviewed during detailed engineering based on manufacturer's recommendation.  
Alarm – 110degC  
Trip - 120degC
- vii) In addition to the above, the following equipment shall be provided for remote indication of winding temperature for each of the winding:

a) Signal transmitter for each winding

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

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equipment for sending the signal to remote WTI and DAS shall be provided. In lieu, separate RTD for each of the functions shall be provided.

#### **b) Remote winding temperature indicator**

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

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

#### **3.1.9 Earthing Terminals**

3.1.9.1 Two (2) earthing pads (each complete with two (2) nos. holes, M 10 bolts, plain and spring washers) suitable for connection to 75 x 6 mm galvanised steel grounding flat shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

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

#### **3.2 Core**

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

The core of the transformer shall be primary core material. The manufacturer is required to submit the purchase order and other documental proof that core used in the transformer is of the primary core material. The employer reserves the right to check the quality of the core material during manufacturing of the materials.

3.2.2 The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations which may cause local heating. The temperature of any part of the core or its support structure in contact with oil shall not exceed 120 deg C under normal operating condition and 130 deg C under most extreme operating condition. Adequate temperature margin shall be provided to maintain longer life expectancy for this material.

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

3.2.4 Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

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

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



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3.2.7 The supporting frame work of the core shall be so designed as to avoid presence of pockets which would prevent complete emptying of tank through drain valve or cause trapping of air during oil filling.

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

3.2.9 The core shall be earthed to the core clamping structure at one point only, through a removable external link suitably located and protected to facilitate testing after installation of the transformer.

In case core laminations are divided into sections by insulating barriers or cooling ducts parallel to the plane of the lamination, tinned copper bridging strips shall be inserted to maintain electrical continuity between sections.

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

### 3.3 Windings

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

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

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

3.3.4 Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.

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

3.3.6 The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalise the distribution of currents and temperature along the winding.

### 3.4 Unused inhibited Insulating Oil

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

Sl. No.	Property	Test Method	Limits
A1.	Function		
1a.	Viscosity at 100degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.) 3 mm <sup>2</sup> /s
1b.	Viscosity at 40degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.)12 mm <sup>2</sup> /s
1c.	Viscosity at -30degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.)1800 mm <sup>2</sup> /s
2.	Appearance	A representative sample of the oil shall be examined in	The oil shall be clear and bright, transparent and free

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		a 100 mm thick layer, at ambient temperature	from suspended matter or sediment
3.	Pour point	ISO 3016 or ASTM D97	(Max.)- 40degC
4.	Water content a) for bulk supply b) for delivery in drums	IEC 60814 or ASTM D1533	(Max.) 30 mg/kg 40 mg/kg
5.	Electric strength (breakdown voltage)	IEC 60156 or ASTM D1298	(Min.) 50 kV(new unfiltered oil) / 70 kV (after treatment)
6.	Density at 20 deg C	ISO 3675 or ISO 12185 or ASTM D 4052	0.820 - 0.895 g/ml
7.	Dielectric dissipation factor (tan delta) at 90 deg C	IEC 60247 or IEC 61620 Or ASTM D924	(Max) 0.0025
8.	Resistivity at 90 deg C	IEC 60247	150 X 10 <sup>12</sup> Ohm –cm, (Min.) for records only.
9.	Negative impulse testing KVp @ 25 deg C	ASTM D-3300	145 (Min.)
10.	Carbon type composition (% of Aromatic, Paraffins and Naphthenic compounds.)	IEC 60590 or ASTM D 2140	Max.Aromatic : 4 to12 % Paraffins : <50% & balance shall be Naphthenic compounds.
B1.	Refining / Stability		
1.	Acidity	IEC 62021-1 or ASTM D974	(Max) 0.01 mg KOH/g
2.	Interfacial tension at 27degC	ISO 6295 or ASTM D971	(Min) 0.04 N/m
3.	Total sulfur content	BS 2000 part 373 or ISO 14596	0.15 % (Max.)
4.	Corrosive sulphur	IEC 62535	Non-Corrosive on copper and paper
		ASTM D1275B	Non-Corrosive
5.	Presence of oxidation inhibitor	IEC 60666 or ASTM D2668 or D4768	0.08% (Min.) to 0.4% (Max.) Oil should contain no other additives .Supplier should declare presence of additives, if any.
6.	2-Furfural content	IEC 61198 or ASTM D5837	25 Microgram/litre (Max.)
C1.	Performance		
1	Oxidation stability -Total acidity -Sludge - Dielectric dissipation factor (tan delta) at 90degC	IEC 61125 (method c) Test duration 500 hour  IEC 60247	Max 0.3 mg KOH/g Max 0.05 % Max 0.05
2.	Gassing	IEC 60628A or ASTM D2300	No general requirement
3.	Oxidation stability (Rotating Bomb test )	IEC : 61125(Method B) / ASTM D2112 (e)	220 Minutes (Min.)
D1.	Health, safety and environment (HSE)		
1.	Flash point	ISO 2719	(Min.)135degC
2.	PCA content	BS 2000 Part 346	Max 3%
3.	PCB content	IEC 61619 or ASTM D4059	Not detectable (Less than 2 mg/kg)

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

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

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

1. Break Down voltage (BDV) : 70 kV (min.)
2. Moisture content : 10 ppm (max.)
3. Tan-delta at 90 °C : 0.01 (max.)
4. Resistivity at 90 °C :  $6 \times 10^{12}$  ohm-cm (min.)
5. Interfacial tension : 0.035 N/m (min.)
6. \*Oxidation Stability (Test method as per IEC 61125 method C, Test duration: 500hour for inhibited oil)
  - a) Acidity : 0.3 (mg KOH /g) (max.)
  - b) Sludge : 0.05 % (max.)
  - c) Tan delta at 90 °C : 0.05 (max.)
7. \* Total PCB content : Not detectable (2 mg/kg total)

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

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

Oil sample shall be drawn before and after heat run test and shall be tested for dissolved gas analysis. Oil sampling to be done 2 hours prior to commencement of temperature rise test. For ONAN/ONAF cooled transformers, sample shall not be taken earlier than 2 hours after shutdown. The acceptance norms with reference to various gas generation rates shall be as per IEC 61181.

### **3.5 Terminal Arrangements**

#### **3.5.1 Bushings**

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

3.5.1.2 Bushing for various voltage rating shall be as follows

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

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

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

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- 3.5.1.4 Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.
- 3.5.1.5 Bushings of identical rating shall be interchangeable.
- 3.5.1.6 Porcelain used in bushing manufacture shall be homogenous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.
- 3.5.1.7 Clamps and fittings shall be of hot dip galvanised steel.
- 3.5.1.8 Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.
- 3.5.1.9 No arcing horns shall be provided on the bushings.
- 3.5.1.10 Suitable insulating cap (preferably of porcelain) shall be provided on the terminal of Bushing of tertiary winding to avoid accidental external short circuit.
- 3.5.1.11 Installation procedures for the various voltage class bushings shall be clearly brought out in the Instruction manual.

**3.5.2 Terminal Marking**

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

**3.5.3 Neutral Earthing Arrangement**

**3.5.3.1 For 3-Phase Unit**

The neutral terminals of transformer shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to two (2) 75 x 6 mm galvanised steel flats connected to Employer's grounding mat.

**3.5.3.2 For 1-Phase Unit**

The neutral of the transformer shall be brought out through bushing. The contractor shall connect the neutrals of 1-phase transformers by overhead connection using an overhead common brass/tinned copper/Aluminum pipe /ACSR conductor grounding bus, supported from the tank and fire walls by using porcelain insulators. All material like Bus post insulator, Aluminium tube, conductor, clamps & connectors, earthing materials, support structure, hardware etc required for neutral formation and connection with neutral CT and earthing of neutral shall be provided by contractor. The neutral formation shall be such that neutral winding of single-phase spare transformer can be disconnected or connected to either of the three phase banks.

**3.5.4 Delta Formation (applicable for 1-Phase Transformer)**

The tertiary/LV winding terminals of the transformer shall be brought out through bushing. The contractor shall connect Tertiary/LV of 1-phase transformers in DELTA configuration by overhead connection to operate in 3-Phase Bank. The Delta shall be formed by approximate size of 3" IPS Al tube, which shall be insulated with heat shrinkage insulating sleeve or cable of suitable voltage class and adequate thickness and shall be supported by structure mounted bus post insulators at suitable intervals.

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The minimum phase to phase horizontal spacing for delta formation shall be 1.5 meter. All associated materials like bus post insulators, Aluminium tube, clamps & connectors, support structures; hardware etc. required for tertiary delta formation shall be provided by the contractor.

#### **3.5.5 Spare Unit connection arrangement (as applicable for 1-Phase Transformer)**

The contractor shall make connection arrangement as well as control scheme of OLTC and Cooler in such a way that spare unit of transformer can be connected in place of faulty unit without physically shifting it from its location. For this purpose, HV, IV, Tertiary and Neutral Connections of spare unit are to be extended upto the other unit by forming auxiliary buses with tertiary connection insulated with heat shrinkage insulating sleeve of suitable voltage class and adequate thickness and shall be supported by structure mounted bus post insulators at suitable intervals to enable spare unit connection through flexible/rigid conductor and suitable connector in place of existing unit to be replaced. For connection of spare unit in place of other units, HV, LV, Tertiary delta and neutral connection change over will be achieved by the help of manual connection changeover. Provision of manual changeover should be such that changeover can be achieved in very less time. However, the detail configuration and actual sizes of various items shall be finalized during detailed engineering and shall be subject to Employer's approval. All associated materials like Bus post insulators, Aluminum tube, conductors, clamps & connectors, insulator strings, hardware, cables, support structures, required for the above-mentioned arrangement shall be provided by the contractor.

#### **3.6 Cooling Equipment and its Control**

##### **3.6.1 Cooling Equipment**

3.6.1.1 The cooler shall be designed using sufficient number of tank mounted radiators. Design of cooling system shall satisfy the performance requirements.

3.6.1.2 Tank mounted radiators shall have its cooling fans, shut off valves at the top and bottom of suitable size, lifting lugs, top and bottom oil filling valves, air release plug at the top, a drain and sampling valve and thermometer pocket fitted with captive screw cap on the inlet and outlet.

3.6.1.3 Required number of standby fans of approximately 20% capacity shall also be provided with radiators.

3.6.1.4 Cooling fans shall be directly mounted on radiator. Each fan shall be suitably protected by galvanised wire guard. The exhaust air flow from cooling fan shall not be directed towards the main tank in any case.

3.6.1.5 Cooling fans motors shall be suitable for operation from 400 volts, three phase 50 Hz power supply and shall conform to IEC. Each cooling fan motors shall be provided with starter thermal overload and short circuit protection. The motor winding insulation shall be conventional class 'B' type. Motors shall have hose proof enclosure equivalent to IP: 55.

3.6.1.6 The cooler and its accessories shall preferably be hot dip galvanised or corrosion resistant paint (as per clause 3.1.1.8) should be applied to it.

3.6.1.7 Air release device and oil plug shall be provided on oil pipe connections. Drain valves shall be provided in order that each section can be drained independently.

##### **3.6.2 Cooling Equipment Control (ONAN/ONAF COOLING)**

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- 3.6.2.1 Automatic operation control of fans shall be provided (with temperature change) from contacts of winding temperature indicator. The Contractor shall recommend the setting of WTI for automatic changeover of cooler control from ONAN to ONAF. The setting shall be such that hunting i.e. frequent start-up operations for small temperature differential do not occur.
- 3.6.2.2 Suitable manual control facility for cooler fans shall be provided.
- 3.6.2.3 Selector switches and push buttons shall also be provided in the cooler control cabinet to disconnect the automatic control and start/stop the fans manually.
- 3.6.2.4 Indicating Devices

Following lamp indications shall be provided in cooler control cabinet:

- a) Control Supply failure.
- b) Cooling fan failure.
- c) Common thermal overload trip

One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of cooler control cabinet for further wiring to Common Marshalling Box (CMB).

- 3.6.2.5 Two auxiliary power supplies, 400 volt, three phase four (4) wire shall be provided at common marshalling box. All loads shall be fed by one of the two sources through an electrically interlocked automatic transfer scheme housed in the CMB. Power supply to individual phase unit shall be extended from the CMB. Power supply to spare unit shall be extended from nearest CMB only. Suitably rated power contactors, separate MCBs/MCCBs shall be provided in the Common Marshalling Box for each circuit.
- 3.6.2.6 Control and power supplies are to be given for Cooler circuits after suitable selection at Common Marshalling Box. Necessary isolating switches and protective devices shall be provided at suitable points as per Purchaser's approved scheme. The Contractor shall derive AC power for Cooler Control Circuitry from the AC feeder as mentioned above. In case auxiliary power supply requirement for Cooler Control Mechanism is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor.
- 3.6.2.7 For each circuit, suitably rated MCBs/MCCBs as required for further distribution of auxiliary power supply to DM boxes, Online Gases and moisture monitoring system, Online drying system and Fibre optic sensor Box etc. (as applicable), shall be provided by contractor, in individual marshalling boxes /cooler control boxes.
- 3.6.3 Auxiliary power supply distribution scheme shall be submitted for approval. Supply and laying of Power, Control and special cables from common marshalling box to individual MB/Cooler Control Cubicle (including spare unit) & further distribution from IMB/CCC to all accessories is in the scope of the contractor. Further any special cable (if required) from CMB to Owner's Control Panels/RTCC panels are also in the scope of the contractor.
- 3.6.4 The cooler control cabinet / Individual Marshalling box shall have all necessary devices meant for cooler control and local temperature indicators. All the contacts of various protective devices mounted on the transformer and all the secondary terminals of the bushing CTs shall also be wired upto the terminal board in the cooler control cabinet/Individual Marshalling box. All the CT secondary terminals in the cooler control cabinet shall have provision for shorting to avoid CT open circuit while it is not in use.



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All the necessary terminations for remote connection to Purchaser's panel shall be wired upto the Common Marshalling box.

- 3.6.5 Connection arrangement for spare unit shall be in such a way that spare unit of transformer can be connected in place of faulty unit without physically shifting and all the control, protection, indication signals of spare unit shall also be brought in common marshalling box of all the banks. Necessary arrangement in schematic of Common marshalling box is required to facilitate change-over of all the signals of faulty units to spare unit of Transformer, to ensure flow of control, protection and indication signals between Purchaser's Control panels / Digital RTCC Panel / SCADA and individual units under operation (i.e. any designated unit for bank or spare unit, if it replace any designated unit). To facilitate change-over of spare unit signals with faulty unit in CMB, male-female plug-in connector or better arrangement shall be provided to reduce the outage time

#### **3.6.6 Valves**

- 3.6.6.1 All valves shall be of gun metal or of cast steel/cast iron. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel.
- 3.6.6.2 Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.
- 3.6.6.3 Each valve shall be provided with the indicator to show clearly the position of the valve.
- 3.6.6.4 All valves flanges shall have machined faces.
- 3.6.6.5 All valves in oil line shall be suitable for continuous operation with transformer oil at 115 deg C.
- 3.6.6.6 The oil sampling point for main tank shall have two identical valves to be put in series .Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.
- 3.6.6.7 A valve or other suitable means shall be provided to fix (in future) on line dissolved gas monitoring system to facilitate continuous dissolved gas analysis. The location & size of the same shall be finalised during detail engineering stage
- 3.6.6.8 After testing, inside surface of all cast iron valves coming in contact with oil shall be applied with one coat of oil resisting paint/varnish with two coats of red oxide zinc chromate primer followed by two coats of fully glossy finishing paint conforming to international standards. Outside surface except gasket setting surface of butterfly valves shall be painted with two coats of red oxide zinc chromate conforming to International Standards followed by two coats of fully glossy finishing paint.
- 3.6.6.9 All hardware used shall be cadmium plated/electro galvanised steel.
- 3.6.6.10 For estimation purpose of spares one set of valves would mean one valve of each type used in Transformer.

#### **3.7 Tap Changing Equipment**

Each transformer shall be provided with On Load Tap changing equipment.

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**3.7.1 On Load Tap Changing Gear (OLTC)**

OLTC shall be motor operated for local as well as remote operation. An external handle shall be provided for local manual operation. This handle shall be suitable for operation by a man standing at ground level

3.7.1.1 Each three phase transformer shall be provided with voltage control equipment of the tap changing type for varying its effective transformation ratio whilst the transformers are on load and without producing phase displacement.

3.7.1.2 The requirements of on load tap changing equipment are given here below:

- a) The current diverting contacts shall be housed in a separate oil chamber not communicating with the oil in main tank of the transformer.
- b) The contacts shall be accessible for inspection without lowering oil level in the main tank and the contact tips shall be replaceable.
- c) The Bidder shall indicate the safeguards in order to avoid harmful arcing at the current diverting contacts in the event of operation of the OLTC gear under overload conditions of the transformer. Necessary tools and tackles shall be furnished for maintenance of OLTC gear.
- d) The diverter switch or arcing switch oil chamber shall have oil filling and drain plug, oil sampling valve, relief vent and level glass. It shall also be fitted with a oil surge relay the outlet of which shall be connected to a separate conservator tank.
- e) The diverter switch or arcing switch shall be designed so as to ensure that its operation once commenced shall be completed independently of the control relays or switches, failure of ancillary supplies etc. To meet any contingency which may result in incomplete operation of the diverter switch, adequate means shall be provided to safeguard the transformer and its ancillary equipment.
- f) Tap changer shall be so mounted that bell cover of transformer can be lifted without removing connections between windings and tap changer.
- g) Local OLTC control cabinet shall be mounted on the tank in accessible position. It should be adequately ventilated and provided with anti-condensation metal clad heaters. All contactors relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.
- h) Operating mechanism for on load tap changer shall be designed to go through one step of tap change per command. Subsequent tap changes shall be initiated only by a new or repeat command.
- i) On load tap changer shall be equipped with a time delayed INCOMPLETE STEP alarm consisting of a normally open contact which closes, if the tap changer fails to make a complete tap change. The alarm shall not operate for momentary loss of auxiliary power.
- j) The selsyn units or approved equivalents shall be installed in the local OLTC control cabinet to provide tap position indication for the transformer .The Bidder shall also provide a set of instruments for tap position indication in the control room. Complete mounting details shall be included in the approved diagram.
- k) Transformer on load tap shall be equipped with a fixed resistor network capable of providing discrete voltage steps for input to the supervisory system.



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- l) Limit switches shall be provided to prevent overrunning of the mechanism and shall be directly connected in the circuit of the operating motor. In addition, a mechanical stop shall be provided to prevent over-running of the mechanism under any condition.
- m) Limit switches may be connected in the control circuit of the operating motor provided that a mechanical de-clutching mechanism is incorporated.
- n) Thermal device or other means shall be provided to protect the motor and control circuit. All relays, switches, fuses etc. shall be mounted in the local OLTC control cabinet and shall be clearly marked for the purpose of identification.
- o) A permanently legible lubrication chart if required, shall be fitted within the local OLTC control cabinet.
- p) Any 'DROP DOWN' tanks associated with the tap changing apparatus shall be fitted with guide rod to control the movements during lifting or lowering.
- q) A counter of at least five digits shall be fitted to the tap changing equipment to indicate the number of operations completed and shall have no provision for resetting.
- r) All relays and operating devices shall operate correctly at any voltage between the limits specified.
- s) It shall not be possible to operate the electric drive when the manual operating gear is in use.
- t) It shall not be possible for any two controls to be in operation at the same time.
- u) The equipment shall be suitable for supervisory control and indication with make before break multi-way switch, having one potential free contact for each tap position. This switch shall be provided in addition to any other switch/switches which may be required for remote tap position indication.
- v) Operation from the local or remote control switch shall cause one tap movement only until the control switch is returned to the off position between successive operations.
- w) All electrical control switches and the local operating gear shall be clearly labelled in a suitable manner to indicate the direction of tap changing.
- x) Transfer of source in the event of failure of one AC supply shall not affect the tap changer.

**3.7.1.3 OLTC Control of Three Phase Transformers**

Each three phase transformer shall be suitable for local and remote control. The control feature shall provide the following:

**3.7.1.3.1 Local Electrical Control**

- (a) 'Local-remote' selector switch mounted in the local OLTC control cabinet shall switch control of all load tap changers as followings:

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- i) When the selector switch is in 'local' position, it shall be possible to operate the 'raise-lower' control switches specified in clause 3.9.3.1(b) below. Remote control of the raise-lower functions shall be prevented.
- ii) When the selector switch is in 'remote' position the local OLTC control cabinet mounted 'raise-lower' switch specified in clause 3.9.3.1(b) below shall be in-operative. Remote control of the raise/lower function shall be possible from the remote control panel. The 'local-remote' selector switch shall have at least two spare contacts per position which are closed in that position but open in the other position.
- (b) A 'raise-lower' control switch/push button shall be provided in the local OLTC control cabinet. This switch shall be operative only when 'local remote' selector switch is in 'local' position.
- (c) An OFF-ON tap changer control switch shall be provided in the local OLTC control cabinet of the transformer. The tap changer shall be in-operative in the OFF position. Also the OFF-ON switch shall have atleast one spare contact per position which is closed in that position but open in the other position.

**3.7.1.3.2 Manual Control**

The cranking device for manual operation of the OLTC gear shall be removable and suitable for operation by a man standing at ground level. The mechanism shall be complete with the following:

- a) Mechanical tap position indicator which shall be clearly visible from near the transformer.
- b) A mechanical operation counter.
- c) Mechanical stops to prevent over-cranking of the mechanism beyond the extreme tap positions.
- d) The manual control considered as back up to the motor operated load tap changer control shall be interlocked with the motor to block motor start-up during manual operation. The manual operating mechanism shall be labelled to show the direction of operation for raising the HV terminal voltage and vice-versa.

**3.7.1.3.3 Remote Electrical Group Control**

The OLTC control scheme offered shall have provision of remote electrical group control during the parallel operation of transformer. This is in addition to independent control of OLTC:

- i) A four position selector switch having Master, Follower, Independent and Off position shall be provided in the remote OLTC control panel for each transformer. This shall be wired to enable operator to select operation of OLTC in either Master, Follower or Independent mode.
- ii) Out of step relays with timer contacts shall also be provided to give alarm and indication in case tap position in all the transformers under group control are not in same position.
- iii) Master Position

If the selector switch is in Master position, it shall be possible to control the OLTC units in the follower mode by operating the controls of the master unit.

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Independent operation of the units under Follower mode shall have to be prevented. However the units under independent mode will be controlled independently.

#### iv) Follower Position

If the selector switch is in Follower mode, control of OLTC shall be possible only from panel of the Master unit.

#### v) Independent Position

In this position of Selector Switch, Control of OLTC of individual unit shall only be possible.

#### 3.7.1.5 The control circuits shall comply with following conditions:

3.7.1.5.1 An interlock to cut off electrical control automatically upon recourse being taken to the manual control in emergency.

3.7.1.5.2 Reinforcement of the initiating impulse for a tap change, ensuring a positive completion once initiated to the next (higher or lower) tap.

3.7.1.5.2.3 "Step-by-Step" operation ensuring only one tap change from each tap changing impulse and a lock-out of the mechanism if the control switch (or push button) remains in the "operate" position.

3.7.1.5.2.4 An interlock to cut-out electrical control when it tends to operate the gear beyond either of the extreme tap positions.

3.7.1.5.2.5 An electrical interlock to cut-off a counter impulse for reverse step change being initiated during a progressing tap change and until the mechanism comes to rest and resets circuits for a fresh position.

3.7.1.5.2.6 Tap change in progress indication shall be provided by means of an indicating lamp at the Employer's control panel. Necessary contacts for this and for remote tap position indicator at Employer's control panel shall be provided by the Bidder.

3.7.1.5.2.7 Protective apparatus, considered essential by the Bidder according to specialities of the gear.

#### 3.7.2 Local OLTC Control Cabinet, Cooler Control Cabinet and Remote Tap Changer Control Panel

3.7.2.1 Each three phase transformer unit shall be provided with local OLTC control cabinet, cooler control cabinet and RTCC panel.

3.7.2.2 Cabinets and Panels shall be tank mounted, provided with suitable lifting arrangement and have sloping roof.

3.7.2.3 A space heater, and cubicle lighting with ON-OFF switch shall be provided in each panel.

3.7.3 Necessary shorting of terminals shall be done at the cooler control cabinet, local OLTC cabinet and remote OLTC panel. All the CT secondary terminals in the cooler control cabinet shall have provision for short circuiting to avoid CT open circuit while it is not in use.

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**3.7.4 Cooler Control Cabinet**

- 3.7.4.1 The cooler control cabinet shall have all necessary devices meant for cooler control and local temp indicators. All the contacts of various protective devices mounted on the transformer and all the secondary terminals of the bushing CTs shall also be wired upto the terminal board in the cooler control cabinet. All the necessary terminals for remote connection to Employer's panel shall be wired upto the cooler control cabinet.
- 3.7.4.2 The cooler control cabinet shall have two (2) sections. One section shall have the control equipment exclusively meant for cooler control. The other section shall house the temperature indicators, aux. CTs and the terminal boards meant for termination of various alarm and trip contacts as well as various bushing CT secondary. Alternatively the two sections may be provided as two separate panels depending on the standard practice of the Bidder.
- 3.7.4.3 The temperature indicators shall be so mounted that the dials are about 1200 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.

**3.7.5 Local OLTC Control Cabinet**

The Local OLTC control cabinet shall house all necessary devices meant for OLTC control and indication. It shall be complete with the following:

- i) A circuit breaker/contactors with thermal overload devices for controlling the AC Auxiliary supply to the OLTC motor.
- ii) Cubicle light with door switch.
- iii) Space heaters to prevent condensation of moisture.
- iv) Locking arrangement for hinged door of cabinet.
- v) Cable terminal glands for power and control cables to the OLTC gear.

**3.7.6 Remote Tap Changer Control Panel.**

- 3.7.6.1 The Contractor shall supply a Remote Tap Changer Control (RTCC) panel suitable for remote operation of On load tap changing gear.
- 3.7.6.2 The RTCC panel shall house actuating switch for electrical raise/lower control, tap position indicator, signal lamps for "Tap change in progress" and "Tap changer out of step", and all other auxiliary devices for remote electrical control of the OLTC. For tap position indicator, the dual output type OLTC transducer shall be provided in the RTCC panel. One of the outputs of this transducer shall be used for local indication of tap position in RTCC panel and other output (0-10 mA or 4-20 mA) shall be used for RTUs/automation system.
- 3.7.6.3 The RTCC panel shall be located in Employer's control room /Air conditioned switchyard panel room.

**3.8 Auxiliary Power Supply of OLTC, Cooler Control and Power Circuit**

- 3.8.1 Two auxiliary power supplies, 400 volt, three phase four (4) wire shall be provided by the Employer at cooler control cabinet for OLTC and cooler control and power circuit.

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- 3.8.2 All loads shall be fed by one of the two feeders through an electrically interlocked automatic transfer switch housed in the cooler control cabinet for on load tap changer control and cooler circuits.

Design features of the transfer switch shall include the following:

- a) Provision for the selection of one of the feeder as normal source and other as standby.
- b) Upon failure of the normal source, the loads shall be automatically transferred after an adjustable time delay to standby sources.
- c) Indication to be provided at cooler control cabinet for failure of normal source and for transfer to standby source and also for failure to transfer.
- d) Automatic re-transfer to normal source without any intentional time delay following re-energization of the normal source.
- e) Both the transfer and the re-transfers shall be dead transfers and AC feeders shall not be paralleled at any time.

3.8.3 Power Supply for OLTC Circuits

- a) AC feeder shall be brought to the local OLTC control cabinet by the Contractor after suitable selection at cooler control cabinet for which description is given in 3.10.2 above, for control power circuit of OLTC.
- b) The Contractor shall derive AC power for OLTC control circuitry from the AC feeder as mentioned above by using appropriately rated dry type transformers. If the control circuit is operated by DC supply, then suitable main and standby converters shall be provided by the Contractor to be operated from AC power source.

3.8.4 Power Supply for Cooler Circuits

- 3.8.4.1 Control and power supplies are to be given for Cooler circuits after the selection as mentioned above.

- 3.8.4.2 The Contractor shall derive AC power for Cooler Control Circuitry by using appropriately rated dry type transformer in case of using supply voltage different from the Employer's auxiliary supply. If the control circuit is operated by DC supply then suitable main and standby converters shall be provided by the Contractor, to be operated from AC power source.

- 3.8.5 Necessary isolating switches and MCBs/MCCBs shall be provided at suitable points as per Employer's approved scheme.

**4 Fittings**

- 4.1 The following fittings shall be provided with each single phase transformer covered in this specification.

- 4.1.1 Conservator for main tank with oil filling hole and cap, air cell, isolating valves, drain valve, magnetic oil level gauge with low level alarm contacts and dehydrating silicagel breather.

- 4.1.2 Pressure relief devices with alarm/trip contacts.

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- 4.1.3 Buchholz relay double float/reed type with isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm and trip contacts.
- 4.1.4 Air release plug.
- 4.1.5 Inspection openings and covers.
- 4.1.6 Bushing with metal parts and gaskets to suit the termination arrangement.
- 4.1.7 Winding temperature indicators for local and remote mounting. One remote winding temperature indicator with a four point selector switch shall be provided for the three windings for three phase unit to have selection of any of the three windings.
- 4.1.8 Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs.
- 4.1.9 Protected type mercury or alcohol in glass thermometer.
- 4.1.10 Bottom and top filter valves with threaded male adaptors, bottom sampling valve and drain valve.
- 4.1.11 Rating and diagram plates on transformers and auxiliary apparatus.
- 4.1.12 Flanged bi-directional wheels/Trolley for movement
- 4.1.13 Cooler cabinet.
- 4.1.14 Off load / On load tap changing gear.
- 4.1.15 Cooling equipment
- 4.1.16 Bushing current transformers.
- 4.1.17 Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently.
- 4.1.18 Terminal marking plates.
- 4.1.19 Valves schedule plates.
- 4.1.20 Oil temperature indicator for local and remote mounting
- 4.1.21 Oil flow indicator
- 4.1.22 Marshalling box/Common Marshalling box
- 4.1.23 Suitable galvanized iron or stainless steel tray for cabling on main tank for better aesthetics.
- 4.1.24 Terminal clamp & connector
- 4.1.25 The fittings listed above are only indicative and other fittings which generally are required for satisfactory operation of the transformer are deemed to be included.
- 4.1.26 One set of hand tools of reputed make packed in a carry bag/box broadly comprising of double ended spanners (open jaws, cranked ring, tubular with Tommy bar each of

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sizes 9mm to 24mm, one set each), adjustable wrenches (8 & 12 inch one set), gasket punches (of different sizes as used in the reactor one set), pliers (flat nose, round nose & side cutting one of each type), hammer with handle (one), files with handle (two), knife with handle (one), adjustable hacksaw (one), and cold chisel (one) shall be supplied per Substation.

## **5 Inspection and Testing**

The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the equipment. An indication of inspection envisaged by the Employer is given under Clause 5.1. This is however not intended to form a comprehensive programme as it is Contractor's responsibility to draw up and carry out such a programme in the form of detailed quality plan duly approved by Employer for necessary implementation.

### **5.1 Inspection**

#### **5.1.1 Tank and Conservator**

- 5.1.1.1 Certification of chemical analysis and material tests of plates.
- 5.1.1.2 Check for flatness.
- 5.1.1.3 Electrical interconnection of top and bottom by braided tinned copper flexibles.
- 5.1.1.4 Welder's qualification and weld procedure.
- 5.1.1.5 Testing of electrodes for quality of base materials and coatings.
- 5.1.1.6 Inspection of major weld preparation.
- 5.1.1.7 Crack detection of major strength weld seams by dye penetration test.
- 5.1.1.8 Measurement of film thickness of :
  - i) Oil insoluble varnish.
  - ii) Zinc chromate paint.
  - iii) Finished coat.
- 5.1.1.9 Check correct dimensions between wheels, demonstrate turning of wheels through 90 deg C and further dimensional check.
- 5.1.1.10 Check for physical properties of materials for lifting lugs, jacking pads, etc. All load bearing welds including lifting lug welds shall be subjected to NDT.
- 5.1.1.11 Leakage test of the conservator.
- 5.1.1.12 Certification of all test results.
- 5.1.2 **Core**
  - 5.1.2.1 Sample testing of core materials for checking specific loss, bend properties, named characteristics and thickness.



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- 5.1.2.2 Check on the quality of varnish if used on the stampings :
- i) Measurement of thickness and hardness of varnish on stampings.
  - ii) Solvent resistance test to check that varnish does not react in hot oil.
  - iii) Check over all quality of varnish by sampling to ensure uniform shining colour, no bare spots, no over burnt varnish layer and no bubbles on varnished surface.
- 5.1.2.3 Check on the amount of burrs.
- 5.1.2.4 Bow check on stampings.
- 5.1.2.5 Check for the overlapping of stampings. Corners of the sheet are to be part.
- 5.1.2.6 Visual and dimensional check during assembly stage.
- 5.1.2.7 Check for inter-laminar insulation between core sectors before and after pressing.
- 5.1.2.8 Visual and dimensional checks for straightness and roundness of core, thickness of limbs and suitability of clamps.
- 5.1.2.9 High voltage test (2 kV for one minute) between core and clamps.
- 5.1.2.10 Certification of all test results.
- 5.1.3 **Insulation Material**
- 5.1.3.1. Sample check for physical properties of materials.
- 5.1.3.2 Check for dielectric strength.
- 5.1.3.3 Visual and dimensional checks.
- 5.1.3.4 Check for the reaction of hot oil on insulating materials.
- 5.1.3.5 Dimension stability test at high temperature for insulating material.
- 5.1.3.6 Tracking resistance test on insulating material
- 5.1.3.7 Certification of all test results.
- 5.1.4 **Winding**
- 5.1.4.1 Sample check on winding conductor for mechanical properties and electrical conductivity.
- 5.1.4.2 Visual and dimensional checks on conductor for scratches, dent marks etc.
- 5.1.4.3 Sample check on insulating paper for pH value, bursting strength and electric strength.
- 5.1.4.4 Check for the reaction of hot oil on insulating paper.
- 5.1.4.5 Check for the bonding of the insulating paper with conductor.



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- 5.1.4.6 Check and ensure that physical condition of all materials taken for windings is satisfactory and free of dust.
- 5.1.4.7 Check for absence of short circuit between parallel strands.
- 5.1.4.8 Check for brazed joints wherever applicable.
- 5.1.4.9 Measurement of voltage ratio to be carried out when core/yoke is completely restacked and all connections are ready.
- 5.1.4.10 Conductor enamel test for checking of cracks, leakage and pin holes.
- 5.1.4.11 Conductor flexibility test
- 5.1.4.12 Heat shrink test for anameled wire.
- 5.1.4.13 Certification of all test results.
- 5.1.5 Checks Before Drying Process**
  - 5.1.5.1 Check condition of insulation on the conductor and between the windings.
  - 5.1.5.2 Check insulation distance between high voltage connections, cables and earth and other live parts.
  - 5.1.5.3 Check insulating distances between low voltage connections and earth and other parts.
  - 5.1.5.4 Insulation of core shall be tested at 2 kV/minute between core to bolts and core to clamp plates.
  - 5.1.5.5 Check for proper cleanliness and absence of dust etc.
  - 5.1.5.6 Certification of all test results.
- 5.1.6 Checks During Drying Process**
  - 5.1.6.1 Measurement and recording of temperature, vacuum and drying time during vacuum treatment.
  - 5.1.6.2 Check for completeness of drying by periodic monitoring of IR and Tan delta.
  - 5.1.6.3 Certification of all test results.
- 5.1.7 Assembled Transformer**
  - 5.1.7.1 Check completed transformer against approved outline drawings, provision for all fittings, finish level etc.
  - 5.1.7.2 Test to check effective shielding of the tank.
  - 5.1.7.3 Jacking test with oil on all the assembled transformers.
  - 5.1.7.4 Dye penetration test shall be carried out after the jacking test.

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**5.1.8 Bought Out Items**

5.1.8.1 The makes of all major bought out items shall be subject to Employer's approval.

5.1.8.2 The Contractor shall also prepare a comprehensive inspection and testing programme for all bought out/sub-contracted items and shall submit the same to the Employer for approval. Such programme shall include the following components:

- a) Buchholz Relay.
- b) Axles and wheels.
- c) Winding temperature indicators for local and remote mounting.
- d) Oil temperature indicators.
- e) Bushings.
- f) Bushing current transformers.
- g) Cooler cabinet.
- h) ON Load / Off Load Tap change gear.
- i) Oil pumps.
- j) Terminal connectors.
- k) Pressure relief device relay
- l) Cables used for interconnecting Turret CT, equipment relays (exposed), with marshalling box.

The above list is not exhaustive and the Contractor shall also include other bought out items in his programme.

**5.1.9 Pre-Shipment Checks at Manufacturer's Works**

5.1.9.1 Check for interchangeability of components of similar transformers for mounting dimensions.

5.1.9.2 Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

5.1.9.3 Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

5.1.9.4 Gas tightness test to confirm tightness and record of dew point of gas inside the tank.

5.1.9.5 Derivation of leakage rate and ensure the adequate reserve gas capacity.

5.1.9.6 Measure and record the dew point of dry air /Nitrogen at the time of filling and after 24 hours in the transformer tank. Dew point of dry air / nitrogen at the time of transformer dispatch should be better than (-) 30 deg C. Also the dew point of dry air / nitrogen cylinders attached for make up during transportation should of the order of (- ) 50 deg C.

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5.1.9.7 Functioning of impact recorder(s) at their works before installing on the tank.

**5.2 Factory Tests**

The manufacturer shall be fully equipped to perform all the required tests as specified. Bidder shall confirm the capabilities of the proposed manufacturing plant in this regard when submitting the bid. Any limitations shall be clearly stated in. The contractor shall bear all additional costs related to tests which are not possible to carry out at his own works. Procedure for some of tests is given at annexure-I.

The contractor shall submit an Inspection and test plan (ITP) for approval. A typical test plan is indicated below.

No.	Item	Test Category
1.	Measurement of winding resistance	Routine
2.	Voltage ratio measurement	Routine
3.	Polarity & Vector group test	Routine
4.	No-load loss and current measurement	Routine
5.	Impedance voltage and load loss measurement	Routine
6.	Measurement of insulation resistance & Polarization Index	Routine
7.	Measurement of insulation power factor and capacitance between winding and earth	Routine
8.	Measurement of insulation power factor and capacitance of bushings	Routine
9.	Lightning impulse test	Routine
10a	Short duration induced AC withstand Test (ACSD) with PD measurement	Routine
11.	Separate source voltage withstand test	Routine
12.	On-load tap changer test ( Ten complete cycle before LV test)	Routine
13.	Gas-in-oil analysis	Routine
14.	Core assembly dielectric and earthing continuity test	Routine
15.	Oil leakage test on transformer tank	Routine
16.	Appearance, construction and dimension check	Routine
17.	Magnetic balance test	Routine
18.	Measurement of no load current & Short circuit impedance with 400 V, 50 Hz AC.	Routine
19.	High voltage with stand test on auxiliary equipment and wiring after assembly	Routine
20.	Tank vacuum test	Routine
21.	Tank pressure test	Routine
22.	Frequency response analysis (Soft copy of test report in sfra format to be submitted to site along with O & M manual )	Routine
23.	Temperature rise test	*Type
24.	Measurement of harmonic level in no load current	*Type
25.	Measurement of acoustic noise level	*Type
26.	Measurement of Zero seq. reactance	*Type
27.	Measurement of power taken by fans and oil pumps	*Type

All tests shall be done in line with IEC: 60076 and as per “Annexure-A”. Complete test report shall be submitted to purchaser after proper scrutiny and signing on each page by the test engineer of the manufacturer. \* Type test shall be carried out at first unit manufactured against the LOA at each manufacturing plant.

5.2.1 Measurement of capacitance and tan delta to determine capacitance between winding and earth. Tan delta value shall not be more than 0.5% at ambient temperature.

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5.2.2 Measurement of capacitance and tan delta of OIP bushings. Tan delta value shall not be more than 0.4% at ambient temperature.

5.2.3 Type Tests on fittings:

All the following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with the drawings of equipment/ fittings as per the clause no. 9.0 of the Chapter2 – GTR. The list of fittings and the type test requirement is:

1. Bushing (Type Test as per IEC: 60137, including snap back/seismic test)
2. Buchholz relay (Type Test as per IEC and IP-55 Test on terminal box)
3. OLTC (Temperature Rise of contact, Short circuit current test, Mechanical test and Dielectric Test as per IEC: 60214 and IP-55 test on driving mechanism box).
4. Cooling fan and motor assembly – Free air delivery, Temperature rise, sound level, running at reduced voltage, IP-55 degree of protection for terminal box.
5. Air Cell (Flexible air separator) – Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per BS: 903.
6. Cooler Control cabinet (IP-55 test)

7. Pressure Relief device Test

The pressure Relief Device of each size shall be subjected to increase in oil pressure. It shall operate before reaching the test pressure specified in transformer tank pressure test above.. The operating pressure shall be recorded. The device shall seal off after excess pressure has been released.

The terminal box / boxes of PRD should conform to degree of protection as per IP-55.

8. Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.
9. OTI & WTI – Switch setting & operation, switch differential, switch rating.

5.2.4 **Pre-Shipment Checks at Manufacturer's Works**

5.2.5 Check for interchangeability of components of similar transformers for mounting dimensions.

5.2.6 Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

5.2.7 Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

5.2.8 Gas tightness test to confirm tightness and record of dew point of gas inside the tank.

5.2.9 Derivation of leakage rate and ensure the adequate reserve gas capacity.

5.2.10 Measure and record the dew point of dry air /Nitrogen at the time of filling and after 24 hours in the transformer tank. Dew point of dry air / nitrogen at the time of

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transformer despatch should be better than (-) 30 deg C. Also the dew point of dry air / nitrogen cylinders attached for make up during transportation should be of the order of (-) 50 deg C.

#### **5.3 Inspection and Testing at Site**

The Contractor/Manufacturer shall carry out a detailed inspection and testing programme for field activities covering areas right from the receipt of material stage upto commissioning stage. An indicative programme of inspection as envisaged by the Employer is given below. Pre commissioning Procedures and Formats for equipments shall be contractor's responsibility to draw up and carry out such a programme.

##### **5.3.1 Receipt and Storage Checks**

- 5.3.1.1 Check and record condition of each package, visible parts of the transformer etc. for any damage.
- 5.3.1.2 Check and record the gas pressure in the transformer tank as well as in the gas cylinder. Measure and record the dew point of dry air /nitrogen in the transformer tank.
- 5.3.1.3 Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.

##### **5.3.2 Installation Checks**

- 5.3.2.1 Inspection and performance testing of accessories like tap changers etc.
- 5.3.2.2
  - (i) Check the direction of rotation of fans .
  - (ii) Check the bearing lubrication.
- 5.3.2.3 Check whole assembly for tightness, general appearance etc.
- 5.3.2.4 Oil leakage test
- 5.3.2.5 Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.
- 5.3.2.6 Leakage test on bushing before erection.
- 5.3.2.7 Measure and record the dew point of nitrogen/dry air in the main tank before assembly. Manufacturer shall submit dew point acceptable limits along with temperature correction factor and shall form part of instruction manual. In case dew point values are not within permissible limit suitable drying out process shall be applied for dry out of active part in consultation with the Manufacturer.
- 5.3.2.8 **Oil filling.**
  - 5.3.2.8.1 Oil impregnation or drying under vacuum at site shall be done with the transformer and oil at a temperature not exceeding 70 deg C.
  - 5.3.2.8.2 The duration of the vacuum treatment shall be demonstrated as adequate by means of water measurement with a cold trap or other suitable method. The vacuum shall be measured on the top of the transformer tank and should be less than 1mbar.

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- 5.3.2.8.3 Vacuum shall not be broken until the transformer is oil filled up to the Buchholz relay. Whenever the active insulation or any paper insulated HV connections, especially those from the windings to the bushings are exposed, these shall be re-impregnated under vacuum along with the complete transformer. For this purpose the transformer shall first be drained to expose all insulation material.
- 5.3.2.8.4 The minimum safe level of oil filling (if different from the Buchholz level) to which the transformer shall be oil filled under vacuum, shall be indicated in the manual.
- 5.3.2.8.5 Procedures for site drying, oil purification, oil filling etc shall be submitted for approval and complete instructions shall form part of the manual.

**5.3.3 Commissioning Checks**

- 5.3.3.1 Check the colour of silicagel in silicagel breather.
- 5.3.3.2 Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.
- 5.3.3.3 Check the bushing for conformity of connection to the lines etc,
- 5.3.3.4 Check for correct operation of all protection devices and alarms :
- (i) Buchholz relay.
  - (ii) Excessive winding temperature.
  - (iii) Excessive oil temperature.
  - (iv) Low oil flow.
  - (v) Low oil level indication.
  - (vi) Fan and pump failure protection.
- 5.3.3.5 Check for the adequate protection on the electric circuit supplying the accessories.
- 5.3.3.6 Check resistance of all windings on all steps of the tap changer. Insulation resistance measurement for the following:
- (i) Control wiring.
  - (ii) Main windings.
- 5.3.3.7 Check for cleanliness of the transformer and the surroundings.
- 5.3.3.8 Continuously observe the transformer operation at no load for 24 hours.
- Gradually put the transformer on load, check and measure increase in temperature in relation to the load and check the operation with respect to temperature rise and noise level etc.
- 5.3.3.9 Phase out and vector group test.
- 5.3.3.10 Ratio test on all taps.
- 5.3.3.11 Magnetising current test.

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- 5.3.3.12 Capacitance and Tan delta measurement of winding and bushing.
- 5.3.3.13 DGA of oil just before commissioning and after 24 hours energisation at site.
- 5.3.3.14 Frequency response analysis (FRA) at site by the equipment to be provided by the bidder.
- 5.3.3.15 Contractor shall prepare a comprehensive commissioning report including all commissioning test results and forward to Employer for future record.

**6.0 Technical Parameters**

**6.1 Technical Particulars / Parameters of Transformers (220/132/33 kV 1-Phase Auto Transformer)**

Cl. No.	Description	Unit	TECHNICAL PARAMETERS		
1.1	Rated Capacity				
	HV	MVA	10	33.33	53.33
	IV	MVA	10	33.33	53.33
	LV (Tertiary: Active Loading)	MVA	1	2	5
1.2	Voltage ratio (HV/IV/LV) (Line to line)	kV	(220/√3) / (132/√3) / 33		
1.3	Single / Three Phase Design		SINGLE		
1.4	Applicable Standard		IEC 60076		
1.5	Frequency	Hz	50		
1.6	Cooling		ONAN/ONAF	ONAN/ONAF/(OFAF or ODAF) : 60% / 80%/100% OR ONAN/ONAF1/ONAF2	
1.7	Rating at different cooling	%	60 / 100		60% / 80%/100%
1.8	Type of Transformer		Constant Ohmic impedance type (Refer Note1)		
1.9	HV – IV Impedance at 75 Deg C				
i)	Max. Voltage tap	%	8.30	10.3	10.3
ii)	Principal tap	%	10.00	12.5	12.5
iii)	Min. Voltage tap	%	12.30	15.4	15.4
iv)	Tolerance on Impedance	%	As per IEC		
1.10	Service		OUTDOOR		
1.11	Duty		CONTINUOUS		
1.12	Overload Capacity		IEC 60076-7		
1.13	Temperature rise over 50deg C Ambient Temp				
i)	Top oil measured by thermometer	°C	50		
ii)	Average winding measured by resistance method	°C	55		
1.14	Windings				
i)	System Fault level				
	HV	kA	40		
	IV	kA	31.5		
	LV	kA	25		
	Neutral	kA	-		
ii)	Lightning Impulse withstand Voltage				
	HV	kV <sub>p</sub>	950		
	IV	kV <sub>p</sub>	550		
	LV	kV <sub>p</sub>	250		
	Neutral	kV <sub>p</sub>	95		
iii)	Switching Impulse withstand Voltage				

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	HV	kV <sub>p</sub>	750		
iv)	One Minute Power Frequency withstand Voltage				
	HV	kV <sub>rms</sub>	395		
	IV	kV <sub>rms</sub>	230		
	LV	kV <sub>rms</sub>	95		
	Neutral	kV <sub>rms</sub>	38		
v)	Neutral Grounding		Solidly grounded		
vi)	Insulation				
	HV		GRADED		
	IV		GRADED		
	LV		UNIFORM		
vii)	Tertiary Connection (3Ph Bank)		Ungrounded Delta		
viii)	Tan delta of winding	%	<0.5%		
1.15 ix	Vector Group (3 –ph) (unless specified differently elsewhere)		YN0d11		
1.16	Tap Changer		OLTC		
i)	Tap Range & No. of steps		–5% to +15% of HV variation in the step of 1.25%, 16 steps		
ii)	Location of Tap changer		On the 132 kV side of the series winding		
iii)	Design		Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I		
iv)	Tap control		Full capacity - on load tap changer suitable for group / independent, remote /local electrical and local manual operation and bi-directional power flow		
1.17	Bushings				
i)	Rated voltage				
	HV	kV	245		
	IV	kV	145		
	LV	kV	52		
	Neutral	kV	36		
ii)	Rated current (Min.)				
	HV	A	800	800	800
	IV	A	800	800	1250
	LV	A	800	800	800
	Neutral	A	1000	1000	1000
iii)	Lightning Impulse withstand Voltage				
	HV	kV <sub>p</sub>	1050		
	IV	kV <sub>p</sub>	650		
	LV	kV <sub>p</sub>	250		
	Neutral	kV <sub>p</sub>	170		
iv)	Switching Impulse withstand Voltage				
	HV	kV <sub>p</sub>	850		
v)	One Minute Power Frequency withstand Voltage				
	HV	kV <sub>rms</sub>	505		
	IV	kV <sub>rms</sub>	305		
	LV	kV <sub>rms</sub>	105		
	Neutral	kV <sub>rms</sub>	77		
vi)	Minimum total creepage distances				
	HV	mm	6125		
	IV	mm	3625		
	LV	mm	1300		
	Neutral	mm	900		
vii)	Tan delta of bushing				
	HV	%	<0.4		
	IV	%	<0.4		



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	LV	%	<0.4
	Neutral	%	-
viii)	Max Partial discharge level at $U_m$		
	HV	pC	10
	IV	pC	10
	LV	pC	10
1.18	Max Partial discharge level at $1.5U_m/\sqrt{3}$	pC	100
1.19	Max Noise level at rated voltage and at principal tap on full load and all cooling active	dB	75

**Notes:**

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. The criteria for Transformer losses shall be “Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)”.

**6.2 Technical Particulars / Parameters of Transformers**  
**(132/33 kV, 3-Phase Power Transformer)**

Cl. No.	Description	Unit	TECHNICAL PARAMETERS			
1.20	Rated Capacity					
	HV	MVA	50	40	31.5	25
	LV	MVA	50	40	31.5	25
1.21	Voltage ratio (HV/LV) Line to line	kV	132/33			
1.22	Single / Three Phase Design		3 (THREE)			
1.23	Applicable Standard		IEC 60076			
1.24	Frequency	Hz	50			
1.25	Cooling		ONAN/ONAF			
1.26	Rating at different cooling	%	60 / 100			
1.27	Type of Transformer		Constant Ohmic impedance type (Refer note 1)			
1.28	HV-LV Impedance at 75 Deg C					
i)	Max. Voltage tap	%	10.3			
ii)	Principal tap	%	12.5			
iii)	Min. Voltage tap	%	15.4			
iv)	Tolerance on Impedance	%	As per IEC			
1.29	Service		OUTDOOR			
1.30	Duty		CONTINUOUS			
1.31	Overload Capacity		IEC 60076-7			

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1.32	Temperature rise over 50deg C Ambient Temp		
i)	Top oil measured by thermometer	°C	50
ii)	Average winding measured by resistance method	°C	55
1.33	Windings		
i)	System Fault level		
	HV	kA	31.5
	LV	kA	25
	Neutral	kA	-
ii)	Lightning Impulse withstand Voltage		
	HV	kV <sub>p</sub>	550
	LV	kV <sub>p</sub>	170
	Neutral	kV <sub>p</sub>	95
iii)	Switching Impulse withstand Voltage		
	HV	kV <sub>p</sub>	460
iv)	One Minute Power Frequency withstand Voltage		
	HV	kV <sub>rms</sub>	230
	LV	kV <sub>rms</sub>	70
	Neutral	kV <sub>rms</sub>	38
v)	Neutral Grounding		Solidly grounded
vi)	Insulation		
	HV		GRADED
	LV		UNIFORM
vii)	Tan delta of winding	%	<0.5%
1.34	Vector Group (3 –ph) (unless specified differently elsewhere)		YNynO
1.35	Tap Changer		OLTC
i)	Tap Range & No. of steps		–15% to +5% of HV variation in the step of 1.25%, 16 stpes
ii)	Location of Tap changer		On Neutral side of 132 kV winding
iii)	Design		Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I
iv)	Tap control		Full capacity on load tap changer suitable for group/independent, remote /local electrical and local manual operation and bi-directional power flow.
1.36	Bushings		
i)	Rated voltage		
	HV	kV	145
	LV	kV	36
	Neutral	kV	36
ii)	Rated current (Min.)		
	HV	A	800
	LV	A	1250
	Neutral	A	1250

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iii)	Lightning Impulse withstand Voltage		
	HV	kVp	650
	LV	kVp	170
	Neutral	kVp	170
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	305
	LV	kVrms	77
	Neutral	kVrms	77
v)	Minimum total creepage distances		
	HV	mm	3625
	LV	mm	900
	Neutral	mm	900
vi)	Tan delta of bushing		
	HV	%	<0.4
vii)	Max Partial discharge level at $U_m$		
	HV	pC	10
1.37	Max Partial discharge level at $1.5U_m/\sqrt{3}$	pC	100
1.38	Max Noise level at rated voltage and at principal tap on full load and all cooling active	dB	75

**Notes:**

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. The criteria for Transformer losses shall be “**Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)**”.

**7.0 Bushing Current Transformer**

- 7.1 Current transformers shall comply with IEC-60185.
- 7.2 It shall be possible to remove the turret mounted current transformers from the tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.
- 7.3 Current transformer secondary leads shall be brought out to a weather proof terminal box near each bushing. These terminals shall be wired out to cooler control cabinet/ marshalling box using separate cables for each core.

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7.4 Bushing Current transformer parameters indicated in this specification are tentative and liable to change within reasonable limits. The Contractor shall obtain Employer's approval before proceeding with the design of bushing current transformers.

7.5 **Technical Parameters for Bushing CT**

7.5.1 **Technical Parameters of Current Transformers (for 53.33, 33.33 & 10 MVA 220/132kV 1-Ph Transformer)**

Description	Current Transformer Parameters (Transformer)		
	HV Side	IV Side	Neutral Side
<b>(a) Ratio</b>			
CORE 1	1000/1	1000/1	1000/1
CORE 2	600/1	1000/1	-
<b>(b) Minimum knee point voltage or burden and accuracy class</b>			
CORE 1	600V, TPS	600V, TPS	600V, TPS
CORE 2	0.5 Class 15VA ISF $\leq 5$	0.5 Class 15VA ISF $\leq 5$	-
<b>(c) Maximum CT Secondary Resistance</b>			
CORE 1	1.5 Ohm	1.5 Ohm	1.5 Ohm
CORE 2	-	-	-
<b>(d) Application</b>			
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Metering	-
<b>(e) Maximum magnetization current (at knee point voltage)</b>			
CORE 1	100 mA	100 mA	100 mA
CORE 2	-	-	-

NOTE:

- i) For TPS class CT's, Dimensioning parameter "K", Secondary VA shall be considered 1.5 and 20 respectively. Class (for the relevant protection and duties) as per IEC 60185.
- ii) Rated continuous thermal current rating shall be 200% of rated primary current.
- iii) Parameters of WTI CT for each winding shall be provided by the contractor.
- iv) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.
- v) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

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**7.5.2 Technical Parameters of Current Transformers (for 31.5 MVA, 25MVA, 20MVA, 12.5MVA 132/33kV 3-Ph Transformers)**

Description	Current Transformer Parameters (Transformer)			
	HV Side	HV Neutral Side	LV Side	LV Neutral Side
<b>(a) Ratio</b>				
CORE 1	200/1	200/1	600/1	600/1
CORE 2	200/1	-	600/1	-
<b>(b) Minimum knee point voltage or burden and accuracy class</b>				
CORE 1	400V, TPS	400V, TPS	600V, TPS	600V, TPS
CORE 2	0.2 Class 15VA ISF $\leq 5$	-	0.2 Class 15VA ISF $\leq 5$	-
<b>(c) Maximum CT Secondary Resistance</b>				
CORE 1	1.5 Ohm	1.5 Ohm	1.5 Ohm	1.5 Ohm
CORE 2		-	-	-
<b>(d) Application</b>				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Metering	Restricted Earth Fault
CORE 2	Metering			-
<b>(e) Maximum magnetization current (at knee point voltage)</b>				
CORE 1	100mA	100 mA	100 mA	100 mA
CORE 2		-	-	-

NOTE:

- i) For TPS class CT's, Dimensioning parameter "K", Secondary VA shall be considered 1.5 and 20 respectively. Class (for the relevant protection and duties) as per IEC 60185.
- ii) Rated continuous thermal current rating shall be 200% of rated primary current.
- iii) Parameters of WTI CT for each winding shall be provided by the contractor.
- iv) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.
- v) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

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**(Transformer up to 220 kV class)**

**8.0 Oil Storage Tank**

**8.1 General**

This specification is for oil storage tank. Oil Storage tank shall be Supplied if specified in Bid Price schedule.

**8.2 Standard**

The oil storage tank shall be designed and fabricated as per relevant standards.

**8.3 Specifications**

Transformer oil storage tanks shall be towable on pneumatic tyres and rested on manual screw jacks of adequate quantity & size. The tank shall be cylindrical in shape and mounted horizontally and made of mild steel plate of adequate thickness. Size of the storage tank shall be as follows:

Diameter	:	1.5 meter (For 10 cubic meter capacity) 2.0 meter (For 20 cubic meter capacity)
Minimum Capacity	:	As mentioned in BPS

The tank shall be designed for storage of oil at a temperature of 100°C.

8.3.1 The Bidder may further note that maximum height of any part of the complete assembly of the storage tank shall not exceed 4.0 metres above road top.

8.3.2 The tank shall have adequate number of jacking pad so that it can be kept on jack while completely filled with oil. The tank shall be provided with suitable saddles so that tank can be rested on ground after removing the pneumatic tyres.

8.3.3 The tank shall also fitted with manhole, outside & inside access ladder, silicagel breather assembly, inlet & outlet valve, oil sampling valve with suitable adopter, oil drainage valve, air vent etc. Pulling hook on both ends of the tank shall be provided so that the tank can be pulled from either end while completely filled with oil. Bidder shall indicate the engine capacity in horse power to pull one tank completely fitted with oil. Oil level indicator shall be provided with calibration in terms of litre so that at any time operator can have an idea of oil in the tank. Suitable arrangement shall also be provided to prevent overflow in the tank. Solenoid valve (Electro-mechanically operated) with centrifugal pump shall be provided at bottom inlet so that pump shall be utilized both ways during oil fill up and draining. Suitable arrangement shall also be provided to prevent overflow and drain from the tank/

8.3.4 The following accessories shall form part of supply along with each Oil storage tank.

- i) Four numbers of suitable nominal bore rubber hoses for transformer oil application upto temperature of 100°C, full vacuum and pressure up to 2.5 Kg/ cm<sup>2</sup> with couplers and unions each not less than 10 metre long shall be provided.
- ii) Two numbers of suitable nominal bore vacuum hoses, suitable for full vacuum without collapsing and kinking, with couplers and unions each not less than 10 metre long shall also be provided.
- (iii) One number of digital vacuum gauge with sensor capable of reading up to 0.001 torr, operating on 230V 50Hz AC supply shall be supplied. Couplers and unions for sensor should block oil flow in the sensor. Sensor shall be provided with atleast 8 meter cable so as to suitably place the Vacuum gauge at ground level.

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- 8.3.5 The painting of oil storage tank and its control panel shall be as per clause no 3.1.1.8.
- 8.3.6 The tank shall contain a self mounted centrifugal oil pump with inlet and outlet valves, with couplers -suitable for flexible rubber hoses and necessary switchgear for its control. There shall be no rigid connection to the pump. The pump shall be electric motor driven, and shall have a discharge of not less than 3.0 ( For 10 cubic meter capacity) / 6.0 kl/hr ( For 20 cubic meter capacity) with a discharge head of 8.0m. The pump motor and the control cabinet shall be enclosed in a cubical with IP-55 enclosure.

**9.0 OIL SAMPLING BOTTLE**

- 9.1 Oil sampling bottles shall be suitable for collecting oil samples from transformers and shunt reactors, for Dissolved Gas Analysis. Bottles shall be robust enough, so that no damage occurs during frequent transportation of samples from site to laboratory.
- 9.2 Oil sampling bottles shall be made of stainless steel having a capacity of one litre.
- 9.3 Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.
- 9.4 The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.
- 9.5 An impermeable oil-proof, transparent plastic or rubber tube of about 5 mm diameter, and of sufficient length shall also be provided with each bottle along with suitable connectors to fit the tube on to the oil sampling valve of the equipment and the oil collecting bottles respectively.

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**(Transformer up to 220 kV class)**

**Annexure -A**

All tests shall be carried out as per IEC: 60076 on transformer.

**1) Magnetic Circuit Test**

After assembly each core shall be tested for 1 minute at 2000 Volts between all bolts, side plates and structural steel work.

**2) Tank Tests**

**(i) Oil Leakage Test**

All tanks and oil filled compartments shall be tested for oil tightness by being completely filled with air or oil of a viscosity not greater than that of insulating oil conforming to IEC-60296 at the ambient temperature and applying a pressure equal to the normal pressure plus 35 KN/Sq.m (5 psi) measured at the base of the tank. The pressure shall be maintained for a period of not less than 12 hours for oil and one hour for air during which time no leak shall occur.

**(ii) Vacuum Test**

All transformer tank of each size shall be subjected to the specified vacuum. The tank designed for full vacuum shall be tested at an internal pressure of 3.33 KN/Sq.m absolute (25 torr) for one hour. The permanent deflection of flat plate after the vacuum has been released shall not exceed the values specified below:

<b>Horizontal Length of flat plate (in mm)</b>	<b>Permanent deflection (in mm)</b>
Upto and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.5
2501 to 3000	16.0
Above 3000	19.0

**(iii) Pressure Test**

All transformer tank of each size, its radiator, conservator vessel and other fittings together or separately shall be subjected to an air pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 KN/m<sup>2</sup> whichever is lower measured at the base of the tank and maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified above for vacuum test.

**3) Measurement of capacitance and tan delta** to determine capacitance between winding and earth. Tan delta value shall not be more than 0.5% corrected at 20deg C. Temperature correction factor table shall be given by the Contractor and shall form the part of test results.

**4) Temp. Rise Test (as per IEC 60076)**

Gas chromatographic analysis on oil shall also be conducted before and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC 60567. For the evaluation of the gas analysis in temperature rise test the



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### **(Transformer up to 220 kV class)**

procedure shall be as IEC: 60567 and results will be interpreted as per IEC -61181. The DGA results shall generally conform to IEC/IEEE guidelines.

The temperature rise test shall be conducted at a tap for the worst combination of loading on the three windings of the transformer. The Contractor before carrying out such test shall submit detailed calculations showing alternatives possible, on various taps of the transformer and shall recommend the combination that results in highest temperature rise for the test.

#### **6) Type Tests on fittings:**

All the following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with the drawings of equipment/ fittings. The list of fittings and the type test requirement is:

- a. Bushing (Type Test as per IEC: 60137)
- b. Buchholz relay (Type Test and IP-55 Test on terminal box)
- c. Marshalling box (IP-55 test)
- d. Pressure Relief device Test

The pressure Relief Device of each size shall be subjected to increase in oil pressure. It shall operate before reaching the test pressure specified in transformer tank pressure test. The operating pressure shall be recorded. The device shall seal off after excess pressure has been released. The terminal box / boxes of PRD should conform to degree of protection as per IP-55.

- e. Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.
- f. Air Cell (Flexible air separator) –Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per BS: 903.
- g. OTI & WTI – Switch setting & operation, switch differential, switch rating.

#### **7) Inspection and Testing at Site**

The Contractor/Manufacturer shall supervise testing & commissioning at site. Testing & commissioning shall be carried out by the owner (MOEP-2). Contractor shall submit a detailed procedure for Testing & Commissioning at site including receipt, storage & installation checks as mentioned below.

##### **a) Receipt and Storage Checks**

- Check and record condition of each package, visible parts of the transformer etc. for any damage.
- Check and record the gas pressure in the transformer tank as well as in the gas cylinder.
- Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.
- Check and record reading of impact recorder at receipt and verify the allowable limits as per manufacturer's recommendations.

##### **b) Installation Checks**

- Check whole assembly for tightness, general appearance etc.
- Oil leakage test
- Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.
- Leakage check on bushing before erection.

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### **(Transformer up to 220 kV class)**

- Measure and record the dew point of nitrogen/dry air in the main tank before assembly. Manufacturer shall submit dew point acceptable limits along with temperature correction factor and shall form part of instruction manual. In case dew point values are not within permissible limit suitable drying out process shall be applied for dry out of active part in consultation with the Manufacturer.

#### **c) Oil filling**

Oil impregnation or drying under vacuum at site shall be done with the transformer and oil at a temperature not exceeding 70°C.

The duration of the vacuum treatment shall be demonstrated as adequate by means of water measurement with a cold trap or other suitable method but shall generally not be less than 72 hours. The vacuum shall be measured on the top of the transformer tank and should be less than 1mbar.

Vacuum shall not be broken until the transformer is oil filled up to the Buchholz relay. Whenever the active insulation or any paper insulated HV connections, especially those from the windings to the bushings are exposed, these shall be re-impregnated under vacuum along with the complete transformer. For this purpose the transformer shall first be drained to expose all insulation material.

The minimum safe level of oil filling (if different from the Buchholz level) to which the transformer shall be oil filled under vacuum, shall be indicated in the manual.

Procedures for site drying, oil purification, oil filling etc shall be submitted for approval and complete instructions shall form part of the manual.

#### **d) Commissioning Checks**

- Check the colour of silicagel in silicagel breather.
- Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.
- Check the bushing for conformity of connection to the lines etc,
- Check for correct operation of all protection devices and alarms:
  - (i) Buchholz relay.
  - (ii) Excessive winding temperature.
  - (iii) Excessive oil temperature.
  - (iv) Low oil level indication.
- Check for the adequate protection on the electric circuit supplying the accessories.
- Check resistance of all windings on all steps of the tap changer. Insulation resistance measurement for the following:
  - (i) Control wiring.
  - (ii) Main windings.
- Check for cleanliness of the transformer and the surroundings.
- Continuously observe the transformer operation at no load for 24 hours.
- Gradually put the transformer on load, check and measure increase in temperature in relation to the load and check the operation with respect to temperature rise and noise level etc.
- Phase out and vector group test.
- Ratio test on all taps.
- Magnetising current test.
- Capacitance and Tan delta measurement of winding and bushing.
- DGA of oil just before commissioning and after 24 hours energisation at site.

## **SECTION – GAS INSULATED SWITCHGEAR**

Revision 00

## 1. GENERAL CHARACTERISTICS

- 1.1. The SF6 gas insulated metal enclosed switchgear shall be totally safe against inadvertent touch of any of its constituent parts. It should be designed for indoor application with meteorological conditions at site as per Section Project.
- 1.2. All parts of the switchgear and the bus ducts (for both indoor and outdoor applications) shall be single phase/three phase enclosed for 220kV and three phase enclosed for 132 KV.
- 1.3. The design should be such that all parts subjected to wear and tear are easily accessible for maintenance purposes. The equipment offered shall be protected against all types of voltage surges and any equipment necessary to satisfy this requirement shall be deemed to be included.
- 1.4. The required overall parameters of GIS are as follows:-

Sl.No	Technical particulars	220 kV System	132KV system
1.	Rated Voltage (RMS)	245 kV	145 kV
2.	Rated frequency	50 HZ	50 HZ
	Grounding	Effectively earthed	Effectively earthed
3.	Rated power frequency withstand Voltage (1 min ) line to earth (rms)	460 kV	275 kV
4.	Impulse withstand BIL (1.2/50/mic. Sec) Line to earth	±1050 kVp	±650 kVp
5.	Rated short time withstand current (1 sec) (As applicable)	40 kA (rms)	31.5kA (rms)
6.	Rated peak withstand current (as applicable)	125/100 kA (peak)	78.75kA (peak)
7.	Rated current (at 50 degree C design ambient temperature)	As per BPS	

## 2. REFERENCE STANDARDS

The metal-enclosed gas-insulated switchgear, including the operating devices, accessories and auxiliary equipment forming integral part thereof, shall be designed, manufactured, assembled and tested in accordance with the following International Electro-technical

Commission (IEC) Publications including their parts and supplements as amended or revised as on date of bid opening:

<b>IEC 62271-203</b>	Gas Insulated metal-enclosed switchgear for rated voltages above 52 KV
<b>IEC 62271-207</b>	Seismic qualification for gas-insulated switchgear assemblies for rated voltages above 52 kV
<b>IEC 60376</b>	New sulphur hexafluoride
<b>IEC 62271- 100</b>	High voltage alternating current Circuit breakers
<b>IEC 62271-1</b>	Common clauses for high voltage Switchgear and control-gear standards
<b>IEC 62271-102</b>	Alternating current disconnectors(isolate) and earthing switches
<b>IEC 60044-1</b>	Current transformers
<b>IEC 60044-2</b>	Voltage transformers
<b>IEC 60137</b>	Bushings for alternating voltages above 1000 V
<b>IEC 62271-209</b>	Cable connections for gas-insulated switchgear
<b>IEC 60480</b>	Guide to checking of sulphur hexafluoride taken from electrical equipment
<b>IEC 60099 -1/4</b>	Non-linear resistor type arresters for AC systems
<b>IEC 60439</b>	Factory-built assemblies of low-voltage switchgear and control Gear.
<b>IEEE 80 (2000)</b>	IEEE Guide for Safety in AC Substation grounding.
<b>CIGRE-44</b>	Earthing of GIS- an application guide. (Electra no.151,Dec'93).
<b>IEC 61639</b>	Direct connection between Power Transformers and gas insulated metal enclosed switchgear for rated voltage 72.5 kV and above.

The components and devices which are not covered by the above standards shall conform to, and comply with, the applicable standards, rules, codes and regulations of the internationally recognized standardizing bodies and professional societies as may be approved by the Owner/consultant and the manufacturer shall list all such applicable standards, codes etc.

In case the requirements laid down herein differ from those given in above standard in any aspect the switchgear shall comply with the requirements indicated herein in regard thereto.

### **3. DEFINITIONS**

- 3.1. **Assembly:** Assembly refers to the entire completed GIS equipment furnished under contract.
- 3.2. **Bay:** Bay refers to the area occupied by one Circuit Breaker and associated equipment.
- 3.3. **Compartment:** When used in conjunction with GIS equipment, compartment refers to a gas tight volume bounded by enclosure walls and gas tight isolating barriers.

- 3.4. **Enclosure:** When used in conjunction with GIS equipment, enclosure refers to the grounded metal housing or shell which contains and protects internal Power system equipment (breaker, disconnecting switch, grounding switch, voltage transformer, current transformer, surge arresters, interconnecting bus etc.)
- 3.5. **Manual Operation:** Manual operation means operation by hand without using any other source of power.
- 3.6. **Module:** When used in conjunction with GIS equipment, module refers to a portion of that equipment. Each module includes its own enclosure. A module can contain more than one piece of equipment, for example, a module can contain a disconnecting switch and a grounding switch.
- 3.7. **Reservoir:** When used in conjunction with GIS equipment reservoir refers to a larger gas-tight volume.

#### **4. GENERAL DESIGN AND SAFETY REQUIREMENT**

- 4.1. The GIS shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. Adequate safety margin with respect to thermal, mechanical, dielectric stress and insulation coordination etc. shall be maintained during design, selection of raw material, manufacturing process etc. so that the GIS provides long life with least maintenance.

The workmanship shall be of the highest quality and shall conform to the latest modern practices for the manufacture of high technology machinery and electrical switchgear

- 4.2. The GIS assembly shall consist of separate modular compartments e.g. Circuit Breaker compartment, Bus bar compartment filled with SF<sub>6</sub> Gas and separated by gas tight partitions so as to minimize risk to human life, allow ease of maintenance and limit the effects of gas leaks failures & internal arcs etc. These compartments shall be such that maintenance on one feeder may be performed without de-energising the adjacent feeders. These compartments shall be designed to minimize the risk of damage to adjacent sections and protection of personnel in the event of a failure occurring within the compartments. Rupture diaphragms with suitable deflectors shall be provided to prevent uncontrolled bursting pressures developing within the enclosures under worst operating conditions, thus providing controlled pressure relief in the affected compartment.
- 4.3. The switchgear, which shall be of modular design, shall have complete phase isolation. The conductors and the live parts shall be mounted on high graded epoxy resin insulators. These insulators shall be designed to have high structural strength and electrical dielectric properties and shall be free of any voids and free of partial discharge at a voltage which is at least 5% greater than the rated voltage. These shall be designed to have high structural and dielectric strength properties and shall be shaped so as to provide uniform field distribution and to minimize the effects of particle deposition either from migration of foreign particles within the enclosures or from the by-products of SF<sub>6</sub> breakdown under arcing conditions.



- 4.4. Gas barrier insulators shall be provided so as to divide the GIS into separate compartments. These shall be suitably located in order to minimize disturbance in case of leakage or dismantling. They shall be designed to withstand any internal fault thereby keeping an internal arc inside the faulty compartment. Due to safety requirement for working on this pressurized equipment, whenever the pressure of the adjacent gas compartment is reduced during maintenance, this compartment shall be designed so that it shall remain in service to perform its intended duty. The gas tight barriers shall be clearly marked on the outside of the enclosures.

The bus enclosure should be sectionalized in a manner that maintenance work on any bus disconnector (when bus and bus disconnector are enclosed in a single enclosure) can be carried out by isolating and evacuating the small effected section and not the entire bus.. The design of 220/132 kV GIS shall be such that in case a circuit breaker module of a feeder is removed for maintenance, both busbars shall remain in service. For achieving the above requirements, adequate Mechanical support and number of intermediate gas tight compartments as required, shall be provided to ensure equipment and operating personnel's safety.

Typical drawings indicating gas tight compartments are enclosed at **Annexure-A**.

- 4.5. The material and thickness of the enclosures shall be such as to withstand an internal flash over without burn through for a period of 300 ms at rated short time withstand current. The material shall be such that it has no effect of environment as well as from the by-products of SF6 breakdown under arcing condition.
- 4.6. Each section shall have plug- in or easily removable connection pieces to allow for easy replacement of any component with the minimum of disturbance to the remainder of the equipment. Inspection windows shall be provided for Disconnectors and earth switches.
- 4.7. The material used for manufacturing the switchgear equipment shall be of the type, composition and have physical properties best suited to their particular purposes and in accordance with the latest engineering practices. All the conductors shall be fabricated of aluminum/ copper tubes of cross sectional area suitable to meet the normal and short circuit current rating requirements. The finish of the conductors shall be smooth so as to prevent any electrical discharge. The conductor ends shall be silver plated and fitted into finger contacts or tulip contacts. The contacts shall be of sliding type to allow the conductors to expand or contract axially due to temperature variation without imposing any mechanical stress on supporting insulators.
- 4.8. Each pressure filled enclosure shall be designed and fabricated to comply with the requirements of the applicable pressure vessel codes and based on the design temperature and design pressures as defined in IEC-62271-203.
- 4.9. The maximum SF6 gas leakage shall not exceed 0.5% (half percent) per year for the whole equipment and for any individual gas compartment separately. The SF6 gas leakage should not exceed 0.5% per year and the leakage rate shall be guaranteed for at least 10 years. In case the leakage under the specified conditions is found to be greater than 0.5% after one year of commissioning, the manufacturer will have to supply free of

- cost, the total gas requirement for subsequent ten (10) years, based on actual leakage observed during the first year of operation after commissioning
- 4.10. Each gas-filled compartment shall be equipped with static filters, density switches, filling valve and safety diaphragm. The filters shall be capable of absorbing any water vapour which may penetrate into the enclosures as well as the by-products of SF<sub>6</sub> during interruption. Each gas compartment shall be fitted with non-return valve connectors for evacuating & filling the gas and checking the gas pressure etc.
  - 4.11. The switchgear line-up when installed and operating under the ambient conditions shall perform satisfactorily and safely under all normal and fault conditions. Even repeated operations up to the permissible servicing intervals under 100% rated and fault conditions shall not diminish the performance or significantly shorten the useful life of the switchgear. Any fault caused by external reasons shall be positively confined to the originating compartment and shall not spread to other parts of the switchgear.
  - 4.12. The thermal rating of all current carrying parts shall be minimum for one sec. for the rated symmetrical short-circuit current.
  - 4.13. The switchgear shall be of the free standing, self-supporting with easy accessibility to all the parts during installation & maintenance with all high-voltage equipment installed inside gas-insulated metallic and earthed enclosures, suitably sub-divided into individual arc and gas-proof compartments preferably for:
    - 1) Bus bars
    - 2) Intermediate compartment
    - 3) Circuit breakers
    - 4) Line Disconnectors
    - 5) Voltage Transformers
    - 6) Gas Insulated bus duct section between GIS and XLPE cable/Overhead Conductor.
    - 7) Gas Insulated bus section between GIS & Oil filled Transformer (if applicable)
  - 4.14. The arrangement of the individual switchgear bays shall be such so as to achieve optimum space-saving, neat and logical arrangement and adequate accessibility to all external components.
  - 4.15. The layout of the substation equipment, bus bars and switchgear bays shall preferably be based on the principle of “phase grouping”. Switchgear layout based on the “mixed phases” principle shall not be accepted without mutual agreement between supplier and employer/consultant. The arrangement of the equipment offered must provide adequate access for operation, testing and maintenance.
  - 4.16. All the elements shall be accessible without removing support structures for routine inspections. The removal of individual enclosure parts or entire breaker bays shall be possible without disturbing the enclosures of neighboring bays.



- 4.17. It should be impossible to unwillingly touch live parts of the switchgear or to perform operations that lead to arcing faults without the use of tools or brute force. All interlocks that prevent potentially dangerous mal-operations, shall be constructed such that they cannot be operated easily, i.e. the operator must use tools or brute force to over-ride them.
- 4.18. In general the contours of energized metal parts of the GIS and any other accessory shall be such, so as to eliminate areas or points of high electrostatic flux concentrations. The surfaces shall be smooth with no projection or irregularities which may cause visible corona. No corona shall be visible in complete darkness which the equipment is subjected to specified test voltage. There shall be no radio interference from the energized switchgear at rated voltage.
- 4.19. The GIS shall be designed, so as to take care of the VFT over voltages generated as a result of pre-strikes and re-strikes during isolator operation. Maximum VFT over voltages peak shall not be higher than rated lightning impulse withstand voltage (LIWV) of the equipment. Necessary measures shall be under taken by GIS manufacture to restrict maximum VFT over voltages lower than the LIWV. Manufacturer shall submit the study report of VFTO generated for GIS installation.
- 4.20. The enclosure shall be of continuous design and shall meet the requirement as specified in clause no. 10 (special considerations for GIS) of IEEE- 80, Year- 2000.
- The enclosure shall be sized for carrying induced current equal to the rated current of the Bus. The conductor and the enclosure shall form the concentric pair with effective shielding of the field internal to the enclosure.
- 4.21. The fabricated metal enclosures shall be of Aluminum alloy having high resistance to corrosion, low electrical losses and negligible magnetic losses. All joint surfaces shall be machined and all castings shall be spot faced for all bolt heads or nuts and washers. All screws, bolts, studs and nuts shall conform to metric system.
- 4.22. The elbows, bends, cross and T-sections of interconnections shall include the insulators bearing the conductor when the direction changes take place in order to ensure that live parts remain perfectly centered and the electrical field is not increased at such points.
- 4.23. The enclosure shall be designed to practically eliminate the external electromagnetic field and thereby electro-dynamic stresses even under short circuit conditions. The average intensity of electromagnetic field shall not be more than 50 micro –Tesla on the surface of the enclosure. The contractor shall furnish all calculations and documents in support of the above during detailed engineering.
- 4.24. The switchgear shall have provision for connection with ground mat risers. This provision shall consist of grounding pads to be connected to the ground mat riser in the vicinity of the equipment.
- 4.25. The ladders and walkways shall be provided wherever necessary for access to the equipment.

- 4.26. Wherever required, the heaters shall be provided for the equipment in order to ensure the proper functioning of the switchgear at specified ambient temperatures. The heaters shall be rated for 230V AC supply and shall be complete with thermostat, control switches and fuses, connected as a balanced 3-phase. 4-wire load. The heaters shall be so arranged and protected as to create no hazard to adjacent equipment from the heat produced.
- 4.27. The enclosure & support structure shall be designed that person of 1780 mm in height and 80 Kg in weight is able to climb on the equipment for maintenance.
- 4.28. The sealing provided between flanges of two modules / enclosures shall be such that long term tightness is achieved.
- 4.29. Alarm circuit shall not respond to faults for momentary conditions. The following indications including those required elsewhere in the specifications shall be generally provided in the alarm and indication circuits.

**Gas Insulating System:**

- i) Loss of Gas Density.
- ii) Loss of Heater power(if required)
- iii) Any other alarm necessary to indicate deterioration of the gas insulating system.

**Operating System:**

- i) Low operating pressure.
  - ii) Loss of Heater power.
  - iii) Loss of operating power.
  - iv) Loss of control supply.
  - v) Pole Discordance.
- 4.30. The equipment will be operated under the following ambient conditions(or as defined in the section project):
- a) The ambient temperature varies between 0 degree-C and 50 degree-C. However, for design purposes, ambient temperature should be considered as 50 degree-C.
  - b) The humidity will be about 95% (indoors)
  - c) The elevation as per section project.
- 4.31. Temperature rise of current carrying parts shall be limited to the values stipulated in IEC-62271-1, under rated current and the climatic conditions at site. The temperature rise for all enclosures shall not exceed 20 degree C above the ambient temperature of 50 degree C. These conditions shall be taken into account by the supplier in the design of the equipment
- 4.32. **Bellows or Compensating Units:-** Adequate provision shall be made to allow for the thermal expansion of the conductors & enclosures and of differential thermal expansion between the conductors and the enclosures. The bellows metallic( preferably stainless steel) with suitable provision for permitting the movement during expansion and contraction may be provided and shall be of following types:.

1. Lateral / Vertical mounting units: These shall be inserted, as required, between sections of busbars, on transformer and XLPE cable etc. Lateral mounting shall be made possible by a sliding section of enclosure and tubular conductors.
2. Axial compensators: These shall be provided to accommodate changes in length of busbars due to temperature variations.
3. Parallel compensators: These shall be provided to accommodate large linear expansions and angle tolerances.
4. Tolerance compensators: These shall be provided for taking up manufacturing, site assembly and foundation tolerances.
5. Vibration compensators: These bellow compensators shall be provided for absorbing vibrations caused by the transformers when connected to SF6 switchgear by oil- SF6 bushings.

The electrical connections across the bellows or compensating units shall be made by means of suitable connectors. For sliding type compensators, markers/pointers shall be provided to observe expansion or contraction during climatic conditions.

- 4.33. **Indication and verification of switch positions:** Indicators shall be provided on all circuit breakers, isolators and earth-switches, which shall clearly show whether the switches are open or closed. The indicators shall be mechanically coupled directly to the main contact operating drive rod or linkages and shall be mounted in a position where they are clearly visible from the floor or the platform in the vicinity of the equipment.

Inspection windows shall also be provided with all isolators and earth switches so that the switch contact positions can be verified by direct visual inspection.

- 4.34. **Pressure relief device :** Pressure relief devices shall be provided in the gas sections to protect the gas enclosures from damage or distortion during the occurrence of abnormal pressure increase or shock waves generated by internal electrical fault arcs (preferably in downward direction).

Pressure relief shall be achieved either by means of diaphragms or plugs venting directly into the atmosphere in a controlled direction.

If the pressure relief devices vent directly into the atmosphere, suitable guards and deflectors shall be provided. Contractor shall submit to the owner the detailed criteria/design regarding location of pressure relief devices/rupture diaphragms.

- 4.35. **Pressure vessel requirements:** The enclosure shall be designed for the mechanical and thermal loads to which it is subjected in service. The enclosure shall be manufactured and tested according to the pressure vessel code (ASME/CENELEC code for pressure Vessel.)

The bursting strength of Aluminum castings has to be at least 5 times the design pressure. A bursting pressure test shall be carried out at 5 times the design pressure as a type test on each type of enclosure.

Each enclosure has to be tested as a routine test at 1.5 times the design pressure for one minute.

**4.36. Grounding:**

- 4.36.1. The grounding system shall be designed and provided as per IEEE-80-2000 and CIGRE-44 to protect operating staff against any hazardous touch voltages and electro-magnetic interferences.
- 4.36.2. The GIS supplier shall define clearly what constitutes the main grounding bus of the GIS. The contractor shall supply the entire material for grounding bus of GIS viz conductor, clamps, joints, operating and safety platforms etc. The contractor is also required to supply all the earthing conductors and associated hardware material for connecting all GIS equipment, bus ducts, enclosures, control cabinets, supporting structure, GIS surge arrester etc. to the ground bus of GIS.
- 4.36.3. The enclosure of the GIS may be grounded at several points so that there shall be grounded cage around all the live parts. A minimum of two nos. of grounding connections should be provided for each of circuit breaker, cable terminals, surge arrestors, earth switches and at each end of the bus bars. The grounding continuity between each enclosure shall be effectively interconnected externally with Copper /Aluminum bonds of suitable size to bridge the flanges. Subassembly to subassembly bonding shall be provided to bridge the gap & safe voltage gradients between all intentionally grounded parts of the GIS assembly & between those parts and the main grounding bus of the GIS.
- 4.36.4. Each marshaling box, local control panel, power and control cable sheaths and other non-current carrying metallic structures shall be connected to the grounding system of GIS via connections that are separated from GIS enclosures.
- 4.36.5. The grounding connector shall be of sufficient mechanical strength to withstand electromagnetic forces as well as capable of carrying the anticipated maximum fault current without overheating. At least two grounding paths shall be provided to connect each point to the main grounding bus. Necessary precautions should be under taken to prevent excessive currents from being induced into adjacent frames, structures of reinforcing steel and to avoid establishment of current loops via other station equipment.
- 4.36.6. All flexible bonding leads shall be tinned copper. All connectors, for attaching flexible bonding leads to grounding conductors and grounding conductors to support structures shall be tinned bronze with stainless steel or tinned bronze hardware.
- 4.36.7. The contractor shall provide suitable measure to mitigate transient enclosure voltage caused by high frequency currents caused by lightning strikes, operation of surge arrester, phase to earth fault and discharges between contacts during switching operation. The grounding system shall ensure safe touch & step voltages in all the enclosures.
- 4.37. **UHF sensors for PD detection:** Contractor shall provide adequate number of UHF sensors in the offered GIS for detection of Partial discharge (of 5 pC and above) as per IEC 60270 through Partial Discharge (PD) monitoring system and the number and

location of these sensors shall be subject to approval of the employer/consultant. Further UHF sensors shall necessarily be provided in close proximity to VT compartments

However adequacy of number of sensors and their location shall be verified at site by the contractor as per recommendations of CIGRE task force TF 15/33.03.05 (**Task force on Partial discharge detection system for GIS: Sensitivity verification for the UHF method and the acoustic method**). In case during site testing additional UHF sensors are required, the same shall also be supplied & installed to complete the technical requirement.

**4.38. Gas Insulated Bus (GIB) layout :**

GIB shall be designed based on the following criteria

- (1) Maximum weight of gas in a gas tight section of GIB shall not exceed 250 Kg for 220 kV & 132 kV.
- (2) GIS bus ducts of each circuit shall be arranged in preferably horizontal formation and the clearance (outer to outer) between nearest bus ducts of two adjacent circuits shall be minimum one (1) meter.
- (3) GIB shall be generally in only one horizontal layer. However in exceptional circumstance two horizontal GIB layers can be provided with the approval of Owner/consultant and the vertical clearance between layers shall be minimum one (1) meter in such case.
- (4) The minimum outer to outer horizontal clearance between each GIS bus duct shall 0.5 meter for 220 kV & 132 kV voltage level.
- (5) The minimum vertical ground clearance of GIB at road crossing shall be 5.5 meters
- (6) The horizontal clearance between GIB and GIS building /any other building wall shall be minimum three (3) meters.
- (7) The GIB route inside the GIS Hall shall not obstruct easy access to GIS and control room buildings and shall not obstruct movement of crane, equipment including HV test equipment for maintenance works.
- (8) The GIB height outside the GIS hall in switchyard area shall not obstruct easy access to GIB, movement of crane for maintenance work.
- (9) Optimisation of outdoor GIB length using overhead AIS connection with Bus Post Insulator of respective voltage class is generally acceptable subject to meeting the electrical clearances as stipulated.
- (10) For the maintenance of GIB of one circuit, only that circuit shall be isolated

4.39. A portable ladder with adjustable height shall be supplied to access the GIS equipment for O&M purpose.

**4.40. Extension of GIS**

- 4.40.1. The arrangement of gas sections or compartments shall be such as to facilitate future extension of any make without any drilling, cutting or welding on the existing equipment. To add equipment, it shall not be necessary to move or dislocate the existing switchgear bays.
- 4.40.2. As the GIS is likely to be extended in future, the contractor shall make available during detailed engineering stage, the complete design detail of interface module such as cross section, enclosure material, enclosure dimensions (inner & outer), Flange diameter (inner & outer), conductor connection arrangement, bolt spacing & dimension, rated gas pressure etc. Further GIS manufacturer supplying GIS under present scope shall furnish all the required details in addition to mentioned above necessary for design and successful implementation of an interface module during later stage while extending GIS by any other GIS manufacturer, without any help of GIS manufacturer who has supplied the GIS equipment in present scope.
- 4.40.3. The Interface module shall be designed to provide Isolating link with access hole on enclosure. The Isolating link shall be provided in such a way so that HV test can be performed on either side of the interface module separately, keeping other side of GIS remain isolated.
- 4.40.4. Further the contractor who is extending the existing GIS installation shall optimally utilize the space inside the GIS hall (including the extension portion) for accommodating the interface module being supplied under the contract and the space (along the length of the hall) inside the GIS hall for interface module shall preferably be limited to 1 meter for 220/132kV

#### 4.41. **SF6 GAS**

The SF6 gas insulated metal-clad switchgear shall be designed for use with SF6 gas complying with the **recommendations** of IEC 376, 376A & 376B, at the time of the first charging with gas. All SF6 gas supplied as part of the contract shall comply with the requirements of IEC as above as a minimum & should be suitable in all respects for use in the switchgear under all operating conditions.

The high pressure cylinders in which SF6 gas is supplied & stored at site shall comply with the requirements of following standards & regulations :

**IS : 4379** Identification of the contents of industrial gas cylinders.

**IS : 7311** Seamless high carbon steel cylinders for permanent & high pressure liquefiable gases. The cylinders shall also meet Indian Boilers Regulations. (Mandatory)

SF6 gas shall be tested for purity, dew point, air, hydrolysable fluorides and water contents as per IEC:376, 376A & 376B and test certificates shall be furnished to the owner indicating all test results as per IEC standards for each lot of SF6 gas. Further site tests for moisture, air content, flash point and dielectric strength to be done during commissioning of GIS. Gas bottles should be tested for leakage during receipt at site.

The contractor shall indicate diagnostic test methods for checking the quality of gas in the various sections during service. The method proposed shall, as a minimum check the moisture content & the percentage of purity of the gas on annual basis.

The contractor shall also indicate clearly the precise procedure to be adopted by maintenance personnel for handling equipment that are exposed to the products of arcing in SF6 Gas so as to ensure that they are not affected by possible irritants of the skin and respiratory system. Recommendations shall be submitted for suitable protective clothing, method of disposal of cleaning utensils and other relevant matters.

The contractor shall also indicate the details and type of filters used in various gas sections, and should also submit the operating experience with such filters.

- 4.41.1. **SF6 gas monitoring devices and alarm circuits:** Dial type temperature compensated gas density monitoring devices with associated pressure gauge will be provided. The devices shall provide continuous & automatic monitoring of gas density & a separate device shall be provided for each gas compartment so that each compartment can be monitored simultaneously as follows:-

Compartment/ Sl No.	Compartments except CB	Circuit Breaker compartments
1	<b>“Gas Refill level:</b> This will be used to annunciate the need for the gas refilling. The contractor shall provide a contact for remote indication.	<b>'Gas Refill' level :</b> This will be used to annunciate the need for gas refilling. The contractor shall provide a contact for remote indication.
2	<b>“SF6 low level” :</b> This will be used to annunciate the need for urgent gas filling . A contact shall be provided for remote indication	<b>“SF6 low level” :</b> This will be used to annunciate the need for urgent gas filling . A contact shall be provided for remote indication
3	<b>'Zone Trip' level:</b> This is the minimum level at which the manufacturer will guarantee the insulation rating of the assembly.	<b>Breaker Block' level :</b> This is the minimum gas density at which the manufacturer will guarantee the rated fault interrupting capability of the breaker .At this level the breaker block contact shall operate and the closing & tripping circuit shall be blocked
4	<b>Not Applicable</b>	<b>'Zone Trip' level:</b> This is the minimum level at which the manufacturer will guarantee the

		insulation rating of the assembly.
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The density monitor/pressure switch contacts shall be in accordance with the above requirement.

- 4.41.2. The contractor should furnish temperature v/s pressure curves for each setting of density monitor along with details of the monitoring device.

It shall be possible to test all gas monitoring relays/devices without de-energizing the primary equipment & without reducing pressure in the main section. Plugs & sockets shall be used for test purposes. It shall also damp the pressure pulsation while filling the gas in service, so that flickering of the pressure switch contacts does not take place.

- 4.41.3. **Gas Supply:** The contractor shall include the supply of all SF6 gas necessary for filling & putting into operation the complete switchgear installation being supplied. The empty gas cylinders shall be returnable to the contractor.

## 5. CIRCUIT BREAKERS

- 5.1. **General :** SF6 gas insulated metal enclosed circuit breakers shall comply with the latest revisions of IEC- 62271-100 & relevant IEC except to the extent explicitly modified in the specification and shall meet with requirements specified

Circuit breakers shall be equipped with the operating mechanism. Circuit breakers shall be of single pressure type. Complete circuit breaker with all necessary items for successful operation shall be supplied. The circuit breakers shall be designed for high speed single and three phase reclosing with an operating sequence and timing as specified.

- 5.2. **Duty Requirements:** Circuit breaker shall be C2 - M2 class as per IEC 62271-100.

Circuit breaker shall meet the duty requirements for any type of fault or fault location also for line charging and dropping when used on effectively grounded system and perform make and break operations as per the stipulated duty cycles satisfactorily.

- 5.3. The circuit breaker shall be capable of:

1. Interrupting the steady and transient magnetizing current shall be as follows:

Voltage Level	Type of Transformer	Rating in MVA
220kV	220/132 kV	50 to 200
132kV	132/11kV	10 to 50

2. Interrupting line/cable charging current as per IEC without re-strikes and without use of opening resistors. The breaker shall be able to interrupt the rated line charging



current as per IEC-62271-100 with test voltage immediately before opening equal to the product of  $U/\sqrt{3}$  and 1.4

3. Clearing short line fault (Kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.
4. Breaking 25% the rated fault current at twice the rated voltage under phase opposition condition.
5. The breaker shall satisfactorily withstand the high stresses imposed on them during fault clearing, load rejection and re-energisation of shunt reactor and/or series capacitor compensated lines with trapped charges.
6. Withstanding all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. shall be designed for 2 p.u. across the breaker continuously, for validation of which a power frequency withstand test conducted for a duration of at least 15 minutes is acceptable).

5.4. **Total Break Time :** The total break time shall not be exceeded under any of the following duties :

- a) Test duties T10, T30, T60, T100 (with TRV as per IEC- 62271-100 )
- b) Short line fault L90, L75 (with TRV as per IEC-62271-100 )

The Contractor may please note that total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage (70-110%), pneumatic/hydraulic pressure and SF6 gas pressure etc. While furnishing the proof for the total break time of complete circuit breaker, the contractor may specifically bring out the effect of non-simultaneity between poles and show how it is covered in the total break time.

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

5.5. **Constructional features :** The features and constructional details of breakers shall be in accordance with requirements stated hereunder:

- 5.5.1. **Contacts:** All making and breaking contacts shall be sealed and free from atmospheric effects. Contacts shall be designed to have adequate thermal and current carrying capacity for the duty specified and to have a life expectancy so that frequent replacement due to excessive burning will not be necessary. Provision shall be made for rapid dissipation of heat generated by the arc on opening.
- 5.5.2. Any device provided for voltage grading to damp oscillations or, to prevent re-strike prior to the complete interruption of the circuit or to limit over voltage on closing, shall have a life expectancy comparable of that of the breaker as a whole.
- 5.5.3. Breakers shall be so designed that when operated within their specified rating, the temperature of each part will be limited to values consistent with a long life for the

material used. The temperature rise shall not exceed that indicated in IEC-62271-100 under specified ambient conditions.

- 5.5.4. The gap between the open contacts shall be such that it can withstand atleast the rated phase to ground voltage for eight hours at zero pressure above atmospheric level of SF6 gas due to its leakage. The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lockout pressure continuously (i.e. 2 pu. power frequency voltage across the breaker continuously)
- 5.5.5. In the interrupter assembly there shall be an adsorbing product box to minimize the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be such as to be fully compatible with SF6 gas decomposition products.
- 5.5.6. Provisions shall be made for attaching an operational analyzer to record travel, speed and making measurement of operating timings etc. after installation at site. The contractor shall supply three set of transducer for each substation covered under the scope.
- 5.5.7. Circuit Breaker shall be supplied with auxiliary switch having additional 8 NO( normally open) and 8 NC ( normally closed) contacts for future use over and above those required for switchgear interlocking and other control and protection function. These spare NO and NC contacts shall be wired upto the local control cubicle.

## **5.6. Operating mechanism**

### **5.6.1. General Requirements :**

- a) Circuit breaker shall be operated by spring charged mechanism or electro hydraulic mechanism or a combination of these. The mechanism shall be housed in a dust proof cabinet and shall have IP: 42 degree of protection.
- b) The operating mechanism shall be strong, rigid, not subject to rebound or to critical adjustments at site and shall be readily accessible for maintenance.
- c) The operating mechanism shall be suitable for high speed reclosing and other duties specified. During reclosing the breaker contacts shall close fully and then open. The mechanism shall be anti-pumping and trip free (as per IEC definition) under every method of closing.
- d) The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause trip or closing operation of the power operating devices.
- e) A mechanical indicator shall be provided to show open and close position of the breaker. It shall be located in a position where it will be visible to a man standing on the ground level with the mechanism housing closed. An operation counter shall also be provided.
- f) Working parts of the mechanism shall be of corrosion resisting material, bearings which require grease shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or changing adjustment with repeated operation of the breaker.

- g) The contractor shall furnish detailed operation and maintenance manual of the mechanism along with the operation manual for the circuit breaker.

#### **5.6.2. Control**

- a) The close and trip circuits shall be designed to permit use of momentary-contact switches and push buttons.
- b) Each breaker pole shall be provided with two (2) independent tripping circuits and trip coils which may be connected to a different set of protective relays.
- c) The breaker shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. However, provisions shall be made for local electrical control. For this purpose a local/remote selector switch and close and trip control switch/push buttons shall be provided in the breaker control cabinet.
- d) The trip coil shall be suitable for trip circuit supervision during both open and close position of breaker.
- e) Closing coil and associated circuits shall operate correctly at all values of voltage between 85% and 110% of the rated voltage. Shunt trip and associated circuits shall operate correctly under all operating conditions of the circuit breaker upto the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage.
- f) Densimeter contacts and pressure switch contacts shall be suitable for direct use as permissive in closing and tripping circuits. Separate contacts have to be used for each of tripping and closing circuits. If contacts are not suitably rated and multiplying relays are used then fail safe logic/schemes are to be employed. DC supplies shall be monitored for remote annunciations and operation lockout in case of dc failures.
- g) The auxiliary switch of the breaker shall be positively driven by the breaker operating rod.

#### **5.6.3. Spring operated Mechanism**

- a) Spring operated mechanism shall be complete with motor in accordance with Section GTR. Opening spring and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit shall also be provided.
- b) As long as power is available to the motor, a continuous sequence of the closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty.
- c) After failure of power supply to the motor one close open operation shall be possible with the energy contained in the operating mechanism.
- d) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring

shall also be provided. The motor rating shall be such that it required preferably not more than 90 seconds for full charging of the closing spring.

- e) Closing action of circuit breaker shall compress the opening spring ready for tripping.
- f) When closing springs are discharged after closing a breaker, closing springs shall automatically be charged for the next operation and an indication of this shall be provided in the local control cabinet & SAS .
- g) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition.
- h) Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is in the closed position.
- i) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

#### **5.6.4. Hydraulically Operated Mechanism :**

- a) Hydraulically operated mechanism shall comprise of operating unit with power cylinder, control valves, high and low pressure reservoir, motor etc.
- b) The hydraulic oil used shall be fully compatible for the temperature range to be encountered during operation.
- c) The oil pressure switch controlling the oil pump and pressure in the high pressure reservoir shall have adequate no. of spare contacts, for continuous monitoring of low pressure, high pressure etc. at switchyard control room.
- d) The mechanism shall be suitable for at-least two close open operations after failure of AC supply to the motor starting at pressure equal to the lowest pressure of auto reclose duty plus pressure drop for one close open operation.
- e) The mechanism shall be capable of operating the circuit breaker correctly and performing the duty cycle specified under all conditions with the pressure of hydraulic operated fluid in the operating mechanism at the lowest permissible pressure before make up.
- f) Trip lockout shall be provided to prevent operations of the circuit breaker below the minimum specified hydraulic pressure. Alarm contacts for loss of Nitrogen shall also be provided.
- g) All hydraulic joints shall have no oil leakage under the site conditions and joints shall be tested at factory against oil leakage.

5.7. The technical parameters of Circuit breakers are as per Annexure -1

#### **5.8. Additional data to be furnished during detailed engineering :**

- a) Drawing showing contacts in close, arc initiation, full arcing, arc extinction and open position.

- b) Data on capabilities of circuit breakers in terms of time and number of operations at duties ranging from 100 fault currents to load currents of the lowest possible value without requiring any maintenance or checks.
- c) Curves supported by test data indicating the opening time under close open operation with combined variation of trip coil voltage and hydraulic pressure.

## **5.9. Tests :**

### **5.9.1. Type Tests:**

- i. In accordance with the requirements stipulated under Section GTR the circuit breaker along with its operating mechanism shall conform to the type tests as per IEC-62271-100.
- ii. The type test report of Electromagnetic Compatibility Test (EMC) of CSD shall be submitted for approval

### **5.9.2. Routine Tests:**

Routine tests as per IEC: 62271-100 shall be performed on all circuit breakers.

In addition to the mechanical and electrical tests specified by IEC, the following shall also be performed.

- i. Speed curves for each breaker shall be obtained with the help of a suitable operation analyzer to determine the breaker contact movement during opening, closing, auto-reclosing and trip free operation under normal as well as limiting operating conditions (control voltage, pneumatic pressure etc.). The tests shall show the speed of contacts directly at various stages of operation, travel of contacts, opening time, closing time, shortest time between separation and meeting of contacts at break make operation etc. This test shall also be performed at site for which the necessary operation analyzer along with necessary transducers, cables, console etc. shall be provided.
- ii. Functional tests are to be carried out on circuit breaker along with Control Switching device (CSD).
- iii. DCRM (Dynamic Contact Resistance Measurement) to be carried out for all CBs during routine test.

## **6. DISCONNECTORS (ISOLATORS)**

- 6.1. Disconnectors shall be three-pole group operated or Single-pole individual operated (as per single line diagram of the substation/section project) and shall be installed in the switchgear to provide electrical isolation. The disconnectors shall conform to IEC-62271-102 and shall have the ratings as specified in BPS.

### **6.2. Construction & Design.**

- 6.2.1. The disconnectors shall be operated by electric motor suitable for use on DC system and shall be equipped with a manual operating mechanism for emergency use. The motor shall be protected against over current and short circuit.

- 6.2.2. Disconnectors shall be suitable to switch the bus charging currents during their opening and closing and shall confirm to all three test duties viz TD1,TD2 and TD3 as per Annexure –F of IEC: 62271- 102.They shall also be able to make and break rated bus transfer current at rated bus transfer voltage which appears during transfer between bus bars in accordance with Annexure –B of IEC: 62271-102. The contact shielding shall also be designed to prevent restrikes and high local stresses caused by transient recovery voltages when these currents are interrupted.
- 6.2.3. The disconnecting switches shall be arranged in such a way that all the three phases operate simultaneously. All the parts of the operating mechanism shall be able to withstand starting torque of the motor mechanism without damage until the motor overload protection operates.
- 6.2.4. It shall be possible to operate the disconnecting switches manually by cranks or hand wheels. The contacts shall be both mechanically and electrically disconnected during the manual operation.
- 6.2.5. The operating mechanisms shall be complete with all necessary linkages, clamps, couplings, operating rods, support brackets and grounding devices. All the bearings shall be permanently lubricated or shall be of such a type that no lubrication or maintenance is required.
- 6.2.6. The opening and closing of the disconnectors shall be achieved by either local or remote control. The local operation shall be by means of a two-position control switch located in the Local Control Cabinet (LCC) .
- 6.2.7. Remote control of the disconnectors from the control room/SAS shall be made by means of remote/ local transfer switch.
- 6.2.8. The disconnector operations shall be inter-locked electrically with the associated circuit breakers in such a way that the disconnector control is inoperative if the circuit breaker is closed.
- 6.2.9. Each disconnector shall be supplied with auxiliary switch having additional 4 NO (Normally Open) and 4 NC (Normally Closed) contacts for future use over and above those required for switchgear interlocking and automation purposes. These spare NO and NC contacts shall be wired up to the local control cabinet.
- 6.2.10. The signaling of the closed position of the disconnector shall not take place unless it is certain that the movable contacts will reach a position in which the rated normal current, peak withstand current and short-time withstand current can be carried safely.
- 6.2.11. The signaling of the open position of the disconnector shall not take place unless the movable contacts have reached such a position that the clearance between the contacts is at least 80 percent of the rated isolating distance.
- 6.2.12. The disconnectors and safety grounding switches shall have a mechanical and electrical inter-locks to prevent closing of the grounding switches when isolator switches are in the closed position and to prevent closing of the disconnectors when the grounding switch is

in the closed position. Integrally mounted lock when provided shall be equipped with a unique key for such three phase group. Master key is not permitted.

6.2.13. The local control of the Isolator and high-speed grounding switches from the Local Control Cabinet (LCC) should be achieved from the individual control switches with the remote/local transfer switch set to local.

6.2.14. All electrical sequence interlocks will apply in both remote and local control modes.

6.2.15. Each disconnecter shall have a clearly identifiable local, positively driven mechanical position indicator, together with position indicator on the local control cubicle (LCC) and provisions for taking the signals to the control room. The details of the inscriptions and colouring for the indicator are given as under :

	INSCRIPTION	COLOUR
Open position	OPEN	GREEN
Closed position	CLOSED	RED

6.2.16. All the disconnecting switches shall have arrangement allowing easy visual inspection of the travel of the switch contacts in both open and close positions, from the outside of the enclosure.

6.2.17. The disconnecting switches shall be provided with rating plates and shall be easily accessible.

6.2.18. The mechanical endurance class shall be M2 as per IEC for 765kV, 400kV and 220kV and it shall be M1 class for 132kV disconnectors

6.2.19. Mechanical position indication shall be provided locally at each disconnector and Electrical indication at each Local Control Cabinet (LCC) / SAS.

6.3. The technical parameters of disconnectors are as per **Annexure-2**

## **7. SAFETY GROUNDING SWITCHES**

7.1. Safety grounding switches shall be three-pole group operated or single-pole individual operated (as per single line diagram of the substation/section project). It shall be operated by DC electric motor and shall be equipped with a manual operating mechanism for emergency use. The motor shall be protected against over-current and short circuit.

7.2. Each safety grounding switch shall be electrically interlocked with its associated disconnectors and circuit breaker such that it can only be closed if both the circuit breaker and disconnectors are in open position. Safety grounding switch shall also be mechanically key interlocked with its associated disconnectors.

7.3. Each safety grounding switch shall have clearly identifiable local positive driven mechanical indicator together with position indicator on the Local Control Cabinet (LCC) and provision for taking the signal to Control room.

7.4. The details of the inscription and colouring for the indicator are given as under :

	INSCRIPTION	COLOUR
Open position	OPEN	GREEN
Closed position	CLOSED	RED

- 7.5. Interlocks shall be provided so that manual operation of the switches or insertion of the manual operating device will disable the electrical control circuits.
- 7.6. Each ground switch shall be fitted with auxiliary switches having 4 NO (Normally Open) and 4 NC (Normally Closed) contacts for use by others over and above those required for local interlocking and position indication purposes.
- 7.7. Provision shall be made for padlocking / suitable locking arrangement for the ground switches in either the open or closed position.
- 7.8. All portions of the grounding switch and operating mechanism required for grounding shall be connected together utilizing flexible copper conductors having a minimum cross-sectional area of 100 sq. mm.
- 7.9. The main grounding connections on each grounding switch shall be rated to carry the full short circuit current for 1 sec. and shall be equipped with a silver- plated terminal connector suitable for steel strap of adequate rating for connection to the grounding grid.
- 7.10. The safety grounding switches shall conform to the requirements of IEC- 62271- 102 and shall have electrical endurance class: E0 & shall have mechanical endurance class M1 for 220/132 kV voltage level.
- 7.11. Combined Disconnectors & Safety grounding switch arrangement shall also be acceptable.
- 7.12. Mechanical position indication shall be provided locally at each switch and Electrical indication at each Local Control Cabinet (LCC) / SAS.
- 7.13. Continuous current rating of the grounding switches (not less than 100A) shall be specified by the manufacturer, which can be safely injected for Bay/ Bus equipment testing.
- 8. HIGH SPEED MAKE PROOF GROUNDING SWITCHES:**
  - 8.1. Grounding switches located at the beginning of the line feeder bay modules shall be of the high speed, make proof type and will be used to discharge the respective charging currents, trapped charge in addition to their safety grounding function. These grounding switches shall be capable of interrupting the inductive and capacitive currents and to withstand the associated TRV. These shall conform to class B and electrical endurance class E1 as per annexure – C of IEC : 62271-102
  - 8.2. High Speed Grounding switches shall be provided with individual/three pole operating mechanism suitable for operation from DC.



- 8.3. The switches shall be fitted with a stored energy closing system to provide fault making capacity.
- 8.4. The short circuit making current rating of each ground switch shall be at least equal to its peak withstand current rating as stated in clause 1.4 above. The switches shall have inductive/ capacitive current switching capacity as per IEC-62271-102.
- 8.5. Each high speed make proof grounding switch shall have clearly identifiable local positive driven mechanical indicator together with position indicator on the Local Control Cabinet (LCC) and provision for taking the signal to Control Room/SAS.
- 8.6. The details of the inscription and colouring for the indicator shall be as under:-

	INSCRIPTION	COLOUR
Open position	OPEN	GREEN
Closed position	CLOSED	RED

- 8.7. High speed ground switch operation should be possible locally from Local Control Cabinet (LCC)
- 8.8. These high speed grounding switches shall be electrically interlocked with their associated circuit breakers and disconnectors so that the grounding switches cannot be closed if disconnectors are closed. Interlocks shall be provided so that the insertion of the manual operating devices will disable the electrical control circuits.
- 8.9. Each high speed ground switch shall be fitted with auxiliary switches having 4 NO (Normally Open) and 4 NC (Normally Closed) contacts for use by others, over and above these required for local interlocking and position indication. All contacts shall be wired to terminal blocks in the Local Control Cabinet. Provision shall be made for padlocking the ground switches in their open or closed position.
- 8.10. All portion of the grounding switches and operating mechanism required for connection to ground shall be connected together utilizing copper conductor having minimum cross-sectional area of 100 sq. mm.
- 8.11. The main grounding connection on each grounding switch shall be rated to carry the peak withstand current rating of the switch for 1 sec. and shall be equipped with a silver plated terminal connector suitable for steel strap of adequate design for connection to the grounding grid.
- 8.12. The high speed make proof grounding switches shall confirm to the requirements of IEC-62271-102.
- 8.13. Continuous current rating of the High speed grounding switches (not less than 100A) shall be specified by the manufacturer, which can be safely injected for Bay/ Bus equipment testing.

## 9. INSTRUMENT TRANSFORMERS

### 9.1. **Current Transformers**

The current transformers and accessories shall conform to IEC: 60044-1 and other relevant standards except to the extent explicitly modified in the specification.

- 9.1.1. **Ratios and Characteristics:** The CT core distribution for various voltage levels shall be as per Table 3. Further the numbers of cores, rating, ratios, accuracy class, etc. for the individual current transformers secondary cores shall be in accordance with above table.

Where multi-ratio current transformers are required the various ratios shall be obtained by changing the effective number of turns on the secondary winding.

- 9.1.2. **Rating and Diagram Plates:** Rating and diagram plates shall be as specified in the IEC specification incorporating the year of manufacture. The rated extended current rating voltage and rated thermal current shall also be marked on the name plate.

The diagram plates shall show the terminal markings and the relative physical arrangement of the current transformer cores with respect to the primary terminals (P1 & P2).

The position of each primary terminal in the current transformer SF6 gas section shall be clearly marked by two plates fixed to the enclosure at each end of the current transformer.

#### 9.1.3. **Constructional Details:**

- a) The current transformers incorporated into the GIS will be used for protective relaying and metering purposes and shall be of metal- enclosed type.
- b) Each current transformer shall be equipped with a secondary terminal box with terminals for the secondary circuits, which are connected to the Local Control Cubicle. The star/ delta configuration and the inter connection to the line protection panels will be done at the CT terminal block located in the local control cubicle.
- c) Current transformers guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.
- d) For 245/145 kV class CTs, the rated extended primary current shall be 120% (or 150% if applicable) on all cores of the CTs as specified in the Section – Project.
- e) For 245/145 kV current transformer, characteristics shall be such as to provide satisfactory performance of burdens ranging from 25% to 100% of rated burden over a range of 5% to 120%(or specified rated extended current whichever is higher) of rated current in case of metering CTs and up to the accuracy limit factor/knee point voltage in case of relaying CTs.
- f) The instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably built in construction of the CTs.

- g) The wiring diagram, for the interconnections of the three single phase CTs shall be provided inside the Secondary terminal box.
- h) The current transformers shall be suitable for high speed auto-reclosing.
- i) Provisions shall be made for primary injection testing either within CT or outside.
- j) All the current transformers shall have effective electromagnetic shields to protect against high frequency transients. Electromagnetic shields to be provided against high frequency transients typically 1-30 MHz.

## 9.2. **VOLTAGE TRANSFORMERS**

The voltage transformers shall conform to IEC- 60044-2 and other relevant standards except to the extent explicitly modified in the specification.

Voltage transformers shall be of the electromagnetic type with SF6 gas insulation. The earth end of the high voltage winding and the ends of the secondary winding shall be brought out in the terminal box.

- 9.2.1. **Ratios and Characteristics:** The rating, ratio, accuracy class, connection etc. for the voltage transformers shall be in accordance with annexure -4 & Table 4
- 9.2.2. **Rating and diagram plates :** Rating and diagram plate shall be provided complying with the requirements of the IEC specification incorporating the year of manufacture and including turns ratio, voltage ratio, burden, connection diagram etc.

### 9.2.3. **Secondary Terminals, Earthing**

The beginning and end of each secondary winding shall be wired to suitable terminals accommodated in a terminal box mounted directly on the voltage transformer section of the SF6 switchgear.

All terminals shall be stamped or otherwise marked to correspond with the marking on the diagram plate. Provision shall be made for earthing of the secondary windings inside the terminal box.

- 9.2.4. The transformer shall be able to sustain full line to line voltage without saturation of transformer.

### 9.2.5. **Constructional Details of Voltage Transformers :**

- a) The voltage transformers shall be located as a separate bay module and will be connected phase to ground and shall be used for protection, metering and synchronization.
- b) The voltage transformers shall be of inductive type, nonresistant and shall be contained in their own-SF6 compartment, separated from other parts of installation. The voltage transformers shall be effectively shielded against high frequency electromagnetic transients. The supplier shall ensure that there is no risk of Ferro resonance due to the capacitance of the GIS.
- c) The voltage transformers shall have three secondary windings.

- d) Voltage transformers secondary shall be protected by Miniature Circuit breakers (MCBs) with monitoring contacts for all the windings. The secondary terminals of the VT's shall be terminated to preferably stud type non-disconnecting terminal blocks in the secondary boxes via the fuse.
- e) The voltage transformer should be thermally and dielectrically safe when the secondary terminals are loaded with the guaranteed thermal burdens.
- f) The accuracy of 0.2 on secondary III should be maintained throughout the entire burden range up to 50 VA on all the three windings without any adjustments during operation.
- g) The diagram for the interconnection of the VTs shall be provided inside secondary terminal box.

### 9.3. **Tests:**

Current and voltage transformers shall conform to type tests and shall be subjected to routine test in accordance with IEC.

## 10. **SURGE ARRESTORS**

10.1. The surge arrestors shall conform in general to latest IEC –60099-4.

10.2. **Insulation co-ordination and selection of surge arrestor:** The contractor shall be fully responsible for complete insulation co-ordination of switchyard including GIS. Contractor shall carry out detailed studies and design calculations to evolve the required parameters locations, energy capability etc. of surge arrestors such that adequate protective margin is available between peak impulse, surge and power frequency discharge voltages and BIL of the protected requirement. The locations of surge arrestors shown in single line diagram is indicative only. If the contractor feels that at some more locations the surge arrestors are required to be provided the same should also be deemed included in the offer.

The contractor shall perform all necessary studies and the report shall detail the limits of all equipment parameters which could affect the insulation co-ordination. The report shall also detail the characteristics of the surge arrestor and shall demonstrate that the selected arrestor's protective and withstand levels, discharge and coordinating currents and arrestor ratings and comply with the requirement of this specification.

The contractor shall also consider in the studies the open circuit breaker condition, fast transients generated by slow operation of disconnecting switches. The study report and design calculations shall be submitted for Owner's approval.

### 10.3. **Duty requirements of GIS Surge Arrestor**

10.3.1. The surge arrestor shall be of heavy duty station class and gapless (Metal oxide) type without any series or shunt gaps.

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

10.3.3. 245 & 145kV class arrester shall be capable of discharging energy equivalent to class 3 of IEC for 245 kV & 145 kV system respectively on two successive operations.\

10.3.4. The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

10.3.5. The surge arresters are being provided to protect the followings whose insulation levels are indicated in the table given below:-

Equipment to be protected	220KV system	132KV system
	Lightning impulse (kVp)	Lightning impulse (kVp)
Power Transformer	$\pm 950$	$\pm 550$
Instrument Transformer	$\pm 1050$	$\pm 650$
Reactor	-	-
CB/Isolator Phase to ground	$\pm 1050$	$\pm 650$
CB/Isolator Across open contacts	$\pm 1200$	$\pm 750$

#### 10.3.6. Constructional Features

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

The arrester enclosure shall be vertically or horizontally mounted to suit the layout of the switchgear as suggested by the supplier and each arrester shall be fitted with a Online continuous resistive leakage current monitoring system. The system shall be provided with an interface to integrate with the substation automation system.

The main grounding connection from the surge arrester to the earth shall be provided by the contractor. The size of the connecting conductor shall be such that all the energy is dissipated to the ground without getting overheated.

#### 10.4. Tests

10.4.1. In accordance with the requirements stipulated, the surge arrestors shall conform to type tests and shall be subjected to routine and acceptance tests in accordance with IEC document.

- 10.4.2. Each metal oxide block shall be tested for the guaranteed specific energy capability in addition to the routine/acceptance test as per IEC-60099.
- 10.4.3. Test on Surge Monitors: The Surge monitors shall also be connected in series with the test specimens during residual voltage and current impulse withstand tests to verify efficacy of the same. Additional routine/functional tests with one 100A and 10 kA current impulse, (8/20 micro sec.) shall also be performed on the surge monitor.
- 10.5. **Technical Parameters** : Technical parameters are as per annexure 5;

## **11. OUTDOOR BUSHINGS :**

Outdoor bushings, for the connection of conventional external conductors to the SF6 metal enclosed switchgear, shall be provided where specified and shall conform to the requirements given in GTR.

The dimensional and clearance requirements for the metal enclosure will be the responsibility of the manufacturer and their dimensions must be coordinated with the switchgear.

Bushings shall generally be in accordance with the requirements of IEC -60137.

- 11.1. **Insulation levels and Creepage distances:** All bushings shall have an impulse and power frequency withstand level that is greater than or equal to the levels specified for GIS.

The creepage distance over the external surface of outdoor bushings shall not be less than 25 mm/kV and in highly polluted area it shall not be less than 31mm/kV (as per section-Project).

- 11.2. **Bushing types and fitting:** The details of bushing shall be as follows

SF6 to air Bushing shall be of Polymer / composite type and shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout. The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137. All details of the bushing shall be submitted for approval and design review.

Polymer / composite insulator shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution and humidity. The hollow silicone composite insulators shall comply with the requirements of the IEC publications IEC 61462 and the relevant parts of IEC 62217. The design of the composite insulators shall be tested and verified according to IEC 61462 (Type & Routine test)

- 11.3. **Mechanical forces on bushing terminals:** Outdoor bushings must be capable of withstanding cantilever forces due to weight of bus duct (GIB) on one side & AIS conductor/Al tube on the other side and short circuit forces. Design calculations in support of the cantilever strength chosen shall be submitted for owners review and approval.

11.4. Type test reports as per applicable IEC including radio interference voltage (RIV) test shall be submitted in line with the requirement as specified in section GTR for approval.

11.5. The technical parameters of Bushing are as per Annexure -6

## **12. SF6 GIS TO XLPE CABLE TERMINATION (If Applicable)**

12.1. The underground cables shall be connected to GIS by the interfacing of XLPE cable sealing end to GIS Cable termination enclosure.

12.2. The SF6 GIS to XLPE cable termination shall conform to IEC-62271-209.

12.3. The rating of XLPE cables for different voltages are specified in the Section project.

12.4. Cable termination kit shall be in the scope of the contract. The ducts and the casing shall be suitable for the requirements for which it is designed. This interface section shall be designed in a manner which will allow ease of operation and maintenance.

12.5. The provision shall be made for a removable link. The gap created when the link is removed should have sufficient electric strength to withstand the switchgear high voltage site tests. The contractor may suggest alternative arrangements to meet these requirements. The corona rings/stress shields for the control of electrical field in the vicinity of the isolation gap shall be provided by the GIS manufacturer.

12.6. All supporting structures for the SF6 bus-duct connections between the XLPE cable sealing ends and the GIS shall be the scope of the contract. The supplier may specify alternative connecting & supporting arrangements for approval of the purchaser.

12.7. The opening for access shall be provided in each phase terminal enclosures as necessary to permit removal of connectors to isolate the XLPE cables to allow carrying out the insulation tests. The general arrangement drawing of interconnecting bus-duct from GIS bay module to XLPE cable termination end shall also be submitted.

12.8. Type test reports of radio interference voltage (RIV) level shall be submitted for approval

## **13. TRANSFORMER TERMINATION MODULE (If applicable)**

13.1.1. The transformer termination module enables a direct transition from the SF6 gas insulation to the bushing of an oil-insulated transformer / reactor. For this purpose, the transformer/reactor bushing must be oil-tight, gas-tight and pressure resistant. Any temperature related movement and irregular setting of the switchgear's or transformer's/reactor's foundations are absorbed by the expansion fitting.

13.1.2. The oil filled transformers and reactors are as shown in the substation SLD. The oil to air bushings of the transformers and reactors shall be supplied by the respective supplier's and the same shall be connected to the SF6 ducts thru air to SF6 bushings to be provided under present scope.

13.1.3. Terminal connection arrangement to connect GIS duct to bushing and duct mounting arrangement details shall be submitted during detailed engineering for Employer's/consultant approval and for co-ordination with transformer and reactor

supplier. Any modification suggested by autotransformer and reactor supplier shall have to be carried out by the supplier to facilitate proper connection with the bushings of the autotransformer and reactors.

- 13.1.4. In case of single phase transformers are being installed in the substation, HV & LV auxiliary bus for the transformer bank for connecting spare unit shall be formed inside the GIS.

## **14. LOCAL CONTROL CUBICLE (LCC)**

### **14.1. Functions**

- 14.1.1. Each circuit-breaker bay shall be provided with a local control cubicle containing local control switches and a mimic diagram for the operation and semaphore for status indication of the circuit-breaker and all associated isolators and earth switches together with selector switches to prevent local and remote and supervisory controls being in operation simultaneously
- 14.1.2. Status indications in the LCC shall be semaphore type or LED type.
- 14.1.3. Closing of the circuit- breaker from the local control unit shall only be available when the breaker is isolated for maintenance purposes. Circuit-breaker control position selector, operating control switch and electrical emergency trip push button shall be installed in the Local Control Cubicle. Circuit-breaker control from this position will be used under maintenance and emergency conditions only. The emergency trip push buttons shall be properly shrouded.
- 14.1.4. If Disconnecter or earth switch is not in the fully open or closed position a "Control Circuit Faulty" alarm shall be initiated, and electrical operation shall be blocked.
- 14.1.5. 20% spare terminals shall be provided in each LCC apart from terminals provided for the termination and interconnection of all cabling associated with remote and supervisory control, alarms, indications, protection and main power supply etc .
- 14.1.6. Where plugs and sockets connect control cabling between the local control cubicle and the switchgear these shall not be interchanged.
- 14.1.7. Hydraulic/pneumatic and SF6 auxiliary equipment necessary for the correct functioning of the circuit breaker, isolators and earth switches shall be located in a separate cubicle compartment.
- 14.1.8. LCC shall be suitable for remote operation from substation automation system (SAS) . Each gas tight compartment shall be monitored individually per phase basis through SAS

### **14.2. Constructional features**

- 14.2.1. Local Control cubicle shall be either mounted on the GIS with front access or free standing, floor mounting type. It shall comprise structural frames completely enclosed with specially selected smooth finished, cold rolled sheet steel of thickness not less



than 3 mm for weight bearing members of the panels such as base frame, front sheet and door frames, and 2.0mm for sides, door, top and bottom portions. There shall be sufficient reinforcement to provide level transportation and installation.

- 14.2.2. Access to all compartments shall be provided by doors. All fastenings shall be integral with the panel or door and provision made for locking. Cubicles shall be well ventilated through vermin-proof louvers having anti insect screen. All doors shall be gasketed all around with suitably profiled Neoprene/EPDM gaskets conforming with provision of IS 11149. However, XLPE gaskets can also be used for fixing protective glass doors.
- 14.2.3. Each LCC panel should have its own separate AC supply source feed from the ACDB. The DC supply shall be from respective relay & protection panel power, control, interlocking, signaling. Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with Fuses. All fuses shall be HRC cartridge type mounted on plug-in type fuse bases. The short time fuse rating of Fuses shall be not less than 9 KA. Fuse carrier base shall have imprints of the fuse 'rating' and 'voltage'.
- 14.2.4. Each LCC Panel shall be provided with the following
  - 1. **Plug Point:** 230V, Single phase 50Hz, AC socket with switch suitable to accept 5 Amps and 15 Amps pin round standard Indian plug, shall be provided in the interior of each cubicle with ON-OFF switch.
  - 2. **Interior Lighting:** Each panel shall be provided with a fluorescent lighting fixture rated for 230 Volts, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch. Adequate lighting shall also be provided for the corridor in Duplex panels.
  - 3. **Space Heater:** Each panel shall be provided with a thermostatically connected space heater rated for 230V, single phase, 50 Hz AC supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with switch unit
- 14.2.5. Operating mechanisms, auxiliary switches and associated relays, control switches, control cable terminations, and other ancillary equipment shall be accommodated in sheet steel vermin proof cubicles.
- 14.2.6. Local control cubicles shall be provided to be free standing and shall be equipped with anti-condensation heaters. A suitable humidity stat and thermostat shall be included in the heater circuit.
- 14.2.7. The interior of each cubicle shall be finished with a semi gloss white surface. An interior lamp suitable for the local LVAC supply, controlled by a door-operating switch, shall be fitted at the top of each panel.

- 14.2.8. The arrangement of equipment within cubicles shall be such that access for maintenance or removal of any item shall be possible with the minimum disturbance of associated apparatus. All the control switches shall be internal i.e. installed behind a lockable glass door.
- 14.2.9. An interlocking scheme shall be provided that takes into account the following basic requirements.
- To safeguard maintenance personnel who may be working on one section of the equipment with other sections live.
  - prevent incorrect switching sequences that could lead to a hazardous situation to plant, equipment and personnel.
- 14.2.10. Electrical bolt interlocks shall be energized only when the operating handle of the mechanism is brought to the working position. Visible indication shall be provided to show whether the mechanism is locked or free. Means, normally padlocked, shall be provided whereby the bolt can be operated in the emergency of a failure of interlock supplies.
- 14.2.11. Where key interlocking is employed tripping of the circuit breaker shall not occur if any attempt is made to remove the trapped key from the mechanism. Any local emergency-tripping device shall be kept separate and distinct from the key interlocking.
- 14.2.12. Disconnecting switches shall be so interlocked that they cannot be operated unless the associated circuit-breaker is open except that where double bus bar arrangements are specified, on-load transfer of feeder circuits from one bus bar to another shall be made possible by interlocks which ensure that the associated bus coupler and its isolators are closed.
- 14.2.13. Bus coupler circuit breaker shall be interlocked so that it shall not be possible to open a bus coupler circuit breaker while on load change over on that side of the breaker is in progress.
- 14.2.14. All isolating devices shall be interlocked with associated circuit-breakers and isolators in the same station so that it shall not be possible to make or break current on an isolating device unless a parallel circuit in that station is already closed.

## **15. GIS BUILDING**

- 15.1. The buildings shall house each voltage class Gas Insulated Switchgear (GIS) separately and other associated equipment inside in each of the GIS buildings. GIS building(s) shall be constructed for the specified number of bays/diameters as per section project
- 15.2. Wherever GIS hall of proposed voltage is already existing, then the existing GIS hall of respective class shall be suitably extended (wherever applicable) to accommodate the number of bays/diameters as specified in the Section Project.

- 15.3. The contractor shall submit the design & construction proposal of the building along with necessary information, data, and drawings during the detailed engineering according to the complete requirements.
- 15.4. The area for GIS hall(s) is indicated in the enclosed General Arrangement drawing. The area given is for reference only and may vary according to requirement of the equipment to be installed inside. The contractor shall finalize the dimensions according to the equipment offered by them providing enough space & access for erection, operation and maintenance.
- 15.5. The contractor shall place their panels i.e. Bay level units, bay mimic, relay and protection panels, RTCC panels, PLCC panels etc. in a separate room in the GIS building.. The size of the room shall be such that all the panels for the future bays/ diameters as per clause 15.1 shall be accommodated in the above room. The panel room shall be air-conditioned. Further, the temperature of the room shall be monitored through substation automation system by providing necessary temperature transducers. The Switchyard panel room as detailed in section Sub-station Automation System is not required for GIS station.

## **16. ELECTRIC OVERHEAD CRANE :**

- 16.1. One EOT Crane each for GIS hall of suitable capacity shall be provided for erection & maintenance of largest GIS component/assembly. The crane shall consist of all special requirements for erection & maintenance of GIS equipment.
- 16.2. The capacity of the crane shall be sized to lift the heaviest GIS switchgear component crane.
- 16.3. The Crane shall be used for the erection and maintenance of the GIS switchgear component and all plant installed in the GIS switchgear room .On completion of erection of the switchgear, the Contractor shall completely service the crane before the Taking Over Certificate is issued.
- 16.4. Crane hook approaches shall be of the minimum possible dimensions to ensure maximum coverage of the plant area.
- 16.5. The crane(s) shall be capable of lifting and accurately positioning all loads ranging from full crane rated capacity to at least 10% rated capacity.
- 16.6. The crane shall have minimum speeds under full load of:  
Speed
  - (a) Hoisting 2 meters/minute
  - (b) Cross Travel 10 meters/minute
  - (c) Long Travel 20 meters/minute
  - (d) Creep speed shall be of 25% of operating speed
- 16.7. The electric overhead cranes shall be provided with walkways, platforms. Guard hand rails shall be provided along the bridge rails and on the crab of EOT crane to facilitate

- cleaning/maintenance of the crane and to give access to the GIS room high bay lighting and ventilation duct and grilles.
- 16.8. The platform and walkways shall be designed to support any weight to be imposed upon them during crane overhaul.
  - 16.9. An access platform shall be provided together with a guarded ladder on the crane to allow access to the bridge rails.
  - 16.10. The crane shall be possible to be operated through the cable, through the pendant control and which shall be easily accessible from the floor of GIS building and through remote control device.
  - 16.11. Contractor shall submit the capacity calculation of crane for GIS hall considering a factor of safety of 5.
    - a) The crane for 220kV GIS/132kV GIS shall have capacity of minimum 5T safe working load & minimum height of crane have shall be 8.0 meters or as per actual requirement whichever is higher.
  - 16.12. In case the GIS hall is to be extended, the scope of work also involves extension of EOT crane girders to facilitate movement of EOT crane in the extended portion of GIS hall.
  - 16.13. The following tests may be EOT Crane
    1. The crane shall be tested at manufacturer work under full load and 25 percent overload of hoisting and cross transverse motions as a routine test .
    2. Further the following tests may be done at site after installation of the crane at site
      - a. Check althea accessories for proper function
      - b. No load test
      - c. Load test as per site conditions

## **17. VENTILATION SYSTEM FOR GIS HALL**

- 17.1. Each GIS Hall shall have an independent ventilation system. Each Ventilation system shall consist of two 100% capacity systems, one operating and one stand-by.
- 17.2. To ensure that the air being supplied to the GIS hall is free from dust particles, a minimum two stage dust filtration process shall be supplied. This shall consist of at least the following:
  1. Pre Filters: To remove dust particles down to 10 micron in size with at least 95% efficiency.
  2. Fine Filters: To remove dust particles down to 5 microns in size with at least 99% efficiency.

All the filters shall be panel type. Easy access should be available to the filters for replacement/cleaning.

The ventilation of the GIS hall shall be of a positive pressure type with minimum 4 air changes per hour. The pressure inside the GIS hall shall be maintained 5 mm of water above the atmospheric pressure. Fresh outdoor air shall be filtered before being blown into the GIS hall by the air fans to avoid dust accumulation on components present in the GIS hall. GIS hall shall be provided with motorized exhaust dampers with local control.

## **18. SEISMIC DESIGN CRITERIA:**

- 18.1. The equipment shall be designed for operation in seismic zone for earthquake resistance. The seismic loads are due to the horizontal and vertical acceleration which may be assumed to act on concurrently. Seismic Qualification requirements shall be as per IEC 62271-207 for the design of equipment. The equipment along with its parts shall be strong enough and sufficiently well connected to resist total operating stresses resulting from the forces in normal operation, but in case of abnormal condition shall also resist with forces superimposed due to earthquakes. The copies of type test reports for similar rated equipment, if tested earlier, should be furnished. If the equipment has not been type tested earlier, Test Report/Analysis Report should be furnished.
- 18.2. To prevent the movement of GIS sub-assemblies i.e. various bay modules during the earthquake, suitable devices shall be provided for fixing the sub-assemblies to the foundation. The contractor shall supply necessary bolts for embedding in the concrete foundation. The fixing of GIS sub-assemblies to the foundation shall be designed to withstand the seismic events. It will also be ensured that the special devices as well as bolts shall not be over stressed. The details of the devices used and the calculations for establishing the adequacy shall be furnished by the supplier and shall be subject to the employer's/consultant approval.

## **19. DESIGN REVIEW**

- 19.1. Design reviews shall be conducted by Employer/consultant or an appointed consultant during the detailed Engineering of the GIS; however the entire responsibility of design shall be with the supplier.
- 19.2. Employer/consultant may also visit to the supplier's works to inspect design, manufacturing and test facilities.
- 19.3. The design review will commence after placement of award with the successful contractor and shall be finalised before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the GIS under the scope of this specification. Employer/consultant reserve the right to waive off the design review during detailed engineering.
- 19.4. The design review shall be conducted generally following the, "User Guide for the application of Gas Insulator Switchgear (GIS) rated voltage of 72.5kV and above" – CIGRE report No. 125 prepared by CIGRE Working Group 23.10.
- 19.5. The manufacturer will be required to demonstrate the use of adequate safety margins for thermal, mechanical, dielectric, insulation coordination and vibration etc. design to take into the account the uncertainties of his design and manufacturing processes.

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

1.	Dielectric Stress of Solid Insulation like Gas Barrier, support insulator etc.
2.	Dielectric stress of SF6 Gas Volume.
3.	Mechanical strength of enclosure, expansion joints etc.
4.	Criteria for providing expansion joint.
5.	Sealing system
6.	Insulation coordination
7.	Thermal stress and resulting increase in gas pressure during short circuit condition.
8.	Earthing of enclosure w.r.t circulating current.
9.	Seismic design, as per IEC 62271-207
10.	Circuit Breaker .
11.	Isolator and Earth switch.
12.	Voltage transformer.
13.	Current Transformer.
14.	Surge Arrester.
15.	Bushing.
16.	Ducting.
17.	Corrosion protection .
18.	Electrical and physical Interfaces with substation .
19.	Testing capabilities.
20.	Inspection and test plan.
21.	Transport and storage.
22.	Maintainability.
23.	Site Test.

19.7. Further, the manufacturer shall furnish the following information

- a) Details regarding the loosely distributed metallic particles within the GIS encapsulation and calculations of critical field strength for specific particles of defined mass and geometry.
- b) Study report of VFTO generated for GIS installation.
- c) The methodology and all the equipment for electrical partial discharge (PD) detection, including that mentioned in the specification else-where.
- d) The calculations and documents in support of the average intensity of electromagnetic field on the surface of the enclosure above during detailed engineering.
- e) The detailed criteria/ design regarding location of pressure relief devices/rupture diaphragms

- f) Calculations to show that there is no Ferro resonance due to capacitance of GIS for the voltage transformers
- g) Design calculation for simulated parameters for Seismic level as applicable
- h) Insulation Coordination studies including studies to recommend for additional surge arrestor
- i) Calculation in support of touch & step voltages in all enclosures and earthing of complete GIS installation.
- j) Measures to mitigate transient enclosure voltage by high frequency currents.
- k) Calculation for providing bus duct supports.

## 20. TYPE TESTS

The offered GIS equipment shall conform to the type tests as per IEC-62271-203. Contractor shall submit type test reports for the following type tests & additional type tests.

Sl.	Description of the Type Test for GIS
1	Tests to verify the insulation level of the equipment and dielectric test on auxiliary circuits
2	Tests to prove the temperature rise of any part of the equipment and measurement of the resistance of the main circuit
3	Tests to prove the ability of the main and earthing circuits to carry the rated peak and rated short time withstand current
4	Tests to verify the making and breaking capacity of the included switching devices
5	Tests to prove the satisfactory operation of the included switching devices
6	Tests to prove the strength of the enclosures
7	Gas tightness tests
8	Tests on partitions
9	Tests to prove the satisfactory operation at limit temperatures
10	Tests to assess the effects of arcing due to internal fault
11	Verification of the degree of protection of the enclosure
12	Tests to prove performance under thermal cycling and gas tightness tests on insulators
13	Additional tests on auxiliary and control circuits
14	Reactor current switching test
15	Test to demonstrate the Power frequency withstand capability of breaker in open condition at lock out pressure.
16	Electromagnetic compatibility tests (if applicable)
17	Radio inference voltage tests (RIV) , if applicable

The test reports of the above type tests for GIS (including type test report on Circuit breaker, Disconnectors, Grounding switches, Current and Voltage transformers as per relevant IEC and type tests of SF6/Air & Oil bushing as per IEC 60137 shall be submitted for approval as per Section- GTR, Technical Specification.

## **21. GENERAL**

21.1. **Painting of enclosure:** All enclosures shall be painted externally as per manufacturer's painting procedure. The painting procedures as followed shall be submitted during detailed engineering.

21.2. **Heaters:** Wherever required, heaters shall be provided to prevent moisture condensation. Heaters are not allowed inside the main circuit.

### **21.3. Identification & rating plate**

Each bay shall have a nameplate showing

- a) A listing of the basic equipment (such as a breaker, Disconnectors grounding switches, current transformers, voltage transformers, and bushings etc ).
- b) A schematic diagram indicating their relative locations.
- c) NEA Contract Number.
- d) Each module will have its own Identification & rating plate. The rating plate marking for each individual equipment like Circuit breaker, Disconnectors Grounding switches, Current transformer, Voltage transformers, Surge arrester etc shall be as per their relevant IEC.

## **22. TRANSPORT OF EQUIPMENT TO SITE**

The contractor shall be responsible for the loading, transport, handling and offloading of all equipment and materials from the place of manufacture or supply to site. The contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities as well as determining any transport restrictions and regulations imposed by the government and other local authorities. All transport packages containing critical units viz Circuit breakers and Voltage transformers shall be provided with sufficient number of electronic impact recorders (on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. The acceptance criteria and limits of impact in all three directions which can be withstood by the equipment during transportation and handling shall be submitted by the contractor during detailed engineering. The recording shall commence in the factory and must continue till the units reach site. The data of electronic impact recorders shall be downloaded at site and a soft copy of it shall be handed over to Engineer – in –charge. Further, contractor shall communicate the interpretation of the data within three weeks.

## **23. PACKING, STORAGE AND UNPACKING**



- 23.1. All the equipment shall be carefully packed for transport by sea, rail and road in such a manner that it is protected against the climatic conditions and the variations in such conditions that will be encountered enroute from the manufacturer's works to the site.
- 23.2. The SF6 metal clad equipment shall be shipped in the largest factory assembled units that the transport and loading limitations and handling facilities on site will allow to reduce the erection and installation work on site to a minimum.
- 23.3. Where possible all items of equipment or factory assembled units shall be boxed in substantial crates or containers to facilitate handling in a safe and secure manner. Should the units be considered too large for packing in crates, they shall be suitably lagged and protected to prevent damage to any part, particularly small projections, during transport and handling. Special lugs or protective supports shall be provided for lifting to prevent slings and other lifting equipment from causing damage. Each crate, container or shipping unit shall be marked clearly on the outside to show where the weight is bearing and the correct position for the slings.
- 23.4. Each individual piece to be shipped, whether crate, container or large unit, shall be marked with a notation of the part or parts contained therein.
- 23.5. Special precautions shall be taken to protect any parts containing electrical insulation against the ingress of moisture. This applies particularly to the metal clad equipment of which each gas section shall be sealed and pressurized prior to shipping. Either dry nitrogen/air or dry SF6 gas shall be used and the pressure shall be such as to ensure that, allowing for reasonable leakage, it will always be greater than the atmospheric pressure for all variations in ambient temperature and the atmospheric pressure encountered during shipment to site and calculating the pressure to which the sections shall be filled to ensure positive pressure at all times during shipment. The type of gas, the maximum pressure to which sections will be filled prior to shipment and the minimum allowable pressure during shipment shall be advised prior to dispatch.
- 23.6. All blanking plates, caps, seals, etc., necessary for sealing the gas sections during shipment to site shall be provided as part of the contract and shall remain the property of NEA. If considered necessary, blanking plates or other sealing devices shall be provided with facilities for measuring the gas pressure and recharging at any time during the transport period. Any seals, gaskets, 'O' rings, etc. that may be used as part of the arrangement for sealing off gas sections for shipment of site, shall not be used in the final installation of the equipment at site. Identification serial numbers shall be stamped into the blanking plates, etc., and on the switchgear equipment to which they are fitted so that they can easily be identified and refitted should it ever be necessary to ship sections of the switchgear back to the manufacturer's works for repair.
- 23.7. Valves and other gas couplings associated with the switchgear gas systems shall be adequately protected against damage from any bumps or physical blows. They shall also be capped to prevent ingress of dirt or moisture or damage to any coupling, pipes, threads or special fittings. Any explosion vents and other pressure relief devices, shall be

suitably sealed and protected to prevent accidental exposure of the sealed sections during shipment to site.

- 23.8. For bus ducts involving male and female joints of the current carrying conductor, the same shall be transported in disassembled condition to avoid any damage during transit. All bright parts liable to rust shall receive a coat of anti rusting composition and shall be suitably protected.
- 23.9. The contractor will be able to use the available storage areas at site. The contractor shall ensure that during the period between arrival at site and erection, all materials and parts of the contract works are suitably stored in such approved manner as to prevent damage by weather, corrosion, insects, vermin or fungoral growth. The scope of providing the necessary protection, storing off the ground, as required etc. is included in the works to be performed by the contractor.
- 23.10. The equipment shall only be unpacked or removed from the containers immediately prior to being installed. They shall not be left lying unnecessarily in open crates or containers. Special precautions shall be taken when gas sections which have been sealed and pressurized for shipping are opened up to reduce the ingress of dirt and atmospheric moisture to a minimum. Whenever possible this shall only be done immediately prior to installation and if any section is to be left outside for any length of time after being opened, it shall be resealed and pressurized with either dry nitrogen/air or SF6 gas until required.

## **24. INSTALLATION OF GIS**

- 24.1. Civil works of GIS Hall shall be completed in all respects for taking up the installation and it shall be ensured that all dust and dirt in the hall are removed. All openings (including Bus Duct) except entry door should be closed and proper sealed
- 24.2. The installation area shall be secured against entry of unauthorized personnel. Only certified manufacturer's engineer and supervisor shall supervise critical & important erection works. The help of local technicians can be taken only for material handling and non-critical erection works. Engineers and supervisors of the manufacturer shall submit authorization and competency certificate.
- 24.3. Assembly drawing for GIS erection for the section under progress shall be available and displayed in GIS hall at the time of work.
- 24.4. Proper power supply shall be ensured by installing DG Set of proper rating and frequency if required prior to commencement of erection work so that assembly work is not interrupted in the middle which is critical for GIS installation.
- 24.5. Working personnel shall clean their shoes or apply covers on shoes before entering the immediate working area. The working clothes of authorized personnel shall be made of non fluffy material.
- 24.6. GIS hall door shall have automatic close facility after entry of personnel to avoid dust and moisture entry. Walls and ceiling shall be in a condition so that neither dirt nor

plaster might fall or rub off and formation of condensation water in ceiling shall be prevented under any circumstances.

- 24.7. Floor in the installation area shall have a firm surface and shall be kept dust free with a vacuum cleaner. Vacuum cleaning to be done at regular interval through out the day with separate team of persons assigned for cleaning work only.
- 24.8. Only T&P and consumables required for GIS erection shall be kept in GIS during erection.
- 24.9. In case of outdoor installation of GIS or of GIS components open gas compartments shall be protected from dust and moisture ingress (by tarpaulin covers etc)
- 24.10. Bus duct exit in the GIS hall wall shall be kept covered by suitable means until permanent cover is provided after installation of bus ducts.
- 24.11. A separate room shall be identified in consultation with NEA/consultant for carrying out repair works/ small part assembly and the room shall be weather protected and lockable. All excess material (not required for immediate installation works) test equipment and tools and tackles to be stored separately from GIS hall in the separate room for rework
- 24.12. All assembly work shall be done by qualified personnel only who are to be identified before starting of erection work.
- 24.13. Erection agency shall submit method statement and make available formats for checking during each stage of hall preparation, assembly process and final checks to be approved before start of erection. Method statement shall include record of shock/ impact recorder at the time of unpacking. Shock recorder down loaded data and analysis shall be submitted before commencement of erection work. In case of violation of shock limits, expert from manufacturer shall visit and do the internal inspection before giving clearance for erection.
- 24.14. Cleaning is of utmost importance and hence before assembly, all the loose metal parts, subassemblies and all contact & sealing surfaces shall be cleaned before installation. Cleaning shall be carried out with specified cleaning agents of the manufacturer in no condition water is to be used except for external surfaces. Further, Prior to opening, gas compartment shall be thoroughly cleaned and vacuum cleaning of the installation area shall also be done specially the immediate vicinity of the flanges to be connected. Dust disturbance in the area to be avoided  
  
Also, before closing a flange connection clean the immediate vicinity and all accessible parts of the components shall be connected with a vacuum cleaner
- 24.15. Once the transport covers are removed installation of flanges shall be done without any interruptions, if interruptions cannot be avoided open flanges are to be covered with clean plastic foil. Transport covers, O-rings and other packing material shall be taken out of GIS after immediately after removal.
- 24.16. O Rings shall be properly stored and taken out only before installation. O Rings are also to be cleaned before use with manufacturer authorized cleaning agent.

- 24.17. At all points of time during installation authorized personnel shall use disposable gloves to avoid contamination.
- 24.18. Cable termination work shall commence only after completion of GIS equipment as during GIS installation period laying and termination of cables interferes with the GIS erection work and affects cleanliness.
- 24.19. Approved Field Quality Plan shall be followed strictly during site work.

## **25. ON SITE TESTING**

After the switchgear has been completely installed on site and filled with SF<sub>6</sub> gas, the complete assembly shall be subjected to the site tests as per IEC – 62271-203 and with the test voltages specified below :-

- 25.1. The adequacy of number of UHF sensors and their location shall be verified as per recommendations of CIGRE task force **TF 15/33.03.05** (Task force on **Partial discharge detection system for GIS: Sensitivity verification for the UHF method and the acoustic method**). In case during site testing additional UHF sensors are required, the same shall also be supplied and installed to complete the technical requirement.
- 25.2. Application of AC voltage equal to 1.2 times the service voltage in order to condition the GIS whilst at the same time permitting measurement of Partial discharge and detection of conductive particles by UHF method.
- 25.3. In case of a disruptive discharge in the gas as outlined in clause no: C.6.2.2 Procedure b) , annexure – C of IEC : 62271-203 , and a repeat test is performed due to failure during the AC voltage test , then the test shall be carried out at 1.2 times the service voltage .

The analysis of PD measured during High voltage test shall done very carefully and presence of PD measured by any sensor shall be attended and HV test shall be repeated after the rectification work. Calibration of PD sensors shall be completed before start of HV test to establish reference for detection of PD above 5 pc

- 25.4. Method statement/ procedure of on site high voltage testing and PD measurement shall be submitted by contractor in advance.

## **26. TESTING & MAINTENACE EQUIPMENT**

All testing & maintenance equipment shall be offered, if specified as per relevant schedule of BPS.

### **26.1. SF<sub>6</sub> Gas leakage detector.**

The detector shall be portable, battery operated with built in battery charger, hand held type and having a minimum SF<sub>6</sub> gas leakage sensitivity of 5gm/year. The sensor shall be connected through a flexible wand for easy accessibility to joints, seals and couplings in GIS equipment and provided with a protection filter. The equipment shall have on/off switch & suitable indicating lamps/LEDs, variable pitch audible signal for leakage indication, and a head phone jack. The equipment shall have automatic zeroing of

background signals suitable for detecting SF6 gas leakage in charged switchyard. The test kit shall be compatible for EMI/EMC environment as per IEC 1000.

## **26.2. Gas filling and evacuating plant :**

26.2.1. The plant necessary for filling and evacuating the SF6 gas in the switchgear shall be supplied to enable any maintenance work to be carried out. **This shall include all the necessary gas cylinders for temporarily storing the evacuated SF6 gas.** The capacity of the temporary storage facilities shall at least be sufficient for storing the maximum quantity of gas that could be removed from at least one phase of one complete bay (switchgear and associated equipment).

26.2.2. Where any item of the filling and evacuating plant is of such a weight that it cannot easily be carried by maintenance personnel, it shall be provided with lifting hooks for lifting and moving with the overhead cranes.

26.2.3. The minimum capacity of evacuation plant will be as under :

Vacuum Pump: 60 M<sup>3</sup>/Hour (Nominal suction pressure)

Compressor : 15 M<sup>3</sup>/Hour (Delivery)

26.2.4. The evacuation equipment shall be provided with all the necessary pipes, couplings, flexible tubes and valves for coupling up to the switchgear for filling or evacuating all the gases.

26.2.5. The gases compartments shall preferably be fitted with permanent non-return valves through which the gas is pumped into or evacuated from the compartments.

Details of the filling and evacuating plant that will be supplied, as well as the description of the filling and evacuating procedures shall be furnished

## **26.3. SF6 gas analyzer:**

The SF6 gas analyser should be of portable type and instruments shall have following features:

- a. In-built calibration facility.
- b. Sensitivity of the equipment shall not be affected by any atmospheric conditions like dust, humidity, heat, wind etc.
- c. Equipment shall work on zero gas loss principle i.e. gas should be pumped back to the compartment after measurement without any exposure to the atmosphere.
- d. Equipment shall be supplied with suitable regulator which can be used to connect SF6 cylinder if required.
- e. Following acidic/impurities products should be detected as per IEC 60480 and IEC 60376
  - i) SF6 purity – Range: 0-100 % & Accuracy: +/- 0.5 %
  - ii) Dew point - Range : -60 to +20 deg C & Accuracy: +/- 0.5 deg C
  - iii) SO2 - Range : 0-150 ppm & Accuracy : +/- 2 %
  - iv) CF4 – Range : 0-60% vol & Accuracy : +/- 1 %
  - v) HF - Range : 0-200ppm & Accuracy : +/- 5 %
- f. Instrument should work on AC source as well as on rechargeable battery

- g. Input pressure: upto 10 bar
- h. It should be housed in a robust IP67 case with wheels

#### **26.3.1. Portable Partial Discharge(PD) monitoring system**

26.3.2. The equipment shall be used for detecting different types of defects in Gas Insulated Stations (GIS) such as Particles, Loose shields and Partial Discharges as well as for detection of Partial discharges in other types of equipment such as Cable Joints, CTs and PTs.

26.3.3. It shall be capable for measuring PD in charged GIS environment as EHV which shall have bandwidth in order of 100 MHz–2GHz with possibility to select a wide range of intermediate bandwidths for best measurement results. The principle of operation shall be based on UHF principle of detection. The instrument should also be able to detect partial discharges in cable joints and terminations.

26.3.4. Detection and measurement of PD and bouncing particles shall be displayed on built in large LCD display and the measurement shall be stored in the instrument and further downloadable to a PC for further analysis to locate actual source of PD such as free conducting particles, floating components, voids in spacers, particle on spacer surfaces etc. Software for display and diagnosis of PD signals and an expert software system for accurate interpretation of cause of PD shall also be supplied and installed by the contractor.

26.3.5. The equipment shall meet the following requirements

1. Measurement shall be possible in noisy environment.
2. Stable reading shall be possible in presence of vibrations within complex GIS assemblies, which can produce signals similar to PD.
3. Equipment should have necessary synchronizing circuits to obtain PD correlation with power cycle and power frequency.
4. The equipment shall be battery operated with built-in-battery charger. It shall also be suitable for 230V AC/50 Hz input.
5. Measurement shall be possible in the charged switchyard in the presence of EMI/EMC. Supplier should have supplied similar detector for GIS application to other utilities. Performance certificate and the list of users shall be supplied along with the offer.
6. Instrument shall be supplied with standard accessories i.e., re-locatable sensors with mounting arrangements, connecting cables (duly screened) to sensors, Laptop PC, diagnostic and expert interpretation software, carrying case, rechargeable battery pack with charger suitable for 230V AC, 50Hz supply connecting cables (duly screened) to view in storage.
7. The function of software shall be covering the following:
  - a) Data recording, storage and retrieval in computer

- b) Data base analysis
  - c) Template analysis for easy location of fault inside the GIS
  - d) Evaluation of PD measurement i.e, Amplitude, Phase Synchronization etc.
  - e) Evaluation of bouncing/loose particles with flight time and estimation on size of particle.
  - f) Expert software system for accurate interpretation of cause of PD.
  - g) Report generation.
8. To prove the suitability in charged switchyard condition, practical demonstration shall be conducted before acceptance.
  9. Supplier shall have “Adequate after sales service” facility .
  10. Necessary training may be accorded to personnel to make use of the kit for locating PD sources inside the GIS
  11. Instrument shall be robust and conform to relevant standard.
- 26.3.6. **Calibration:** The UHF Couplers have to be first calibrated as per CIGRE procedure TF 15/330305 as part of factory acceptance tests to guarantee detection sensitivity of 5pC or better. The GIS of same design shall be used as test specimen during the coupler calibration. The pulse injection level determined through above factory calibration tests shall only be used as reference for site sensitivity checks during commissioning of PDM system. The data sheet/frequency response characteristics shall be submitted for reference.
- 26.3.7. Pulse generator for UHF sensor sensitivity test shall also be supplied as a standard accessory.

**TECHNICAL PARAMETERS FOR CIRCUIT BREAKER**

Sl no	Parameter	220kV system	132 kV system
1.	Rated voltage kV (rms)	245	145
2.	Rated frequency (Hz)	50	50
3.	No. of poles	3	3
4.	Type of circuit breaker	SF6 insulated.	SF6 insulated.
5.	Rated continuous current (A) at an ambient temperature of 50°C	1600/3000 (as applicable)	1250/2000 (as applicable)
6.	Rated short circuit capacity with percentage of DC component as per IEC-62271-100 corresponding to minimum opening conditions as specified.	40 kA ( As applicable )	31.5 kA ( As applicable )
7.	Symmetrical interrupting capability kA (rms) (As applicable)	40	31.5
8.	Rated short circuit making current kAp (As applicable)	100	80
9.	Short time current carrying capability for one second kA (rms) (As applicable)	50/40	80
10.	Rated line charging interrupting current at 90 deg. Leading power factor angle (A rms) (The breaker shall be able to interrupt the rated line charging current with test voltage immediately before opening equal to the product of $U/\sqrt{3}$ and 1.4 as per IEC-62271-100	As per IEC	As per IEC
11.	First pole to clear factor	1.3	As pr IEC
12.	Rated break time as IEC (ms)	60	60
13.	Total break time (ms)	65	65
14.	Total closing time (ms)	Not more than 200	Not more than 200
15.	Rated operating duty cycle	O-0.3s-CO-3 min-CO	
16.	Reclosing	Single phase &Three phase auto reclosing.	Single phase &Three phase auto reclosing.
17.	<b>Rated insulation levels</b>		
	Full wave impulse withstand (1.2 /50 $\mu$ s) between line terminals and ground:	$\pm 1050$ kVp	$\pm 650$ kVp



	Full wave impulse withstand (1.2 /50 $\mu$ s) Between terminals with circuit breaker open:	$\pm 1050$ kVp	$\pm 750$ kVp
	Rated switching impulse withstand voltage (250/2500 $\mu$ s) Dry & wet.	NA	NA
	Rated switching impulse withstand voltage (250/2500 $\mu$ s) Dry & wet Between terminals with circuit breaker open:	NA	NA
	One minute power frequency withstand voltage between line terminals and ground	460 kV rms.	275 kV rms
	One minute power frequency withstand voltage between terminals with circuit breaker open	530 kV rms.	315 kV rms
18.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 266 kV (Micro volts)	1000 $\mu$ V	500 $\mu$ V
19.	Max. difference in the instants of closing/opening of contacts (ms) between poles	As per IEC	As per IEC
20.	Trip coil and closing coil voltage with variation as specified in Sec. GTR	220 V DC	220 V DC
21.	Rating of Auxiliary contacts	10A at 220 V DC	10A at 220 V DC
22.	Breaking capacity of Aux. Contacts less than 20 ms.	10A at 220 V DC	10A at 220 V DC
23.	System neutral earthing	Solidly Gound	

**ANNEXURE-2****TECHNICAL PARAMETERS FOR DISCONNECTORS/ ISOLATORS**

<b>Sl.No</b>	<b>Particulars</b>	<b>220 kV</b>	<b>132kV</b>
1.	Rated voltage (rms) Un	245 kV	145 kV
2.	Rated frequency	50 HZ	50 Hz
3.	System earthing	Effectively earthed	Effectively earthed
4.	Type	SF6 insulated	SF6 insulated
5.	Rated continuous current (A) at 50°C ambient temp.(as applicable)	1600/3000 (as applicable)	1200/600 (for line /transformer /bus coupler)
6.	Rated short time withstand current of isolator and earth switch(as applicable )	40 kA for 1 Sec.	31.5 kA for 1 second
7.	Rated dynamic short circuit withstand current withstand current of isolator and earth switch(As applicable )	1125/00 kAp.(As applicable )	80 kAp
8.	Rated insulation level:		
	One minute power freq. Withstand voltage: To earth :	460 kV rms.	275 kV rms.
	One minute power freq. Withstand voltage: Across isolating distance	530 kV rms.	315 kV rms.
	1.2/50 micro sec. Lighting impulse withstand voltage (+ve or –ve polarity) To earth:	±1050 kVp	±650 kVp
	1.2/50 micro sec. Lighting impulse withstand voltage (+ve or –ve polarity) : Across Isolating distance	±1200 kVp	±750 kVp
	Rated switching impulse withstand voltage (250/2500 micro-sec.) Dry & wet :between line terminals and ground:	N.A	N.A
	Rated switching impulse withstand voltage (250/2500 micro-sec.) Dry & wet :Between	N.A	N.A

	terminals with Isolator open:		
9.	Mechanical Endurance clause as per IEC	M2	M1
10.	No. of spare auxiliary contacts on each isolator	4 NO and 4 NC	4 NO and 4 NC
11.	No. of spare auxiliary contacts on each earthing switch	4 NO and 4 NC	4 NO and 4 NC

**TECHNICAL PARAMETERS FOR CURRENT TRANSFORMERS**

Sl no	Particular	220 kV	132kV
1.	Rated voltage Un	245 kV (rms)	145 KV (rms)
2.	Rated frequency	50 Hz	50 Hz
3.	System neutral earthing	Effectively Earthed	Effectively Earthed
4.	Rated short time thermal current for 1 second (as applicable )	40 kA	31.5 kA
5.	Rated dynamic current	100 kAp.	78.75kA
6.	Rated insulation levels		
i.	1.2/50 micro second impulse voltage	±1050 kVp	±650 kVp
ii.	one minute power frequency withstand voltage	460 kV (rms)	275 kV (rms)
7.	Maximum temperature rise over an ambient temperature of 40 <sup>0</sup> C	As per IEC 60044-1	As per IEC 60044-1
8.	Radio interference voltage at 1.1 Un/√3 and frequency range 0.5 to 2 MHz	1000 μV	500μV
9.	One minute power frequency withstand voltage between sec. Terminal & earth	3 kV (rms)	3 kV (rms)
10.	Partial discharge level	5 pico coulombs	5 pico coulombs

**TABLE-3A****REQUIREMENTS FOR 220 kV CURRENT TRANSFORMER**

No. of cores	Core no.	Application	Current ratio	Output Burden (VA)	Accuracy Class as Per IEC: 44-1	Min. Knee pt. Voltage V <sub>k</sub>	Max. CT Sec. Wdg. Resistance (ohm)	Max. Excitation current at V <sub>k</sub> (in mA)
5	1	BUS DIFF CHECK	1600-800/1	-	-	1600/800	8/4	25 on 1600/1tap. 50 on 800/1tap.
	2	BUS DIFF MAIN	1600-800/1	-	-	1600/800	8/4	25 on 1600/1tap. 50 on 800/1tap.
	3	METERING	1600-800/1	20	0.2S	-	-	-
	4	TRAN BACK UP/ LINE PRTN.	1600-800/1	-	-	1600/800	8/4	25 on 1600/1tap. 50 on 800/1tap.
	5	TRAN. DIFF/ LINE PRTN.	1600-800/1	-	-	1600/800	8/4	25 on 1600/1tap. 50 on 800/1tap.

All relaying CTs shall be of accuracy class PS as per IS: 2705.
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No. of cores	Core no.	Application	Current ratio	Output Burden (VA)	Accuracy Class as Per IEC: 44-1	Min. Knee pt. Voltage V <sub>k</sub>	Max. CT Sec. Wdg. Resistance (ohm)	Max. Excitation current at V <sub>k</sub> (in mA)
5	1	BUS DIFF CHECK	2400-1600/1	-	-	2400/1600	12/8	16.67 on 2400/1tap on 25 on 1600/1tap.
	2	BUS DIFF MAIN	2400-1600/1	-	-	2400/1600	12/8	16.67 on 2400/1tap on 25 on 1600/1tap.
	3	METE- RING	2400-1600/1	20	0.2S	-	-	-
	4	TRAN BACK UP/ LINE PRTN.	2400-1600/1	-	-	2400/1600	12/8	16.67 on 2400/1tap on 25 on 1600/1tap.
	5	TRAN. DIFF/ LINE PRTN.	2400-1600/1	-	-	2400/1600	12/8	16.67 on 2400/1tap on 25 on 1600/1tap.

All relaying CTs shall be of accuracy class PS as per IS: 2705.

**TABLE-3B**

**REQUIREMENTS FOR 132 kV CURRENT TRANSFORMER**

No. of cores	Core no.	Application	Current ratio	Output Burden (VA)	Accuracy Class as Per IEC: 44-1	Min. Knee pt. Voltage Vk	Max. CT Sec. Wdg. Resistance (ohm)	Max. Excitation current at Vk (in mA)
5	1	BUS DIFF CHE-CK	800-400/1	-	-	800/400	8/4	25 on 800/1 50 on 400/1
	2	BUS DIFF MAIN	800-400/1	-	-	800/400	8/4	25 on 800/1 50 on 400/1
	3	METE RING	800-400/1	20	0.2S	-	-	-
	4	TRAN BACK UP/ LINE PRTN.	800-400/1	-	-	800/400	8/4	25 on 800/1 50 on 400/1
	5	DIFF/ LINE PRTN.	800-400/1	-	-	800/400	8/4	25 on 800/1 50 on 400/1

All relaying CTs shall be of accuracy class PS as per IS: 2705.

Table- 3C

**REQUIREMENTS FOR 245 kV CURRENT TRANSFORMER****(For Bus Coupler bay)**

<b>Core no.</b>	<b>Application</b>	<b>Current Ratio</b>	<b>Output Burden (VA)</b>	<b>Accuracy class as per IEC: 60044-1</b>	<b>Min knee point voltage <math>V_k</math></b>	<b>Max. CT sec. Wdg resistance ( ohms)</b>	<b>Max. Excitation current at <math>V_k</math> (in mA)</b>
1	protection	3000-1600-800/1	-	PS	3000-1600-800	15/ 8/ 4	13.3 on 3000/1 25 on 1600/1 50on 800/1
2	protection	3000-1600-800/1	-	PS	3000-1600-800	15/ 8/ 4	13.3 on 3000/1 25 on 1600/1 50on 800/1
3	Metering	3000-1600-800/1	20	0.2S	-	-	-
4	protection	3000-1600-800/1	-	PS	3000-1600-800	15/ 8/ 4	13.3 on 3000/1 25 on 1600/1 50on 800/1
5	protection	3000-1600-800/1	-	PS	3000-1600-800	15/ 8/ 4	13.3 on 3000/1 25 on 1600/1 50on 800/1



**TABLE – 3D****REQUIREMENTS FOR 145 kV CURRENT TRANSFORMER****(For Bus coupler bay)**

<b>Core no.</b>	<b>Application</b>	<b>Current Ratio</b>	<b>Output Burden (VA)</b>	<b>Accuracy class as per IEC: 60044-1</b>	<b>Min knee point voltage <math>V_K</math></b>	<b>Max. CT sec. Wdg resistance ( ohms)</b>	<b>Max. Excitation current at <math>V_K</math> (in mA)</b>
1	protection	2000-1000/1	-	PS	2000-1000/1	10/5	30 on 2000/1 60 on 1000/1
2	protection	2000-1000/1	-	PS	2000-1000/1	10/5	30 on 2000/1 60 on 1000/1
3	Metering	2000-1000/1	20	0.2S	-	-	-
4	protection	2000-1000/1	-	PS	2000-1000/1	10/5	30 on 2000/1 60 on 1000/1
5	protection	2000-1000/1	-	PS	2000-1000/1	10/5	30 on 2000/1 60 on 1000/1

**TECHNICAL PARAMETERS FOR VOLTAGE TRANSFORMERS**

<b>Sl. No.</b>	<b>Particular</b>	<b>220 kV</b>	<b>132kV</b>
1	Rated system voltage (Un)	245 kV (rms)	145 KV (rms)
2	Rated frequency	50 Hz	50 Hz
3	System neutral earthing	Effectively earthed	Effectively earthed
4	System fault level	50/40 kAp.(As applicable)for 1 Second.	31.5 kA
5	Rated insulation levels		
i.	1.2/50 micro second impulse voltage	±1050 kVp	±650 kVp
ii.	one minute power frequency withstand voltage	460 kV (rms)	275 kV (rms)
iii.	250/2500 micro second switching impulse voltage (dry & wet)	NA	NA
6	One minute power frequency withstand voltage for secondary winding	3 kV (rms)	3 kV(rms)
7	Radio interference voltage at $1.1 U_n/\sqrt{3}$ and frequency range 0.5 to 2 MHz	1000 $\mu$ V	500 $\mu$ V
8	Rated total thermal burden	400 VA	
9	Partial discharge level	10 Pico coulombs.	10 pico coulombs

**TABLE -4A****REQUIREMENT OF VOLTAGE TRANSFORMERS**

Sl. No	PARTICULARS	220 kV			132kV		
1	Rated primary voltage	220/ $\sqrt{3}$ kV			132/ $\sqrt{3}$ kV		
2	Type	Electromagnetic			Electromagnetic		
3	No. of secondaries	3			3		
4	Rated voltage factor	1.2 continuous			1.2 continuous		
		1.5 for 30 seconds			1.5 for 30 seconds		
5	Phase angle error	$\pm 10$ minutes (for metering core)			$\pm 10$ minutes (for metering core)		
		Sec I	Sec II	Sec III	Sec I	Sec II	Sec III
6.	Rated secondary voltage (V)	110/ $\sqrt{3}$	110/ $\sqrt{3}$	110/ $\sqrt{3}$	110/ $\sqrt{3}$	110/ $\sqrt{3}$	110/ $\sqrt{3}$
7.	Application	Protection	Protection	Metering	Protection	Protection	Metering
8.	Accuracy	3P	3P	0.2	3P	3P	0.2
9.	Output burden (VA) (minimum)	50	50	50	50	50	50

**TECHNICAL PARAMETERS OF GIS SURGE ARRESTOR**

Sl. No.	Particulars	220 kV	132 kV
1	Rated system voltage	245 kV	132kV
2	System neutral earthing	Effectively earthed	Effectively earthed
3	Rated arrestor voltage	216 kV	120 kV
4	Nominal discharge current	10 kA of 8/20 $\mu$ s wave	10 kA of 8/20 $\mu$ s wave
5	Rated frequency	50 Hz	50 Hz
6	Minimum discharge capability voltage corresponding to minimum discharge characteristics	5 KJ/kV (referred to rated arrestor)	5 KJ/kV (referred to rated arrestor)
7	Continuous operating voltage at 50°C	168 kV	102 kV
8	Min. switching surge residual voltage	-	
	Max. switching surge residual voltage	500 kVp	280kVp
9	Max. residual voltage at 5 kA	560 kVp	310kVp
11	Max. residual voltage at 10 kA nominal discharge current	600 kVp	330 kVp
12	Max. residual voltage at 20 kA nominal discharge current	-	
13	Steep fronted wave residual voltage	650kVp 10kA	
14	Long duration discharge class	3	3
15	High current short duration test value (4/10 micro second wave)	100 kAp	100 kAp
16	Current for pressure relief test	50kA/50kA (as applicable)	31.5 kA
17	Prospective symmetrical fault current	40 kA rms for 0.2 Sec	As per IEC
18	Pressure relief class:	A	A
19	RIV at 1.1 $U_n/\sqrt{3}$ kV rms(micro volts)	Less than 500	Less than 500
20	Partial discharge at 1.05 COV (pC)	Not more than 5	Not more than 5
21	Reference ambient temp.	50 °C	50 °C

**ANNEXURE-6****TECHNICAL PARAMETERS FOR SF6/AIR BUSHING**

<b>Sl. No.</b>	<b>Particular</b>	<b>220 kV</b>	<b>132kV</b>
1	Rated Voltage (kV)	245 kV (rms)	145 kV (rms)
2	Rated Current (Amp)	2400/1600	600
3	1.2/50 micro second impulse voltage (Lightning impulse withstand voltage)	1050 kVp	630 kVp
4	250/2500 micro second switching impulse voltage	-	
5	One minute power frequency withstand voltage		275 kV (rms)
6	Minimum total Creepage distance in mm	6125	3625
7	Minimum Cantilever strength (kN)	8	5


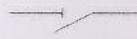





ANNEXURE-A  
(SHEET 2 OF 2)

NOTES

1). PROVISION OF RUPTURE DISC, ABSORBER, GAS FILLING & GAS MONITORING ARRANGEMENT TO BE KEPT IN EACH GAS COMPARTMENT.

\*\* NUMBER OF GAS COMPARTMENTS IN THIS SECTION SHALL BE AS PER THE ACTUAL LAYOUT & SHALL BE FINALISED DURING DETAILED ENGG.

LEGENDS

SIGN	NAME	DESCRIPTION
	CB	CIRCUIT BREAKER
	DS	DISCONNECTING SWITCH
	ES/FES #	EARTHING SWITCH
		BARRIER INSULATOR
		SF6 GAS DENSITY MONITOR
	CT	CURRENT TRANSFORMER
	BSG	SF6/AIR BUSHING

FOR TENDER PURPOSE ONLY

POWER GRID CORPORATION  
OF INDIA LIMITED

(A GOVERNMENT OF INDIA ENTERPRISE)

29.04.2014	HIMANSHU	ANIL BHUTAN	DR. JAYANIRAN	PROJECT:	GIS SUBSTATION
DATE DRAWN	CHKD	APPD	NTS	TITLE:	TYPICAL GAS SCHEMATIC DIAGRAM (DOUBLE MAIN SCHEME)
				DRGNO:	C/ENGG/GIS/GSD/02
				REV.	0

## SECTION: EHV XLPE POWER CABLE

### 1 CABLE CONSTRUCTION DETAILS

- 1.1 The XLPE insulated EHV cable shall conform to the requirements of IEC 60502-2 (applicable clauses only) for construction and IEC 60840/IEC 62067 (as applicable) for testing. The terminating accessories shall conform to IEC 60840/ IEC 62067 (as applicable). The offered cables and its terminating accessories shall be compatible with each other.
- 1.2 The EHV grade cable shall be single core, unarmoured, stranded, compacted **Aluminium/Copper (as specified in BPS)** conductor, core screening by a layer of semiconducting tape followed by a layer of semiconducting compound, cross linked polyethylene (XLPE) dry cured insulation, insulation screening with semiconducting compound extruded directly over the insulation, longitudinal sealing by a layer of non woven tape with water swellable absorbent over insulation screen, followed by radial sealing (Metal sheath of Lead alloy 'E'), metallic screening by concentric layer of plain copper wire (if required) to meet short time current requirement, followed by an open helix of copper & overall HDPE sheathed & graphite coated and conforming to the technical particulars of specification. Bidder may offer necessary layers such as separation tape, binder tapes etc additionally as per their manufacturing practices for meeting required performance of the offered cable.
- 1.3 The cable shall be suitable for laying under the climate conditions (as specified in Section-Project) and underground buried installation with uncontrolled back fill and chances of flooding by water.
- 1.4 Cable shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions.
- 1.5 Progressive sequential marking of the cable length (in metres), at every one metre, shall be provided on the outer sheath of the cable.
- 1.6 Repaired cables shall not be accepted.
- 1.7 Allowable tolerance on the overall diameter of the cables shall be  $\pm 2$  mm.

### 1.8 CONDUCTOR

The conductor shall be of **Copper/Aluminium** wires as specified in the Bid Price Schedule (**BPS**). The shape of conductor shall be compacted segmental having high compactness and smooth surface finish.

### 1.9 CONDUCTOR SCREENING

The conductor screen shall consist of extruded semi-conducting XLPE. Semi-conducting separator tapes may be applied between conductor and the extruded semi-conductor XLPE. The conductors screen (non-metallic semi-conductive) shall be extruded in a single one-time process to ensure homogeneity and absence of voids.

#### **1.10 INSULATION**

The extruded XLPE insulation shall be applied over the conductor screen to the desired thickness in a void free manner.

#### **1.11 INSULATION SCREEN**

The insulation screen shall consist of extruded semi-conducting XLPE. Suitable bedding tapes shall be applied over the extruded semi-conducting XLPE.

#### **1.12 MOISTURE BARRIER**

##### **Longitudinal water barrier:**

The longitudinal water barrier shall be applied over insulation screen by a layer of non woven synthetic tape with suitable water swellable absorbent.

##### **Radial Moisture Barrier:**

This shall be of extruded Lead alloy "E" sheath.

#### **1.13 METALLIC SCREEN:**

The metallic screen shall be of plain copper wires, helically applied over the radial moisture barrier. A binder tape of annealed plain copper shall be applied in the form of an open helix over the copper wire screen. The combination of the metallic sheath (lead sheath) in combination with wire screen shall be designed to meet the requirement of the system short circuit rating as specified in **the bidding documents**.

#### **1.14 OUTER SHEATH**

The outer sheath shall consist of extruded black coloured HDPE with graphite coating. The outer sheath shall be suitably designed by the addition of chemicals in the outer sheath for protection against termite and rodent attack and shall be coated with graphite.

#### **1.15 RATING**

The contractor/ manufacturer shall declare current rating of cable for maximum conductor temperature of 90 degree C under continuous operation and 250 degree C during short-circuit condition. The contractor/ manufacturer shall also declare over



load curve with duration for conductor temperature of 105 Deg C. A complete set of calculation made in arriving at the current rating shall be furnished, for laying condition envisaged under the project, during detailed engineering for Employer/Owner's reference.

## **1.16 CABLE JOINTING ACCESSORIES**

- 1.16.1 The cable jointing accessories shall include all the straight through joints, Cross bonding, earth continuity cables, Link boxes, Sheath Voltage Limiters (SVLs) etc as required for entire cable route. Bidder shall arrange all special tools and tackles required for making these joints at his own cost. **Unless specified separately** in BPS, **cable end terminating kits** shall be deemed included as part of cable jointing accessories.
- 1.16.2 The straight through joint shall preferably be built up from the same material as the main cable and shall have electrical and mechanical withstand capabilities same as or better than the main cable. The joints shall be suitable for tropical conditions as specified in **Section-Project**.
- 1.16.3 The straight through joints and cable end terminations shall be of proven design and should have been type tested as per relevant IEC. A list of supply of cable jointing accessories which are in successful operation in projects, shall be furnished.
- 1.16.4 The detailed description on jointing procedure shall be furnished during detailed engineering.
- 1.16.5 The cable end terminations shall be of anti-fog type and shall be of Polymer type/Porcelain type suitable for withstanding the climatic conditions with required Creepage distance as specified in **bidding documents**. The cable end terminals for terminating the cables shall be complete with accessories & fully compatible with the cables to be supplied. The terminations shall also be capable to withstand mechanical forces during normal and short circuit operations.
- 1.16.6 The cable end terminations envisaged for **mounting on Transmission Line (T/L) Towers** shall necessarily be of Composite Polymer type to reduce the weight on T/L towers. The cable end terminations envisaged for **GIS interface**, shall comply to IEC 60840. It will be the responsibility of the contractor to ensure smooth interface with GIS equipment.

## **2 CABLE DRUMS**

- 2.1 Cables shall be supplied in returnable steel drums of heavy construction of suitable size and packed conforming to applicable standards.
- 2.2 Standard drum lengths for manufacturing shall be finalised during detailed engineering. Each drum shall carry the manufacturer's name, the purchaser's name,

address and contract number and type, size and length of the cable, net and gross weight stencilled on both sides of drum. A tag containing the same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

- 2.3 Packing shall be sturdy and adequate to protect the cables from any injury due to mishandling or other conditions encountered during transportation, handling and storage. Both cable ends shall be sealed with PE/Rubber caps so as to eliminate ingress of water during transportation and erection.

### **3 TESTS ON CABLES**

All XLPE insulated EHV cables shall conform to all Type, Routine and Acceptance tests listed in the relevant IEC & shall submit the type test reports for Employer's approval. If specified in Section-Project, Type tests shall be carried out on the EHV cable as per relevant standard.

### **4 TESTS ON ACCESSORIES**

Contractor shall submit type test reports for accessories, as per IEC 60840:1999/ IEC 62067 for Employer's acceptance. Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Section: GTR for Employer's acceptance.

### **5 TESTS AFTER INSTALLATION**

All tests on cable system as prescribed in IEC 60840:1999/IEC 62067 (as applicable) shall be performed after installation.

### **6 LAYING AND INSTALLATION**

- 6.1 The bidder is advised to visit the site and acquaint themselves with the topography, infrastructure etc. The contractor shall be fully responsible for providing all equipment, materials, system and services specified or otherwise which are required to complete the erection and successful commissioning of XLPE cables in all respects.
- 6.2 Cables shall be laid in the trench throughout the route. Further, as per requirement of the field, the cables shall also have to be laid in the followings (with prior approval of owner):
- a. In ducts
  - b. In HDPE pipes (pipes to be filled with sand/suitable material after cabling)
  - c. In air at terminations
  - d. At varying depths due to obstructions

e. As per approved drawings

- 6.3 At places where the cables cross private roads, gates of residential houses or buildings, the cables shall be laid in HDPE pipes of adequate strength.
- 6.4 Concrete trenches with precast covers may be used in exceptional cases in smaller portions, wherever bending of cables are involved and HDPE pipes can't be laid.
- 6.5 The arrangement of laying the cable en-route shall be submitted by contractor during detailed engineering for Employer's acceptance.

## **7 TRENCHING**

- 7.1 The cable trench work involves earth excavation for cable trench, back filling and removal of excess earth from site. The work site shall be left as clean as possible.
- 7.2 The trench shall be excavated using manual /mechanical modes as per field conditions. Most main roads are of asphalt surface and some of the roads with cement concrete surface. The sides of the excavated trenches shall wherever required, be well shored up.
- 7.3 Where paved footpaths are encountered, the pavement slabs shall be properly stored and reinstated. Identification markers of other services shall be properly stored and restored. The excavated material shall be properly stored to avoid obstruction to public and traffic movement.
- 7.4 Suitable barriers should be erected between the cable trench and pedestrian/ motorway to prevent accidents. The barriers shall be painted with yellow and black or red and white coloured cross stripes. Warning and caution boards should be consciously displayed. Red lights as warning signal should be placed along the trench during the nights.
- 7.5 The bottom of the excavated trench should be levelled flat and free from any object which would damage the cables. Any gradient encountered shall be gradual.

## **8 TREFOIL/FLAT FORMATION**

Cables shall be laid in trefoil/flat formation **(as per bidding documents)** for entire route. The contractor shall submit drawings and arrangements for Employer approval.

## **9 CABLE HANDLING**

The inspection of cable on receipt, handling of cables, paying out, flaking, cushioning with sand or sieved compacted soil, back-filling, reinstatement of road surfaces, providing and fixing joint markers, route indicators, precautions of joint holes, sump holes and all necessary precautions that are required shall be carefully

planned and in accordance with acceptable standard practices/statutory requirements.

## **10 DAMAGE TO PROPERTY**

The contractor shall take all precautions while excavation of trench, trial pits etc., to protect the public and private properties and to avoid accidental damage. Any damage so caused shall be immediately repaired and brought to the notice of the concerned and to the Employer. The contractor shall bear all responsibilities and liabilities and shall bear all costs of the damages so caused by him or by his workman or agents.

## **11 CABLE ROUTE MARKERS/CABLE JOINT MARKERS**

Permanent means of indicating the position of joints and cable route shall be fabricated supplied and erected as per approved drawings.

Markers provided shall be as per the field requirement, if the route passes through open fields, markers should be conspicuously visible and above ground surface.

The marker should incorporate the relevant information such that the name of the Owner, voltage, circuit and distance of cable from the marker.

## **12 DEPTH OF LAYING OF CABLES**

Depth of laying shall be as per **drawing enclosed with Specification**. Laying at varying depths due to obstructions/site conditions may be accepted in extreme cases with prior approval of Employer during detailed engineering.

## **13 PAYING OUT THE CABLE**

The excavated cable trench shall be drained of all water and the bed surface shall be smooth, uniform and fairly hard before paying out the cable. The cable shall be rolled in the trench on cable rollers, spaced out at uniform intervals. The paying out process must be smooth and steady without subjecting the cable to abnormal tension. The cable on being paid out shall be smoothly and evenly transferred to the ground after providing the cushion. The cables shall never be dropped. All snake bends shall be straightened. Suitable size cable stocking pulling eye shall be used for pulling the cable. While pulling the cable by winches or machines, the tension/ loading shall be monitored by tension indicator and shall not exceed the permissible value for the cable. The cable laying shall be performed continuously at a speed as recommended by manufacturer.

The cable end seals shall be checked after laying and if found damaged shall immediately be resealed. Sufficient number of heat shrinkable cable end sealing caps shall be stocked at site stores for testing and jointing work. The integrity of the outer sheath shall be checked after the cable is laid in position.

#### **14 SAND BEDDING**

The cable shall be completely surrounded by well-compacted cable sand to such a thickness and of such size that the cable is protected against damage (applicable where cables are not to be laid in pipes).

#### **15 SNAKING**

Snaking shall be done at necessary places recommended by manufacturer with prior approval of Employer.

#### **16 THERMAL BACKFILL**

If specifically mentioned in Section-Project, Thermal Backfilling shall be carried out based on the evaluation of soil thermal resistivity along the cable route and after approval from the Employer the contractor shall design, specify, supply, lay and monitor the installation of thermal backfill surrounding the cables. Thermal back fill shall be of thermal resistivity of 1.20 Km/W or better.

#### **17 IMMEDIATE ENVELOPE TO CABLE**

The option on the use of the material that immediately envelopes the cable viz., thermal backfill or sand or sieved native soil rests with the Employer/Owner. The contractor shall seek prior approval on the use of the envelop material from the Employer/Owner before execution of the works.

#### **18 BACK FILLING**

Normally back filling shall consist of the material earlier excavated. However, bigger stones or pieces of rock should be removed.

#### **19 WARNING TAPE**

A pre-warning, Red colour plastic/ PVC tape, of atleast 250 mm wide 100 microns thick, shall be laid at approx. 0.4 m above the cable specified depth, throughout the cable route. The tape shall carry the legend printed in black continuously as under CAUTION; OWNER, VOLTAGE CLASS of CABLES.

#### **20 PREVENTION OF DAMAGE DUE TO SHARP EDGES**

After the cables have been laid in the trench and until the cables are covered with protective covering, no sharp metal tool shall be used in the trench or placed in such a position that may fall into the trench. Straight and curved rollers used shall have no sharp projecting parts liable to damage the cable. While pulling through pipes and ducts, the cable shall be protected to avoid damage due to sharp edges. The cables shall never be bent, beyond the specified bending radius.

## **21 ROAD, RAIL & CANAL CROSSINGS**

21.1 The road cutting, whether cement concrete asphalt or macadam road surface; Railway track crossing and canal crossing shall be taken after obtaining approval for cutting/crossing from the concerned authorities i.e. civic authorities, traffic police, telephone authorities, Railway authorities, Irrigation deptt etc., and work should be planned to be completed in the shortest possible time. Where necessary the work shall be planned during night or light traffic periods. HDPE pipes shall be used for crossing. HDPE pipes diameter should not be less than 1.5 times the cable diameter.

### **21.2 Trenchless Digging:**

It is envisaged that trenchless digging shall be used for crossing the National highways, Railway tracks and Canals etc. and the same shall be in the scope of bidder. Trenchless digging shall also be used where the concerned authorities do not permit open cut method and it is essentially required to carry out for installation of underground cables. The trenchless digging methods shall generally conform to ITU-T L.38. The various methods of trenchless digging such as hand/ manual auguring (up to 15m), impact moling (from 16m to about 40-50m), HDD (above 40-50m) shall be adopted based on the soil/site conditions and the requirement. The exact method for trenchless digging shall be finalised during detail engineering as per actual site/soil condition. The equipment used for HDD shall be capable of drilling at least 100m at one go. The contractor shall propose the exact methods and procedures for implementation of trenchless digging at various crossings taking into consideration the following guidelines, for approval by the Employer.

- a) Excavation and backfilling of trial pits and verification of soil condition
- b) Excavation of entry and Exit pits
- c) Erection of drill machine for Drilling of pilot hole
- d) Placement and driving hand augur
- e) Placement and carrying out impact moling
- f) Reaming and widening of bore holes in steps (if required)
- g) Pulling of product pipe

## **22 FOOTPATH CUTTING**

The slabs, kerbstones, on the roads shall be removed and reinstated without damage.

## **23 REINSTATEMENT**

After the cables and pipes have been laid and before the trench is backfilled all joints and cable positions should be carefully plotted and preserved till such time the cable is energized and taken over by the Engineer in charge. The protective covers

shall then be provided, the excavated soil riddled, sieved and replaced. It is advisable to leave a crown of earth not less than 50 mm and not more than 100 mm in the centre and tapering towards the sides of the trench.

The temporary reinstatement of roadways should be inspected at regular intervals, more frequently in rainy season and immediately after overnight rain for checking settlement and if required the temporary reinstatement should be done.

After the subsidence has ceased the trench may be permanently reinstated and the surface restored to the best possible condition.

## **24 MANHOLES**

Manholes shall be provided at every proposed joint location for jointing bays. The bidder shall identify the location of the joint bays after carrying out detailed survey of the cable route and excavation of the trial pits. The delivery lengths of the cables shall match the location.

The Contractor shall get inspected, by a representative of the Employer, all manholes before carrying out the backfilling. Pipe & cable sealing, installation of joint box and cable service loops as per approved drawings shall be visually inspected and checked for tightness.

The contractor shall submit design and drawing of joint bay including manholes for withstanding a live load of 20 ton vehicle plus 30% for impact from moving vehicle. The Contractor shall propose a suitable procedure for testing the manhole for approval by the Employer. Manholes type approved by the Employer only shall be acceptable. The manhole shall include sufficient number of suitable entries.

## **25 TOOLS AND PLANTS**

The successful bidder shall arrange, at his own cost, all necessary tools, plant and equipment to carry out the survey and cable installation work. The bidders are instructed to give all the details of equipment at their disposal, to carry out the work successfully and speedily.

## **26 BENDING RADIUS**

The minimum bending radius of XLPE insulated cables shall be  $20XD$  where "D" means the Outer diameter of the cable.

## **27 JOINTING AND TERMINATION OF CABLES**

The cable jointing personnel and his crew shall have good experience in the type of joints and terminations that are used. The jointing work shall commence as soon as two or three lengths of cables have been laid. All care should be taken to protect

the factory-plumbed caps/ seals on the cable ends, and the cable end shall be sealed whenever the end is exposed for tests.

Jointing of cables in carriage ways, drive ways under costly pavings, under concrete or asphalt surfaces and in proximity to telephone cables and water mains should be avoided whenever possible.

Sufficient over lap of cables shall be allowed for making the joints.

The joint bay should be of sufficient dimensions to allow the jointers to work with as much freedom of movement and comfort as possible. Sufficient space should be kept below the cable to be jointed.

The joints of different phases shall be staggered in the jointing bay.

### **27.1 SUMPHOLES**

When jointing cables in water logged ground or under unforeseen rainy conditions, a sumphole should be made at one end of the joint bay, in such a position so that the accumulated water can be pumped or baled out by buckets, without causing interference to the jointing operation.

### **27.2 TENTS/COVERS**

An enclosure or suitable protection cover shall be used in all circumstances wherever jointing work is carried out in the open, irrespective of the weather conditions. The joint shall be made in dust free, moisture free and clean atmosphere.

### **27.3 PRECAUTIONS BEFORE MAKING A JOINT**

The cable end seals should not be opened until all necessary precautions have been taken to prevent circumstances arising out of rainy/ inclement weather conditions, which might become uncontrollable.

If the cable end seals or cable ends are found to have suffered damage the cables should not be jointed, without tests and rectification.

### **27.4 MEASUREMENT OF INSULATION RESISTANCE**

Before jointing, the insulation resistance of both sections of cables shall be checked.

### **27.5 IDENTIFICATION**



The identification of each phase, shall be clearly and properly noted. The cables shall be jointed as per the approved design. Each cable shall have identification for phase at joint bays.

## **27.6 MAKING A JOINT**

Comprehensive jointing instructions should be obtained from the manufacture of jointing kits and meticulously followed.

The materials used in the joints like ferrules, screen/sheath continuity bonds, lugs etc., shall be of good quality and conform to standards.

The jointing tools shall be appropriate and as per the requirement of jointing EHV XLPE cables.

## **28 CABLE LAYING & TERMINATIONS**

The preparation of the cable end for installing the terminations and the precautions to be taken before fixing the terminations shall be followed as in the case of the cable jointing procedures. The instructions furnished by the termination manufacturer shall be strictly followed.

At cable terminating end, the following provisions for supply and erections are to be included:

- (i) A sufficient length of spare cable shall be left in the ground, for future needs.
- (ii) The rise of the cable immediately from the ground shall be enclosed in PVC/PE pipe of suitable diameter to protect against direct exposure to the sun.
- (iii) The cable shall be properly fastened using non-metallic clamps.
- (iv) Appropriate labels shall be fixed identifying the phase circuit, voltage and date of commissioning etc., on the cable supporting structure.
- (v) The sealing end shall be mounted on pedestal insulators to isolate them from their supporting steel work.
- (vi) Protection from contact with the exposed metal work at the termination shall be provided by resin bonded glass fibre shroud.
- (vii) Providing earth stations with all required materials, like leads, connectors etc. Earth pits shall conform to IS-3043:1987 (Code of practice for earthing)/ or equivalent International standards.

## **29 BONDING OF SCREEN/ SHEATH**

The screens/sheath shall be cross-bonded under each segment of specified route in accordance with IS-3043 (Code of practice for earthing) or applicable International codes & practices. The bidder shall offer complete cable system in order to limit maximum sheath voltage in accordance with relevant standards and furnish

complete set of calculations in support of the same. The screen/sheath shall be connected to the earth stations/ earth pits through disconnecting type link boxes & through Sheath Voltage Limiter (SVL) as required.

All required materials used in the Cross bonding, termination of earth continuity cable, Link box, SVL etc to comply with specification/statutory requirements shall be in the scope of bidder and should be of good quality and compatible with the cable.

### **30 CONNECTION OF RADIAL WATER BARRIER AND CABLE SCREEN**

If the metallic radial water barrier is insulated from the metallic wire screen, a connection suitable to carry the currents occurring during operation must be installed between metallic radial water barrier of the cable and metallic wire screen in joints and sealing ends.

### **31 CABLE TERMINATING STRUCTURES**

- 31.1 The terminating structure being supplied, should be designed as per the project requirement for the cable end terminations i.e. for Standalone Outdoor AIS terminations, GIS end terminations and Transmission line Tower end terminations as per requirement specified in BPS.
- 31.2 The mounting structure shall be fixed on the reinforced cement concrete foundation, the design & drawings of which shall be submitted to Employer for review & acceptance during detailed engineering.
- 31.3 The mounting structure includes the supports for cable end boxes, link boxes and any other item required for the intent of the contract. All steel sections used shall be free from all imperfections, mill scales, slag intrusions, laminations, fillings, rust etc. that may impair their strength, durability and appearance. All materials shall be of tested quality only unless otherwise permitted by the Employer. The steel for mounting structure shall conform to IS-2062 (latest).
- 31.4 In case of cable terminations on transmission line towers, the cable termination kit, LA, Link Box, SVL etc shall be fixed suitably on the tower for which necessary interface details shall be coordinated for Tower design during detailed engineering. After fixing the end terminations, the cable shall be suitably fixed to the tower members, with non-magnetic material clamps to the required height securely. The cable in air shall be suitably protected using HDPE pipes up to certain height.
- 31.5 In case of GIS end terminations, the structure & foundations shall be suitably designed in coordination with GIS terminations during detailed engineering.

### **32 MEASUREMENT (for Civil Works)**

The buried cable trench shall be measured in the running meters including excavation, back filling, thermal back filling (if applicable), compaction, laying of concrete/ reinforcement, placing of warning tap markers, dewatering as required as per the drawing & specification & any other job required for successful completion of work.

### **33 DISTRIBUTED TEMPERATURE MONITORING SYSTEM (DTS)**

The bidder shall include and provide separate "Distributed Temperature Monitoring System (DTS)" for entire route for EHV cables complete in all respects along with terminal coupling equipment, workstation and all required hardware & software for real time monitoring of conductor temperature profile and to provide load predictions. The offered system should be able to provide maximum possible transmission capacity of the cable for each circuit. The distributed temperature monitoring system shall be optical fibre based, must be of proven technology and should be in operation for similar use along with EHV cables as per latest practices. The "terminal coupling equipment" and "workstation" shall preferably be microprocessor based with HMI, for displaying temperature along the length of the cable system. System shall provide potential free output contact for signalling to SCADA. The bidder shall provide brochures and catalogues for offered distributed temperature monitoring system along with the bid.

Optical fibre cables along with all jointing accessories etc required for DTS shall also be included in the scope of bidder. Optical fibre cables associated with DTS shall be laid in the same EHV cable trench.

### **34 OPTICAL FIBRE CABLE (For Communication Equipments)**

If specified in the bidding documents, Optical fibre cable required for Communication Equipments shall also be laid in the same cable trench in separate HDPE pipe.