

NEPAL ELECTRICITY AUTHORITY

(An Undertaking of Government of Nepal)

DISTRIBUTION AND CONSUMER SERVICES DIRECTORATE DISTRIBUTION SYSTEM UPGRADE AND EXPANSION PROJECT



TENDER DOCUMENT

for

Procurement of material, equipment, associated accessories and necessary installation services including design, erection, testing, and commissioning of 132/33 kV substation in Bajhang District

– Package No. EIB-W6

Tender Procedure: Single-Stage Two-Envelope

Issued on:

Invitation for Tenders No.: ICB-DCSD-2080/81-DSUEP-EIB-W6

Contract Ref. No.: ICB-DCSD-2080/81-DSUEP-EIB-W6

Employer: Nepal Electricity Authority

Country: Nepal

Volume II of III

(Technical Specification and Technical Data Sheet)

Nepal Distribution System Upgrade and Expansion Project (EIB)

Distribution and Consumer Services Directorate

Nepal Electricity Authority

Durbarmarg, Kathmandu

Tel: +977-1- 4153145

Email: dsuep.eib@gmail.com; dsuep@nea.org.np



Table of Contents - Summary Description

PART I

TENDER PROCEDURES

Section 1 - Instructions to Tenderers (ITT)----- 1-1

This section specifies the procedures to be followed by Tenderers in the preparation and submission of their Bids. Information is also provided on the submission, opening, and evaluation of bids and on the award of contract.

Section 2 - Tender Data Sheet (TDS) ----- 2-1

This section consists of provisions that are specific to each procurement and supplement the information or requirements included in Section 1 (Instructions to Tenderers).

Section 3 - Evaluation and Qualification Criteria (EQC) ----- 3-1

This section contains the tender evaluation criteria to determine the lowest evaluated Tender and lists the necessary qualifications of Tenderers.

Section 4 - Tender Forms (TDF) ----- 4-1

This section contains the forms which are to be completed by the Tenderer and submitted as part of its Tender.

Section 5 - Eligible Countries (ELC) ----- 5-1

This section contains the list of eligible countries.

PART II

REQUIREMENTS

Section 6 - Employer's Requirements (ERQ) ----- 6-1

This section contains the Scope of Supply of Plant and Services, Specifications, the Drawings, and Supplementary Information that describe the Facilities to be procured, Personnel Requirements, Equipment Requirements, Certificates, and Change Orders.

PART III

CONDITIONS OF CONTRACT AND CONTRACT FORMS

Section 7 - General Conditions of Contract (GCC) ----- 7-1

This section contains the general clauses to be applied in all contracts. These Conditions are subject to the variations and additions set out in Section 8 (Special Conditions of Contract).

Section 8 - Special Conditions of Contract (SCC) ----- 8-1

This section contains provisions that are specific to each contract and that modify or supplement the GCC. Whenever there is a conflict, the provisions herein shall prevail over those in the GCC. The clause number of the SCC is the corresponding clause number of the GCC.

Section 9 - Contract Forms (COF)----- 9-1

This section contains forms, which, once completed, will form part of the Contract. The forms for Performance Security and Advance Payment Security, when required, shall only be completed by the successful Tenderer after contract award.



Volume II

Section 6: Employer's Requirements

Abbreviations & Acronyms

Acronym	Full form
ABC	Ariel Bunched Cables
AC	Alternating Current
ACSR	Aluminium Conductor Steel Reinforced
BoQ	Bill of Quantity
CAGR	Compounded Average Growth Rate
CSP	Completely Self Protected
CT	Current transformer
DC	Direct Current
DC	Distribution Centre
DSUEP	Distribution System Upgrade and Expansion Project
DT	Distribution Transformer
ESMF	Environmental and Social Management Framework
EIB	European Investment Bank
EUR	Euro
GPS	Global Positional System
GoN	Government of Nepal
GSS	Grid Sub-Station
HT	High Tension
IPP	Independent Power Producers
kV	kilo Volt
kVA	kilo Volt Ampere
kWh	kilo Watt Hours
LILO	Loop-In Loop-Out

Acronym	Full form
LT	Low Tension
LV	Low Voltage
MVA	Mega Volt Ampere
MW	Mega Watt
NEA	Nepal Electricity Authority
NEC	NEA Engineering Company Limited
NPR	Nepalese Rupees
NRs	Nepalese Rupees
PIU	Project Implementation Unit
PSC	Pre-stress Concrete Cement
PSS	Power Sub-Station
RMR	Remote Meter Reading
SAS	Substation Automation System
SCADA	Supervisory Control and Data Acquisition System
SIM	Subscriber Identity Module
TVM	Tri-Vector Meter
USD	US Dollars
VCB	Vacuum Circuit Breaker

Volume II

Section 6: Employer's Requirements

Table of Contents

CHAPTER 1: PROJECT SPECIFICATION REQUIREMENT (PSR)

1.	General	2
2.	Scope	2
3.	Specific Exclusions	4
4.	Physical and Other Parameters	4
5.	Schedule of Quantities	5
6.	Basic Reference Drawings	6
7.	Order of Precedence of Different Parts of Technical Specification	6
8.	Spares an Special Tools & Tackles	7
9.	Facilities to be provided by the Employer	7
10.	Specific Requirement.....	8
11.	Precommissioning, Commissioning, Trial-Run and Completion	9
12.	Social Safeguard and Environment Management Plan.....	9
13.	Safety of Personnel.....	12
14.	Service Level Agreement (Sla)	12
15.	Guarantee/Warranty	13
16.	List of Preferred (Shortlisted) Make	13

CHAPTER 1

PROJECT SPECIFICATION REQUIREMENT (PSR)

1. General

- 1.1 As a part of the Distribution System Upgrade and Expansion Project (DSUEP) by Nepal Electricity Authority, an unmanned substation with a voltage rating of 132/22 kV is being established at the premises of Kalanga Hydro Power Station (KHPS) in Bajhang District. The construction of the substation is being funded by the European Investment Bank (EIB) as a component of DSUEP, with POWERGRID serving as the consultant for the project and assisting DSUEP in its execution.
- 1.2 The substation will be built on the land provided by KHPS, and its layout will be tailored to the specific site requirements, designed according to the available land area.
- 1.3 The design, engineering, drawing, and construction of the unmanned substation must adhere to the general technical requirements outlined in the Specification. These requirements are either explicitly stated or implicitly implied based on the relevant international standards such as IEC, IEEE, IS, ASTM, BS, or other equivalents.
- 1.4 A transformer bay consisting of 12.5/15 MVA transformer is envisaged to be constructed in the existing switchyard of the Kalanga Hydro Power Station (KHPS). The transformer is to get power from the 132 kV busbar of KHPS and feed it to 33 kV system. Three nos. of 33 kV line bays are to be constructed, one for the existing Bagthala Substation, one for Kalanga Substation being constructed under DSUEP and one as a spare.
- 1.5 This document enlists the Technical Specifications for HT/LT lines and Distribution Transformers for the sub-projects. Standard requirements of the Installation of HT/LT lines are provided followed by requirements for the distribution transformers. Tender Drawings are provided as part of this volume to assist these specifications.

2. Scope

- 2.1 The scope of this specification covers the following:
 - 2.1.1 Construction of 132/33 kV substation consisting of extension of 132 kV busbar, 132/33 kV transformer bay, 3 nos. of 33 kV Outgoing line bays, control room and associated facilities.
 - 2.1.2 Design, engineering, manufacture, testing at manufacturer's works, transportation, unloading and delivery at site including insurance & storage, erection, testing and commissioning at Site, complete in all respect for but not limited to the following equipment:
 - a. 12.5/15 MVA 132/33 kV Power Transformers
 - b. 132 kV and 33 kV Circuit Breakers, Isolators, Earth Switches, Current Transformers, Capacitor Voltage Transformers and Surge Arresters
 - c. 100 kVA, 33/0.4 kV Station Transformer along with associated equipment like auto-recloser, surge arrester etc.
 - d. Extension of 132 kV Busbar
 - e. Complete Relay and Protection System
 - f. Complete Substation Automation System for Control and Monitoring of the substation and auxiliary equipment through BCU including hardware and software for remote control station

- g. Tele-protection and Communication System
- h. Earthing and Lightning Protection System
- i. Battery and Battery Charger
- j. AC/DC Distribution System
- k. Illumination System
- l. 33 kV XLPE Power Cable, 1.1 kV grade Power & Control Cables
- m. Lattice and Pipe Structures
- n. Erection Hardware
- o. Mandatory Spare

2.1.3 **Civil Works:** The scope of work shall include but shall not be limited to the followings based on design and drawings to be developed in coordination with KHPS by the Contractor according to the available footprint provided by KHPS:

- a. Foundations of Power Transformers along with jacking pad and pylon supports whenever applicable
- b. Foundation for all Gantry, equipment's support structures and LT Transformers.
- c. Cable Trenches along with covers, sump pits and cable trench crossings with roads/drains etc.
- d. Anti-weed treatment, PCC and Stone spreading in switchyard area
- e. Control cum administrative building
- f. Retain wall, re-fencing for switchyard with gates
- g. Drainage, Water supply and Sewage system
- h. Surveying, Sol Investigation, contouring. Leveling and filling wherever required

2.2 It is advised to visit the substation sites and get informed with the topography, infrastructure and also the design philosophy. Before proceeding with the construction work, the Contractor shall fully familiarize with the site conditions and general arrangements and scheme etc. Though the Employer shall endeavor to provide the information, it shall not be binding for the Employer to provide the same. The Contractor shall be fully responsible for providing all equipment, materials, system and services specified or otherwise which are required to complete the construction and successful commissioning, operation & maintenance of the substation in all respects. All materials required for Civil and Construction/Installation work shall be supplied by the Contractor

The complete design (unless specified otherwise in specification elsewhere) and detailed engineering shall be done by the Contractor based on conceptual tender drawings and available footprint. Drawings enclosed with tender drawings are for information only.

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

- 2.3 The Contractor shall also be responsible for the overall co-ordination with internal/external agencies; project management, loading, unloading, handling, moving to final destination for successful erection, testing and commissioning of the substation/switchyard.
- 2.4 Design of substation and its associated electrical & mechanical auxiliaries systems includes preparation of single line diagrams and electrical layouts including layout arrangement for foundation layout, cable trench layout, earth-mat layout, erection key diagrams, electrical and physical clearance diagrams, design calculations for earthing and lightening protection system (including Direct Stroke Lighting Protection), control and protection schematics, wiring and termination schedules, civil designs (as applicable) and drawings, air conditioning system, indoor/outdoor lighting/illumination and other relevant drawings & documents required for engineering of all facilities within the fencing to be provided under this contract, are covered under the scope of the Contractor.
- 2.5 **Any other items not specifically mentioned in the specification but which are required for erection, testing and commissioning and satisfactory operation of the substation are deemed to be included in the scope of the specification unless specifically excluded.**
- 2.6 Employer has standardized its technical specification for various equipment and works for different voltage levels Items, which are not applicable for the scope of this package as per schedule of quantities described in Schedules of Rates and Prices, the technical specification for such items should not be referred to.

3. Specific Exclusions

- 3.1 The following items of work are specifically excluded from the scope of the specifications for all substation:
- Employer's Quarters, site office and stores
 - Cutting and clearing of trees and bushes in yard

4. Physical and Other Parameters

- 4.1 The Substation is located in far-western region of Nepal in Bithadchir Rural Municipality of Bajhang District on the right bank of Kalanga River.
- 4.2 Meteorological Data
- | | |
|---|-----------------------|
| a. Altitude above sea level | 962 m |
| b. Ambient Air Temperature | 40°C (max)/ 5°(min) |
| c. Humidity (%) | 100 (max) / 10 (min) |
| d. Max. wind speed | 50 km/hr |
| e. Max. wind pressure | 150 kg/m ² |
| f. Average number of rainy days | 100/annum |
| g. Max. annual Rainfall | 1500 mm |
| h. Seismic Requirements for Substation | 0.5g (horizontal) |
| i. Seismic Requirements for Civil Works | 0.36g (horizontal) |
| j. Moderately hot and humid tropical climate, conducive to rust and fungal growth | |
| k. Pollution Level is low. | |

4.3 The details system parameter is as below:

S. No.	Description of Parameter	System	
		132 kV	33 kV
a.	System Operation Voltage	132 kV	33 kV
b.	Maximum Operating Voltage (rms)	145 kV	
c.	Rated Frequency	50 Hz	
d.	No. of Phase	3	3
e.	Rated Insulation Levels		
	i. Full wave impulse withstand voltage (1.2/50 μ sec)	650 kV _p	170 kV _p
	ii. One minute power frequency dry and wet withstand voltage (rms)	275 kV	75 kV
f.	Corona extinction voltage	105 kV	-
g.	Max. Radio interference voltage for frequency between 0.5 MHz and 2 MHz at	50 μ V at 92 kV _{rms}	-
h.	Minimum creepage distance (25mm/kV)	3625 mm	900 mm
i.	Minimum Clearance		
	i. Phase to Phase	1300 mm	320 mm
	ii. Phase to Earth	1300 mm	320 mm
	iii. Sectional Clearance	4000 mm	3000 mm
j.	Rated Short Circuit Current	31.5 kA for 1 Sec	25 kA for 3 sec
k.	System Neutral Earthing	Effectively Earthed	

Note

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

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

5. Schedule of Quantities

- 5.1 The requirement of various items/equipment's and civil works are indicated in Schedules of Rates and Prices.
- 5.2 All equipment/items and civil works for which bill of quantity has been indicated in Schedules of Rates and Prices, shall be payable on unit rate basis/quoted rate basis. During actual execution, any variation in such quantities shall be payable as per relevant clauses incorporated in Letter of award.
- 5.3 Wherever the quantities of items/works are not indicated and quantified and given in lot, the Tenderer is required to estimate the quantity required for entire execution and completion of works and incorporate their price in respective

Schedules of Rates and Prices. For erection hardware items, Tenderers shall estimate the total requirement of the works and indicate module-wise lump sum price bay wise and include the same in relevant Schedules of Rates and Prices. For module identification, Tenderer may refer typical drawings enclosed with the specifications. Any material/works for the modules not specifically mentioned in the description in Schedules of rates and prices, as may be required shall be deemed to be included in the module itself.

- 5.4 The quantities specified in the Schedules of Rates and Prices are only estimates. As soon as practicable, the Contractor shall complete all survey, design and investigation works and accordingly revise the quantities and the Schedules of rates and Prices based on the unit/lump sum prices quoted in the Schedules of rates and Prices to complete the Facilities in accordance with the Technical Specifications and submit for Employer's approval. The revised price adjustment due to variation of quantities shall be limited to $\pm 15\%$ of the initial contract amount for the total amount of the respective schedules.
- 5.5 All such items shall be included in the Tender proposal sheets, which are not specifically mentioned but are essential for the execution of the contract. Item which explicitly may not appear in various schedules and required for successful commissioning of substation shall be considered included in the Tender price and shall be provided at no extra cost to the Employer.

6. Basic Reference Drawings

- 6.1 Single line diagram and general arrangements are enclosed with the tender documents for reference, which shall require further engineering.
- 6.2 The overall dimensions of the substation, phase to earth clearance, phase to phase clearance and sectional clearances shall be maintain.
- 6.3 The enclosed drawings give the basic scheme, layout of substation, substation buildings, associated services etc. In case of any discrepancy between the drawings and text of specification, the requirements of text shall prevail in general. However, it is advised to get these clarified from the Employer.

7. Order of Precedence of Different Parts of Technical Specification

- 7.1 For the purpose of present scope of work, the Technical Specification shall consist of following parts and they shall be read in conjunction with each other:

(1)	Chapter 1	Project Specification Requirement (PSR)
(2)	Chapter 2	General Technical Requirement (GTR)
(3)	Chapter 3	Power Transformer
(4)	Chapter 4	Station Transformer
(5)	Chapter 5	Disconnecting Switch
(6)	Chapter 6	Surge Arrester
(7)	Chapter 7	Instrument Transformer
(8)	Chapter 8	Switchgear
(9)	Chapter 9	Control Relay and Protection Panel
(10)	Chapter 10	Substation Automation System
(11)	Chapter 11	Visual Monitoring System
(12)	Chapter 12	Battery and Battery Charger
(13)	Chapter 13	Air Conditioning System
(14)	Chapter 14	Power and Control Cable

(15)	Chapter 15	Switchyard Erection
(16)	Chapter 16	Miscellaneous Material
(17)	Chapter 17	Lighting System
(18)	Chapter 18	Fiber Optic Based Communication Equipment
(19)	Chapter 19	Inspection, Testing and Commissioning
(20)	Chapter 20	Civil Works
(21)	Chapter 21	Substation Equipment Data Sheet
(22)	Chapter 22	Payment of Works

7.2 In case of any discrepancy between Chapter 1-PSR and Chapter 2-GTR and other technical specifications on scope of works, Chapter 1-PSR shall prevail over all other chapters.

7.3 In case of any discrepancy between Chapter 2-GTR and individual chapters for various equipment, requirement of individual equipment chapter shall prevail.

8. Spares and Special Tools & Tackles

8.1 **Mandatory Spares:** The Mandatory Spares shall be included in the relevant Schedule of Rates and Prices. It shall not be binding on the Employer to procure all of these mandatory spares. The Mandatory Spares shall not be used during the commissioning of the Equipment. Any spares required for commissioning purpose shall be arranged by the Contractor. The unutilized spares if any brought for commissioning purpose shall be taken back by the Contractor.

8.2 **Recommended Spares:** Within the Schedule of Rates and Prices, there is a distinct section where the Tenderer is required to propose additional spares and their prices that are not included in the Mandatory Spares list. It shall not be binding on the Employer to procure all of these Recommended Spares. However, it is important to note that the prices of these recommended spares will not be taken into consideration during the Tender Evaluation process.

8.3 **Special Tools & Tackles:** The Tenderer shall include in his proposal the deployment of all special tools and tackles required for operation and maintenance of equipment. The special tools and tackles shall only cover items which are specifically required for the equipment offered and are proprietary in nature. However a list of all such devices should be indicated in the relevant schedule provided in the Schedules of Rates and Prices. In addition to this the Contractor shall also furnish a list of special tools and tackles for the various equipment in a manner to be referred by the Employer during the operation of these equipment. The scope of special tools and tackles are to be decided during detail engineering and the list of special tools and tackles, if any shall be finalized.

9. Facilities to be provided by the Employer

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

9.2 Water supply is available in the premises of KHPS. Coordinating with KHPS, all further distribution for the same shall be made by the Contractor. In case of non-

availability or inadequate availability of water for construction work, the Contractor shall make his own arrangement at his own cost and the Employer shall in no case be responsible for any delay in works because of non-availability or inadequate availability of water.

10. Specific Requirement

- 10.1 The Contractor are advised to visit Sub-stations site and acquaint themselves with the topography, infrastructure, etc.
- 10.2 The Contractor shall be responsible for safety of human and equipment during the working. It will be the responsibility of the Contractor to co-ordinate and obtain Electrical Inspector's clearance before commissioning. Any additional items, modification due to observation of such statutory authorities shall be provided by the Contractor at no extra cost to the Employer.
- 10.3 The Contractor shall arrange all T&P (such as necessary supports, cranes, ladders, platforms etc.) for erection, testing & commissioning of the system at his own cost. Further, all consumables, wastage and damages shall be to the account of Contractor.
- 10.4 The Substation to be built under the package shall be unmanned and be operable from Bajhang DC (Bagthala S/S) and Attariya Grid.
- 10.5 **Augmentation and Integration work related to SCADA System:** The complete substation including auxiliary system shall be integrated by the Contractor to the existing Master Control Centre (MCC) at Attariya Grid. The integration shall include all hardware and software required at the MCC. The Contractor shall study the system at MCC for preparing its integrating system.
- 10.6 The Employer shall make available the auxiliary power supply from NEA on chargeable basis at a single point in the Substation. The prevailing energy rates shall be applicable. All further distribution from the same for construction and permanent auxiliary supply shall be made by the Contractor. However, in case of failure of power due to any unavoidable circumstances, the Contractor shall make his own necessary arrangements like diesel generator sets at his own cost so that progress of work is not affected and the Employer shall in no case be responsible for any delay in works because of non-availability of power.
- 10.7 The operation and maintenance training for Substation Automation System (SAS) shall be provided to the Employer's personnel. All the training costs shall be borne by the Contractor. However, the traveling and living expenses of the Employer's personnel for the training program shall be borne by the Employer.
- 10.8 The lighting fixtures for switchyard shall be mounted on LMs wherever LMs are provided. Where LMs are not available, the fixtures may be mounted on Gantry structures or on lighting poles to be provided by the Contractor. The average illuminance at the ground level shall be as below:

a. Control Room and Office Room	300 Lux
b. Other Indoor area	150 Lux
c. Switchyard	30 Lux
d. Other outdoor area	20 Lux
e. Emergency Lighting	10 Lux
- 10.9 All RCC shall be of M-25 grade (Minimum) with mixed design conforming to relevant international standard/BS/IS. All Reinforcement steel shall be of FE-500 (Minimum) grade conforming to International standards /BS/IS.

- 10.10 The Frequency range for the earthquake spectra shall be as per IEC-62271-300 for Circuit Breaker.
- 10.11 Sufficient number portable fire extinguisher (CO₂ type) of 4.5 kg shall be provided for control room as per Schedules of Rates and Prices.
- 10.12 A Tariff Metering System for KHPS is installed in 132 kV system. The Substation under this package is to be fed from 132 kV system. So, tariff metering system of KHPS needs to be modified i.e. unit wise (2 Units of Generation) metering needs to be done. Existing one set of metering system shall be taken out from 132 kV system and install in one of the Unit. The ditto Metering System shall be purchased under this package and installed in other unit. All the costs including commissioning in presence of representatives from KHPS and Power Trade Department of NEA shall be borne by the Contractor. Another Metering System shall be provided for 132/33kV bay.
- 10.13 Design, engineering, drawing and construction of works shall satisfy the general technical requirements specified in the Specification or implied as per relevant IEC/IEEE/IS/ASTM/British standard codes (B S Codes)/ equivalent International Standards.
- 10.14 Non CFC refrigerant shall be utilized for Air conditioning system, offered for Control room building and switchyard panel room is under the scope of contract.

11. Precommissioning, Commissioning, Trial-Run and Completion

- 11.1 As soon as the Facilities covered by these specifications are physically completed in all respects, the Pre commissioning, Commissioning, Trial-run and Completion of the Facilities, as mentioned below, shall be attained in accordance with the procedure given in the Conditions of Contract.
 - a. **Pre commissioning** As per relevant Chapters
 - b. **Commissioning** Charging of the Facilities at rated voltage
- 11.2 Further, wherever appearing in these specifications, the words – ‘commissioning checks’, ‘installation checks’, ‘site tests’, ‘performance guarantee tests for fire protection system’, are to be considered as ‘pre commissioning checks’.
 - a. **Trial-run**
Operation of the Facilities or any part thereof by the Contractor immediately after the Commissioning for a continuous period of 72 (Seventy two) hours continuously. In case of interruption due to problem / failure in the respective equipment, the Contractor shall rectify the problem and after rectification, continuous 72 (Seventy two) hours period start after such rectification.
 - b. **Completion**
Upon successful completion of Trial-run.
- 11.3 ‘Guarantee Test(s)’ and/or ‘Functional Guarantees’ are applicable only for Substation Automation System as specified in Chapter-10 ‘Substation Automation System.’

12. Social Safeguard and Environment Management Plan

- 12.1 The Contractor shall comply with all Environment and Social Guidelines of European Investment Bank (EIB).
- 12.2 The Contractor shall prepare Social Safeguard and Environment Management Plan to be implemented during execution of the Project. The following major activities applicable shall be considered:

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

Staff Training and Sensitization: At the beginning of works the Contractor shall organize training and awareness-raising workshops intended for his teams to improve their understanding to prevent or minimize the impact of their activities on the environmental and social aspects to promote good relations with the local people. Among others topics addressed should also include the following:

- a. Likely environmental impact of works, good practices, preventive and corrective measures to be adopted;
- b. Rules and procedures for waste management at construction sites; Safety risks associated with the works, and preventive attitude to adopt;
- c. First aid and what to do in case of accident;
- d. General standards concerning relations with the local people;
- e. Risks and prevention of sexually transmitted diseases.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Public information on electrical hazards, behavior and preventive measures: Before switching on the infrastructure installed as part of the project, the neighboring

population should be informed in good time, through public meetings and/or distribution of information leaflets. The information provided to them should focus on the electrical hazards associated with the infrastructure and the behavior that would allow them to avert such hazards. The population of these areas should be particularly targeted.

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

13. Safety of Personnel

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

14. Service Level Agreement (SLA)

- 14.1 **Support services (including Maintenance) for 3 years:** After the successful commissioning of the entire project, the Contractor shall provide the support services which shall include maintenance of the system installed under the project for a period of 3 (three) years from the date of issuance of operational acceptance of the project.

The Scope of Work shall include supervision, operation and maintenance support to be provided by the Contractor in respect of the system (Substation Automation System, Tele-protection and Communication Equipment and Visual Monitoring System operation) supplied under this project for a period of three years after the Operational Acceptance of the entire project. However during the execution of the infrastructure work it is expected that certain portion of the work if completed and put to service before the actual completion and commissioning of the entire project, then in that case also the support services including O&M shall be the responsibility of the Contractor in accordance with this document, at no additional/ extra cost towards payment of support services (O&M) during this intervening period.

- 14.2 **Single window service:** The Tenderer shall provide a single window service to maintain SLA and in case of a joint Tender only one organization shall be held responsible & accountable for the performance of the system as per defined SLA.
- 14.3 The Tenderer shall provide 24x7 support to NEA to comply with SLAs in case of any problem.
- 14.4 It shall be the responsibility of Contractor to resolve any related issues of underground system including HT, LT, DTs, RMUs and OPG Cable.
- 14.5 The Contractor is required to work with the Employer's Technical Personnel during whole SLA period. The Contractor shall support and build the capacities of local counterparts in the day- to-day management, operation and maintenance of the network. Contractor shall conduct on the job training for these counterparts to ensure that they are able to maintain and operate the network in a stable and reliable manner in accordance with established Prudent Utility Practices.
- 14.6 The Contractor is required to provide field personnel for support service including Engineers, Supervisors etc. The numbers of field personnel shall be negotiated.
- 14.7 The cost for the SLA shall be included in the cost of equipment in Schedule of Rates and Prices.

15. Guarantee/Warranty

- 15.1 The Contractor shall correct, without any delay and at its own expense, at any portion of the Work during defect liability period and extended defect liability period including any required correction in defective design, errors, omissions, or changes in documentation, or by providing a non-defective replacement within 3 days of notification of the problem.
- 15.2 The costs of replacement shall be at the Contractor's expense and shall include all shipping costs, duties, fees, and taxes, both to and from the Contractor's facility, and the appropriate technical advice and direction for removal of the defect and installation of the corrected Work including On-Site Services as required. In the event the System or any portion thereof, is down, the Contractor will begin the dispatch process of appropriate personnel as specified.
- 15.3 The Contractor's liability shall be limited to adjusting, repairing, or replacing the defective article(s) and providing technical support and direction in the correction of the Work. In case of replacement of the equipment on or after 2 year a new warranty period shall apply, such new warranty period shall expire on the date 12 months from the date of such replacement, repair, or modification.
- 15.4 If the Contractor shall fail to correct any defect within a reasonable time, Employer shall have the right to employ others to do so. The Supplier shall be liable for all costs and expenses thereby incurred by Employer.
- 15.5 The Contractor shall furnish Employer with a Deficiency incident report upon completion of each visit by such Staff and upon resolution of each inquiry.
- 15.6 The Contractor shall provide to Employer, within 15 Days of the end of each calendar quarter, a list and description of all potential or actual problems.

16. List of Preferred (Shortlisted) Make

- 16.1 It is preferred that the following equipment be supplied from the manufactures listed hereunder or other equivalent manufacturers:
 - a. **Main Protection Relays:** ABB, SIEMENS, Fuji, Reyrolle, Toshiba, Mitsubishi, GE
 - b. **Energy Meters:** ELSTER (ABB), ACTARIS, EDM, SIEMENS, AMETEK
 - c. **SF₆ Circuit Breakers:** ABB, AREVA/ALSTOM, Hitachi, Siemens, Toshiba, Mitsubishi, LG, Fuji, GE
 - d. **VCB Switchgear:** ABB, AREVA/ALSTOM, Hitachi, Siemens, Toshiba, Mitsubishi, LG, Fuji, GE, Schneider Electric
 - e. **On-load Tap Changer:** OLTC and associated control equipment shall be from MR Germany or ABB Sweden
 - f. **AVR:** The AVR to be equipped on RTCC shall be from MR Germany or ABB Sweden
 - g. **Temperature Indicators:** AB Khilstrom
 - h. **Communication System:** Nokia, SIEMENS, ABB
- 16.2 Equipment/brands other than those listed above that are better or equivalent with regard to quality and performance substantiated with appropriate documents may be offered. It is required to submit all technical information, brochures, and test reports of the proposed equipment for assessing equivalence with the shortlisted vendor during the Tender submission. The alternative equipment shall be used in other places, for which the manufacturer shall be shortlisted vendor in any government entity for that particular item and the Vendor list shall be submitted.

Volume II

Section 6: Employer's Requirements

CHAPTER 2: GENERAL TECHNICAL REQUIREMENT (GTR)

Table of Contents

1.	Foreword.....	2
2.	General Requirement.....	2
3.	Standards	2
4.	Services to be performed by the Equipment being furnished.....	3
5.	Engineering Data and Drawings	7
6.	Material/Workmanship	9
7.	Design Improvements/ Coordination	11
8.	Quality Assurance Programme	12
9.	Type Testing, Inspection, Testing & Inspection Certificate.....	13
10.	Tests	15
11.	Packaging & Protection	15
12.	Finishing of Metal Surfaces	15
13.	Handling, Storing and Installation	17
14.	Tools and Tackles	18
15.	Auxiliary Supply	18
16.	Support Structure.....	19
17.	Clamps and Connectors Including Terminal Connectors	19
18.	Control Cabinets, Junction Boxes, Terminal Boxes & Marshalling Boxes for Outdoor Equipment	20
19.	Terminal Blocks and Wiring.....	21
20.	Lamps & Sockets	22
21.	Bushings, Hollow Column Insulators, Support Insulators:	23
22.	Motors.....	24
23.	Technical Requirement of Equipment.....	25
	Annexure - A: List of Specifications	27
	Annexure - B: List of Drawings/Documents.....	33

CHAPTER 2

GENERAL TECHNICAL REQUIREMENT (GTR)

1. Foreword

- 1.1 The provisions under this section are intended to supplement general requirements for the materials, equipment and services covered under other sections of Tender Documents and are not exclusive.

2. General Requirement

- 2.1 The contractor shall furnish catalogues, engineering data, technical information, design documents, drawings etc., fully in conformity with the technical specification during detailed engineering.
- 2.2 It is recognized that the Contractor may have standardized on the use of certain components, materials, processes or procedures different from those specified herein. Alternate proposals offering similar equipment based on the manufacturer's standard practice will also be considered provided such proposals meet the specified designs, standard and performance requirements and are acceptable to Employer.
- 2.3 Equipment furnished shall be complete in every respect with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or needed for erection, completion and safe operation of the equipment as required by applicable codes though they may not have been specifically detailed in the Technical Specifications unless included in the list of exclusions. Materials and components not specifically stated in the specification and price schedule but which are necessary for commissioning and satisfactory operation of the switchyard/substation unless specifically excluded shall be deemed to be included in the scope of the specification and shall be supplied without any extra cost. All similar standard components/parts of similar standard equipment provided, shall be inter-changeable with one another.

3. Standards

- 3.1 The works covered by the specification shall be designed, engineered, manufactured, built, tested and commissioned in accordance with the Acts, Rules, Laws and Regulations of Nepal/ relevant IEC standard or Acceptable International Standard.
- 3.2 The equipment to be furnished under this specification shall conform to latest issue with all amendments (as on the date of Tender opening) of standard specified under **Annexure-A** of this section, unless specifically mentioned in the specification.
- 3.3 The Tenderer shall note that standards mentioned in the specification are not mutually exclusive or complete in themselves, but intended to complement each other.
- 3.4 The Contractor shall also note that list of standards presented in this specification is not complete. Whenever necessary, the list of standards shall be considered in conjunction with specific IEC or equivalent international standard.
- 3.5 When the specific requirements stipulated in the specifications exceed or differ than those required by the applicable standards, the stipulation of the specification shall take precedence.
- 3.6 Other internationally accepted standards which ensure equivalent or better performance than that specified in the standards specified under Annexure-A / individual sections for various equipment shall also, be accepted, however the salient points of difference shall be clearly brought out in the Additional information schedule of the Tender along with English language version of such standard. The equipment conforming to standards other than specified under Annexure-A/ individual sections for various equipment shall be subject to Employer's approval.

4. Services to be performed by the Equipment being furnished

- 4.1 The equipment furnished under this specification shall perform all its functions and operate satisfactorily without showing undue strain, restrike etc. under such over voltage conditions.
- 4.2 All equipment shall also perform satisfactorily under various other electrical, electromechanical and meteorological conditions of the site of installation.
- 4.3 All equipment shall be able to withstand all external and internal mechanical, thermal and electromechanical forces due to various factors like wind load, temperature variation, ice & snow, (wherever applicable) short circuit etc. for the equipment.
- 4.4 The Contractor shall design terminal connectors of the equipment taking into account various forces that are required to withstand.
- 4.5 The equipment shall also comply with the following:
- 4.5.1 To facilitate erection of equipment, all items to be assembled at site shall be "match marked".
- 4.5.2 All piping, if any between equipment control cabinet and operating mechanisms to marshalling box of the equipment, shall bear proper identification to facilitate the connection at site.
- 4.6 Equipment and system shall be designed to meet the following major technical parameters as brought out hereunder.

4.6.1 System Parameter

S. No.	Description of Parameters	System	
		132 kV	33 kV
1.	System Operating Voltage	132 kV	33 kV
2.	Maximum Operating Voltage of the system	145 kV	36 kV
3.	Rated Frequency	50 Hz	
4.	No. of Phase	3	3
5.	Rated Insulation Levels		
	a Full wave impulse withstand voltage (1.2/50 μ sec)	650 kV _p	170 kV _p
	b One minute power frequency dry and wet withstand voltage (rms)	275 kV	75 kV
6.	Corona extinction voltage	105 kV	-
7.	Max. Radio interference voltage for frequency between 0.5 MHz and 2 MHz at	50 μ V at 92 kV _{rms}	-
8.	Minimum creepage distance (25mm/kV)	3625 mm	900 mm
9.	Minimum Clearance		
	a Phase to Phase	1300 mm	320 mm
	b Phase to Earth	1300 mm	320 mm
	c Sectional Clearance	4000 mm	3000 mm
10.	Rated Short Circuit Current	31.5 kA for 1 Sec	25 kA for 3 sec
11.	System Neutral Earthing	Effectively Earthed	

Note:

The insulation and RIV (Radio Interference Voltage) levels of the equipment shall be as per values given in the respective section of the equipment.

- 4.6.2 Major Technical Parameters of Bushing/Hollow Column/Support insulators are given below:

S. No.	Description of Parameters	System	
		132 kV	33 kV
1.	Max. System Voltage U_m	145 kV	36 kV
2.	Impulse withstands voltage (dry & wet)	$\pm 650 \text{ kV}_p$	$\pm 170 \text{ kV}_p$
3.	Power frequency withstand voltage (dry & wet)	275 kV_{rms}	75 kV_{rms}
4.	Total Creepage distance (min)	3625 mm	900 mm

4.6.3 **Major Technical Parameters**

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

a. **For 145 kV Circuit Breaker and Isolator**

S. No.	Description of Parameters	Value
1.	Rated Voltage (rms)	145 kV
2.	Rated Frequency	50 Hz
3.	No. of Poles	3
4.	Design Ambient Temperature	50°C
5.	Rated Insulations Levels	
	a Full wave impulse withstand voltage (1.2/50 μsec)	
	i. Between Line Terminals and Ground	$\pm 650 \text{ kV}_p$
	ii. Between Terminals with Circuit Breaker Open	$\pm 650 \text{ kV}_p$
	iii. Between Terminals with Isolator Open	$\pm 750 \text{ kV}_p$
	b One minute power frequency dry and wet withstand voltage (rms)	
	i. Between Line Terminals and Ground	275 kV_p
	ii. Between Terminals with Circuit Breaker Open	275 kV_p
	iii. Between Terminals with Isolator Open	315 kV_p
6.	Minimum Clearance Distance	
	a Phase to Ground	3625 mm
	b Between CB Terminals	3625 mm
6.	System Neutral Earthing	Effectively earthed
7.	Horizontal Seismic Coefficient	0.5g

8.	Rating of Auxiliary Contacts (as applicable)	10 A at 110 V DC
9.	Breaking Capacity of Auxiliary Contacts with Circuit Time constant of not less than 20ms	2 A DC
10.	Phase to Phase spacing	2700/3000 mm

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

b. For 145 kV CT/CVT/LA (SA)

S. No.	Description of Parameters	Value
1.	Rated Voltage (rms)	145 kV
2.	Rated Frequency	50 Hz
3.	No. of Poles	1
4.	Design Ambient Temperature	50°C
5.	Rated Insulations Levels	
	a Full wave impulse withstand voltage (1.2/50 μ sec)	
	Between Line Terminals and Ground for CT & CVT	± 650 kV _p
	For Arrester Housing	± 650 kV _p
	b One minute power frequency dry and wet withstand voltage (rms)	
	Between Line Terminals and Ground for CT & CVT	275 kV _p
	For Arrester Housing	275 kV _p
6.	Minimum Clearance Distance	
	a Phase to Ground	3625 mm
7.	System Neutral Earthing	Effectively earthed
8.	Horizontal Seismic Coefficient	0.5g
9.	Partial Discharge for	
	a Surge Arrester at 1.05 COV	< 50 pc
	b For CT/VT	<10 pc

c. For 33 kV Circuit Breaker and Isolator

S. No.	Description of Parameters	Value
1.	Rated Voltage (rms)	36 kV
2.	Rated Frequency	50 Hz
3.	No. of Poles	3
4.	Design Ambient Temperature	50°C

5.	Rated Insulations Levels	
	a Full wave impulse withstand voltage (1.2/50 μ sec)	
	i. Between Line Terminals and Ground	± 170 kV _p
	ii. Between Terminals with CB Open	± 170 kV _p
	iii. Between Terminals with Isolator Open	± 170 kV _p
	b One minute power frequency dry and wet withstand voltage (rms)	
	i. Between Line Terminals and Ground	70 kV _p
	ii. Between Terminals with CB Open	70 kV _p
	iii. Between Terminals with Isolator Open	70 kV _p
6.	Minimum Clearance Distance	
	a Phase to Ground	900 mm
	b Between CB Terminals	900 mm
6.	System Neutral Earthing	Effectively Earthed
7.	Horizontal Seismic Coefficient	0.5g
8.	Rating of Auxiliary Contacts (as applicable)	10 A at 110 V DC
9.	Breaking Capacity of Auxiliary Contacts with Circuit Time constant of not less than 20ms	2 A DC

Auxiliary Switch shall also comply with other clauses of Section - GTR

d. For 33 kV CT/CVT/LA (SA)

S. No.	Description of Parameters	Value
1.	Rated Voltage (rms)	36 kV
2.	Rated Frequency	50 Hz
3.	No. of Poles	1
4.	Design Ambient Temperature	50°C
5.	Rated Insulations Levels	
	a Full wave impulse withstand voltage (1.2/50 μ sec)	
	Between Line Terminals and Ground for CT & CVT	± 170 kV _p
	For Arrester Housing	± 170 kV _p
	b One minute power frequency dry and wet withstand voltage (rms)	
	Between Line Terminals and Ground for CT & CVT	70 kV
	For Arrester Housing	70 kV
6.	Minimum Clearance Distance	
	a Phase to Ground	900 mm

7.	System Neutral Earthing	Effectively earthed
8.	Horizontal Seismic Coefficient	0.5g
9.	Minimum Cantilever Strength of Bushing	350 kg

e. Technical Parameters of Bushings/Hollow Column/Support

S. No.	Description of Parameters	Value
1.	Rated Voltage (rms)	36 kV
2.	Impulse withstand voltage (Dry & Wet)	$\pm 170 \text{ kV}_p$
3.	Power Frequency withstand Voltage (Dry & Wet)	75 kV rms
4.	Total Creepage Distance	900 mm
5.	Pollution Class	as per IEC 71

The requirement of alternate long & short sheds stated in model technical specification shall not be applicable in case of 33 kV.

5. Engineering Data and Drawings

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

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

- 5.2 The Contractor shall submit 2 (two) sets of drawings/ design documents /data / detailed bill of quantity and 1 (one) set of test reports for the approval of the Employer. The contractor shall also submit the softcopy of the above documents in addition to hardcopy.

5.3 Drawings

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

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

- 5.3.3 The review of these data by the Employer will cover only general conformance of the data to the specifications and documents interfaces with the equipment provided under the specifications, external connections and of the dimensions which might affect substation layout. This review by the Employer may not indicate a thorough review of all dimensions, quantities and details of the equipment, materials, any devices or items indicated or the accuracy of the

information submitted. This review and/or approval by the Employer shall not be considered by the Contractor, as limiting any of his responsibilities and liabilities for mistakes and deviations from the requirements, specified under these specifications and documents.

- 5.4 All manufacturing and fabrication work in connection with the equipment prior to the approval of the drawings shall be at the Contractor's risk. The Contractor may make any changes in the design which are necessary to make the equipment conform to the provisions and intent of the Contract and such changes will again be subject to approval by the Employer. Approval of Contractor's drawing or work by the Employer shall not relieve the contractor of any of his responsibilities and liabilities under the Contract.
- 5.5 All engineering data submitted by the Contractor after final process including review and approval by the Employer shall form part of the Contract Document and the entire works performed under these specifications shall be performed in strict conformity, unless otherwise expressly requested by the Employer in writing.

5.6 Approval Procedure

- 5.6.1 The scheduled dates for the submission of the drawings as well as for, any data/information to be furnished by the Employer would be discussed and finalized at the time of award. The following schedule shall be followed generally for approval and for providing final documentation.
- | | |
|--|--|
| a. Approval/Comments by the Employer on initial submission | As per agreed schedule |
| b. Resubmission (whenever required) | Within 3 (three) weeks from the date of comments |
| c. Approval or comments | Within 3 (three) weeks of receipt of resubmission |
| d. Furnishing of Distribution Copies (four hard copies and one pdf copy) | Within 2 (two) weeks from the date of approval |
| e. Furnishing of distribution copies of test reports | |
| i. Type Test Reports (One hard copies and one pdf copy) | Within 2 (two) weeks from the date of final approval |
| ii. Routine Test Reports (One hard copies and one pdf copy) | Within 2 (two) weeks from the date of final approval |
| f. Furnishing of instruction/operation manuals (four hard copies and one pdf copy) | As per agreed schedule |
| g. As built drawings (four copies and one pdf copy) | On completion of entire works |

NOTE

- 1) The contractor may please note that all resubmissions must incorporate all comments given in the earlier submission by the Employer or adequate justification for not incorporating the same must be submitted failing which the submission of documents is likely to be returned.
- 2) All drawings should be submitted in softcopy form, however substation design drawings like SLD, GA, all layouts etc. shall also be submitted in AutoCAD Version. SLD, GA & layout drawings shall be submitted for the entire substation in case of substation extension also.

- 3) The instruction Manuals shall contain full details of drawings of all equipment being supplied under this contract, their exploded diagrams with complete instructions for storage, handling, erection, commissioning, testing, operation, trouble shooting, servicing and overhauling procedures.
- 4) If after the commissioning and initial operation of the substation, the instruction manuals require any modifications/ additions/changes, the same shall be incorporated and the updated final instruction manuals shall be submitted by the Contractor to the Employer.
- 5) The Contractor shall furnish to the Employer catalogues of spare parts.
- 6) All As-built drawings/documents shall be certified by site indicating the Changes before final submission.

6. 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 Employer shall decide upon the question of similarity. When required by the specification or when required by the Employer the Contractor shall submit, for approval, all the information concerning the materials or components to be used in manufacture. Machinery, equipment, materials and components supplied, installed or used without such approval shall run the risk of subsequent rejection, it being understood that the cost as well as the time delay associated with the rejection shall be borne by the Contractor.
- 6.1.3 The design of the Works shall be such that installation, future expansions, replacements and general maintenance may be undertaken with a minimum of time and expenses. Each component shall be designed to be consistent with its duty and suitable factors of safety, subject to mutual agreements. All joints and fastenings shall be devised, constructed and documented so that the component parts shall be accurately positioned and restrained to fulfill their required function. In general, screw threads shall be standard metric threads. The use of other thread forms will only be permitted when prior approval has been obtained from the Employer.
- 6.1.4 Whenever possible, all similar part of the Works shall be made to gauge and shall also be made interchangeable with similar parts. All spare parts shall also be interchangeable and shall be made of the same materials and workmanship as the corresponding parts of the Equipment supplied under the Specification. Where feasible, common component units shall be employed in different pieces of equipment in order to minimize spare parts stocking requirements. All equipment of the same type and rating shall be physically and electrically interchangeable.
- 6.1.5 All materials and equipment shall be installed in strict accordance with the manufacturer's recommendation(s). Only first-class work in accordance with the best modern practices will be accepted. Installation shall be considered as being the erection of equipment at its permanent location. This, unless

otherwise specified, shall include unpacking, cleaning and lifting into position, grouting, leveling, aligning, coupling of or bolting down to previously installed equipment bases/foundations, performing the alignment check and final adjustment prior to initial operation, testing and commissioning in accordance with the manufacturer's tolerances, instructions and the Specification. All factory assembled rotating machinery shall be checked for alignment and adjustments made as necessary to re-establish the manufacturer's limits suitable guards shall be provided for the protection of personnel on all exposed rotating and / or moving machine parts and shall be designed for easy installation and removal for maintenance purposes. The spare equipment(s) shall be installed at designated locations and tested for healthiness.

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

6.2 Provisions for Exposure to Hot and Humid climate

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

6.2.2 Space Heaters

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

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.

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

6.2.3 Fungi Static Varnish

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

6.2.4 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.

6.2.5 Degree of Protection

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

a. Installed out door	IP-55
b. Installed indoor in air conditioned area	IP-31
c. Installed in covered area	IP-52
d. Installed indoor in non-air conditioned area where possibility of entry of water is limited	IP-41
e. For LT Switchgear (AC & DC distribution Boards)	IP-52

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

6.3 Rating Plates, Name Plates and Labels

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

6.3.2 All such nameplates, instruction plates, rating plates of transformers, reactors, CB, CT, CVT, SA, Isolators, C & R panels and FO communication equipment shall be provided with English inscriptions and shall be approved by Employer.

6.4 First Fill of Consumables, Oil and Lubricants

6.4.1 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. Design Improvements/ Coordination

7.1 It shall be note that the equipment offered in the Tender only shall be accepted for supply. However, the Employer or the Contractor may propose changes in the specification of the equipment or quality thereof and if the Employer & the Contractor agree upon any such changes, the specification shall be modified accordingly.

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

7.3 The Contractor shall be responsible for the selection and design of appropriate equipment to provide the best coordinated performance of the entire system. The basic design requirements are detailed out in this Specification. The design of various components, sub-assemblies and assemblies shall be so done that it facilitates easy field assembly and maintenance.

- 7.4 The Contractor has to coordinate designs and terminations with the agencies (if any) who are Consultants/Contractor for the Employer. The names of agencies shall be intimated to the Contractor.
- 7.5 The Contractor will be called upon to attend design co-ordination meetings with the Engineer, other Contractor's and the Consultants of the Employer (if any) during the period of Contract. The Contractor shall attend such meetings at his own cost at Employer's Corporate Centre, Nepal or at mutually agreed venue as and when required and fully cooperate with such persons and agencies involved during those discussions.

8. Quality Assurance Programme

- 8.1 To ensure that the equipment and services under the scope of this Contract whether manufactured or performed within the Contractor's Works or at his Sub-contractor's premises or at the Employer's site or at any other place of Work are in accordance with the specifications, the Contractor shall adopt suitable quality assurance programme to control such activities at all points necessary. Such programme shall be broadly outlined by the Contractor and finalized after discussions before the award of contract. The detailed programme shall be submitted by the contractor after the award for reference. A quality assurance programme of the contractor shall generally cover the following:
- His organization structure for the management and implementation of the proposed quality assurance programme;
 - Documentation control system;
 - Qualification data for Contractor's key personnel;
 - 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.
 - System for shop manufacturing and site erection controls including process controls and fabrication and assembly control;
 - Control of non-conforming items and system for corrective actions;
 - Inspection and test procedure both for manufacture and field activities.
 - Control of calibration and testing of measuring instruments and field activities;
 - System for indication and appraisal of inspection status;
 - System for quality audits;
 - System for authorizing release of manufactured product to the Purchaser.
 - System for maintenance of records;
 - System for handling storage and delivery; and
 - A quality plan detailing out the specific quality control measures and procedures adopted for controlling the quality characteristics relevant to each item of equipment furnished and/or services rendered.

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

8.2 Quality Assurance Documents

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

9. Type Testing, Inspection, Testing & Inspection Certificate

- 9.1 All equipment being supplied shall conform to type tests as per technical specification and shall be subject to routine tests in accordance with requirements stipulated under respective sections.
- 9.2 The reports for all type tests as per technical specification shall be furnished by the Contractor along with equipment / material drawings. The type tests conducted earlier should have been conducted in accredited laboratory (accredited based on IEC Guide 25 / 17025 or EN 45001 by the national accreditation body of the country where laboratory is located).

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

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

- a. Lightning Impulse Test
- b. Switching Impulse Test
- c. Multiple Chopped Impulse Test (For CT)

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

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

The Contractor shall intimate the Employer the detailed program about the tests at least three (3) weeks in advance in case of domestic supplies & six (6) weeks in advance in case of foreign supplies.

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

- 9.3 The Employer, his duly authorized representative and/or outside inspection agency acting on behalf of the Employer shall have at all reasonable times free access to the Contractor's/sub-vendors premises or Works and shall have the power at all reasonable times to inspect and examine the materials and workmanship of the Works during its manufacture or erection if part of the Works is being manufactured or assembled at other premises or works, the Contractor shall obtain for the Engineer and for his duly authorized representative permission to inspect as if the works were manufactured or assembled on the Contractor's own premises or works. Inspection may be made at any stage of manufacture, dispatch or at site at the option of the Employer and the equipment if found unsatisfactory due to bad workmanship or quality, material is liable to be rejected.
- 9.4 The Contractor shall give the Employer/Inspector written notice for at least three (3) weeks in advance in case of domestic material & six (6) weeks in advance in case of foreign materials being ready for joint testing including contractor and Employer. Such

tests shall be to the Contractor's account except for the expenses of the Inspector. The Employer/ inspector, unless witnessing of the tests is virtually waived, will attend such tests within three (3) weeks in case of domestic material & six (6) weeks of the date of which the equipment is notified as being ready for test/ inspection. The inspection date shall be according to approved work schedule.

- 9.5 The Employer or Inspector shall, within fifteen (15) days from the date of inspection as defined herein give notice in writing to the Contractor, of any objection to any drawings and all or any equipment and workmanship which in his opinion is not in accordance with the Contract. The Contractor shall give due consideration to such objections and shall either make the modifications that may be necessary to meet the said objections or shall confirm in writing to the Employer /Inspector giving reasons therein, that no modifications are necessary to comply with the Contract.
- 9.6 When the factory tests have been completed at the Contractor's or Sub-Contractor's works, the Employer/inspector shall issue a certificate to this effect within fifteen (15) days after completion of tests but if the tests are not witnessed by the Employer /Inspector, the certificate shall be issued within fifteen (15) days of receipt of the Contractor's Test certificate by the Engineer/Inspector. Failure of the Employer/ Inspector to issue such a certificate shall not prevent the Contractor from proceeding with the Works. The completion of these tests or the issue of the certificate shall not bind the Employer to accept the equipment should, it, on further tests after erection, is found not to comply with the Contract. The equipment shall be dispatched to site only after approval of test reports and issuance of CIP by the Employer.
- 9.7 In all cases where the Contract provides for tests whether at the premises or at the works of the Contractor or of any Sub-Contractor, the Contractor except where otherwise specified shall provide free of charge such items as labor, materials, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Employer /Inspector or his authorized representative to carry out effectively such tests of the equipment in accordance with the Contract and shall give facilities to the Employer /Inspector or to his authorized representative to accomplish testing.
- 9.8 The inspection by Employer and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed quality assurance Programme forming a part of the Contract.
- 9.9 The Employer will have the right of having at his own expenses any other test(s) of reasonable nature carried out at Contractor's premises or at site or in any other place in addition of aforesaid type and routine tests, to satisfy that the material comply with the specification.
- 9.10 The Employer reserves the right for getting any field tests not specified in respective sections of the technical specification conducted on the completely assembled equipment at site. The testing equipment for these tests shall be provided by the Employer.
- 9.11 The contractor has to involve a reputed independent third party inspection agency for the Factory tests as per the specification (Chapter 3, Clause 5.2) and IEC standard at the testing laboratory of Transformer Manufacturer before dispatch of the power transformers supplied under this Contract. The factory tests shall be carried out in presence of reputed independent third party inspector and NEA personnel. **Independent third party inspector shall bear full responsibility for proper testing of all transformer and authenticity of test result. Besides, they shall have to declare in written that power transformers are/aren't as per contract.** The involvement days of third party inspector/s shall not be less than 15 days.

The Contractor have to propose the name of reputed independent third party inspection agency along with their bid. All the cost of Factory tests as per the specification and IEC standard and the cost of independent third party inspector/s shall be borne by the contractor.

10. Tests

10.1 Pre-commissioning Tests

On completion of erection of the equipment and before charging, each item of the equipment shall be thoroughly cleaned and then inspected jointly by the Employer and the Contractor for correctness and completeness of installation and acceptability for charging, leading to initial pre-commissioning tests at Site. The lists of pre-commissioning tests to be performed are given in respective sections and shall be included in the Contractor's quality assurance Programme.

10.2 Commissioning Tests

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

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

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

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

11. Packaging & Protection

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

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

12. Finishing of Metal Surfaces

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

12.2 Hot Dip Galvanizing

- 12.2.1 The minimum weight of the zinc coating shall be 610 gm/m² and minimum average thickness of coating shall be 86 microns for all items having thickness 6mm and above. For items lower than 6mm thickness requirement of coating thickness shall be as per relevant ASTM. For surface which shall be embedded in concrete, the zinc coating shall be 610 gm/m² minimum.
- 12.2.2 The galvanized surfaces shall consist of a continuous and uniform thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be clean and smooth and shall be free from defects like discolored patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel globules, spiky deposits, blistered surface, flaking or peeling off, etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.
- 12.2.3 After galvanizing, no drilling or welding shall be performed on the galvanized parts of the equipment excepting that nuts may be threaded after galvanizing. Sodium dichromate treatment shall be provided to avoid formation of white rust after hot dip galvanization.
- 12.2.4 The galvanized steel shall be subjected to six one-minute dips in copper Sulphate solution as per IEC.
- 12.2.5 Sharp edges with radii less than 2.5 mm shall be able to withstand four immersions of the Standard Preece test. All other coatings shall withstand six immersions. The following galvanizing tests should essentially be performed as per relevant Indian Standards.
- Coating thickness
 - Uniformity of zinc
 - Adhesion test
 - Mass of zinc coating
- 12.2.6 Galvanized material must be transported properly to ensure that galvanized surfaces are not damaged during transit. Application of zinc rich paint at site shall not be allowed.

12.3 Painting

- 12.3.1 All sheet steel work shall be degreased, pickled, and phosphated in accordance with the IS-6005/Equivalent International standard "Code of practice for phosphating iron and sheet". All surfaces, which will not be easily accessible after shop assembly, shall beforehand be treated and protected for the life of the equipment. The surfaces, which are to be finished painted after installation or require corrosion protection until installation, shall be shop painted with at least two coats of primer. Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.
- 12.3.2 After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying. The phosphate coating shall be sealed with application of two coats of ready mixed, stoving type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved.
- 12.3.3 After application of the primer, two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after inspection of first coat of painting.

- 12.3.4 The exterior and interior color of the paint in case of new substations shall preferably be RAL 7032 for all equipment, marshalling boxes, junction boxes, control cabinets, panels etc. unless specifically mentioned under respective sections of the equipment. Glossy white color inside the equipment/boards /panels/junction boxes is also acceptable. The exterior color for panels shall be matching with the existing panels in case of extension of a substation. Each coat of primer and finishing paint shall be of slightly different shade to enable inspection of the painting. A small quantity of finishing paint shall be supplied for minor touching up required at site after installation of the equipment.
- 12.3.5 In case the Tenderer proposes to follow his own standard surface finish and protection procedures or any other established painting procedures, like electrostatic painting etc., the procedure shall be submitted along with the Tender for Employer's review & approval.
- 12.3.6 For aluminium casted surfaces, the surface shall be with smooth finish. Further, in case of aluminium enclosures the surface shall be coated with powder (coating thickness of 60 microns) after surface preparation for painting.

13. Handling, Storing and Installation

- 13.1 In accordance with the specific installation instructions as shown on manufacturer's drawings or as directed by the Employer or his representative, the Contractor shall unload, store, erect, install, wire, test and place into commercial use all the equipment included in the contract. Equipment shall be installed in a neat, workmanlike manner so that it is level, plumb, square and properly aligned and oriented. Commercial use of switchyard equipment means completion of all site tests specified and energization at rated voltage.
- 13.2 The Contractor may engage manufacturer's Engineers to supervise the unloading, transportation to site, storing, testing and commissioning of the various equipment being procured by them separately. Contractor shall unload, transport, store, erect, test and commission the equipment as per instructions of the manufacturer's supervisory Engineer(s) and shall extend full cooperation to them.
- 13.3 The contractor shall have to ensure that the hard and flat indoor and outdoor storage areas are in place prior to commencement of delivery of material at site. Contractor shall also ensure availability of proper unloading and material handling equipment like cranes etc. and polyester/nylon ropes of suitable capacity to avoid damage during unloading and handling of material at site. All indoor equipment shall be stored indoors. Outdoor equipment may be stored outdoors but on a hard and flat raised area properly covered with waterproof and dustproof covers to protect them from water seepage and moisture ingress. However, all associated control panels, marshalling boxes operating boxes etc. of outdoor equipment are to be stored indoors only.
- Storage of equipment on top of another one is not permitted if the wooden packing is used. Material opened for joint inspection shall be repacked properly as per manufacturer's recommendations.
- During storage of material regular periodic monitoring of important parameters like oil level / leakage, SF6 / Nitrogen pressure etc. shall be ensured by the contractor.
- 13.4 In case of any doubt/misunderstanding as to the correct interpretation of manufacturer's drawings or instructions, necessary clarifications shall be obtained from the Employer. Contractor shall be held responsible for any damage to the equipment consequent to not following manufacturer's drawings/instructions correctly.

- 13.5 Where assemblies are supplied in more than one section, Contractor shall make all necessary mechanical and electrical connections between sections including the connection between buses. Contractor shall also do necessary adjustments/alignments necessary for proper operation of circuit breakers, isolators and their operating mechanisms. All components shall be protected against damage during unloading, transportation, storage, installation, testing and commissioning. Any equipment damaged due to negligence or carelessness or otherwise shall be replaced by the Contractor at his own expense.
- 13.6 Contractor shall be responsible for examining all the shipment and notify the Employer immediately of any damage, shortage, discrepancy etc. for the purpose of Employer's information only. The Contractor shall submit to the Employer every week a report detailing all the receipts during the weeks. However, the Contractor shall be solely responsible for any shortages or damages in transit, handling and/or in storage and erection of the equipment at Site. Any demurrage, wharfage and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor.
- 13.7 The Contractor shall be fully responsible for the equipment/material until the same is handed over to the Employer in an operating condition after commissioning. Contractor shall be responsible for the maintenance of the equipment/material while in storage as well as after erection until taken over by Employer, as well as protection of the same against theft, element of nature, corrosion, damages etc.
- 13.8 Where material/ equipment is unloaded by Employer before the Contractor arrives at site or even when he is at site, Employer by right can hand over the same to Contractor and there upon it will be the responsibility of Contractor to store the material in an orderly and proper manner.
- 13.9 The Contractor shall be responsible for making suitable indoor storage facilities, to store all equipment which requires indoor storage.
- 13.10 The words 'erection' and 'installation' used in the specification are synonymous.
- 13.11 Exposed live parts shall be placed high enough above ground to meet the requirements of electrical and other statutory safety codes.
- 13.12 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life. If at any stage during the execution of the Contract, it is observed that the erected equipment(s) do not meet the above minimum clearances as given in clause 4.7.1 the Contractor shall immediately proceed to correct the discrepancy at his risks and cost.
- 13.13 **Equipment Bases**
A cast iron or welded steel base plate shall be provided for all rotating equipment which is to be installed on a concrete base unless otherwise agreed to by the Employer. Each base plate shall support the unit and its drive assembly, shall be of a neat design with pads for anchoring the units, shall have a raised lip all around, and shall have threaded drain connections.

14. Tools and Tackles

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

15. Auxiliary Supply

- 15.1 The sub-station auxiliary supply is normally met through a system indicated under section "Electrical & Mechanical Auxiliaries" having the following parameters. The auxiliary power for station supply, including the equipment drive, cooling system of any

equipment, air-conditioning, lighting etc. shall be designed for the specified Parameters as under. The DC supply for the instrumentation and FO communication system shall also conform the parameters as indicated in the following.

Normal Voltage	Variation in Voltage	Frequency in Hz	Phase/wire	Neutral Connection
400V	± 10	$50 \pm 2.5\%$	3/4 wire	Solidly Earthed
230V	± 10	$50 \pm 2.5\%$	1/2 wire	Solidly Earthed
110V	95V to 120V	DC	-	Isolated 2 wire system
48V	-	DC	-	2 wire system (+) earthed

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

16. Support Structure

- 16.1 All equipment support structures shall be supplied along with brackets, angles, stools etc. for attaching the operating mechanism, control cabinets & marshalling box (wherever applicable) etc.
- 16.2 Support structure shall meet the following mandatory requirements:
- 16.3 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 meters.

17. Clamps and Connectors Including Terminal Connectors

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

For connecting, ACSR conductors	Aluminum alloy casting conforming to BS:1490/ Equivalent International Standard
For connection equipment terminals made of copper with ACSR conductors	Bimetallic connectors made from aluminum alloy casting conforming to BS: 1490/ Equivalent International Standard with 2 mm thick bimetallic liner.
For connecting GI	Galvanized mild shield wire
i. Bolts nuts and plain washers	Electro-galvanized for sizes below M12, for others hot dip galvanized
ii. Spring washers for item	Electrogalvanized mild steel

- 17.2 Necessary clamps and connectors shall be supplied for all equipment and connections. The requirement regarding external corona and RIV as specified for any equipment shall include its terminal fittings. If corona rings are required to meet these requirements they shall be considered as part of that equipment and included in the scope of work.
- 17.3 Where copper to aluminum connections is required, bi-metallic clamps shall be used, which shall be properly designed to ensure that any deterioration of the connection is kept to a minimum and restricted to parts which are not current carrying or subjected to stress.

- 17.4 Low voltage connectors, grounding connectors and accessories for grounding all equipment as specified in each particular case, are also included in the scope of Work.
- 17.5 No current carrying part of any clamp shall be less than 10 mm thick. All ferrous parts shall be hot dip galvanized. Copper alloy liner of minimum 2 mm thickness shall be cast integral with aluminum body or 2 mm thick bi-metallic strips shall be provided for Bi-metallic clamps.
- 17.6 All casting shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be blurred and rounded off.
- 17.7 Flexible connectors, braids or laminated straps made for the terminal clamps for bus posts shall be suitable for both expansion or through (fixed/sliding) type connection of 4" IPS AL. tube as required. In both the cases the clamp height (top of the mounting pad to centre line of the tube) should be same.
- 17.8 Clamp shall be designed to carry the same current as the conductor and the temperature rise shall be equal or less than that of the conductor at the specified ambient temperature. The rated current for which the clamp/connector is designed with respect to the specified reference ambient temperature, shall also be indelibly marked on each component of the clamp/connector, except on the hardware.
- 17.9 All current carrying parts shall be designed and manufactured to have minimum contact resistance.
- 17.10 Clamps and connectors shall be designed to be corona controlled.
- 17.11 **Tests**
Clamps and connectors should be type tested as per NEMA CC1/ Equivalent International Standard and shall also be subjected to routine tests as per NEMA CC1/ Equivalent International Standard. Following type test reports shall be submitted for approval as per clause 9.2 above except for S. no.(b) & (c) for which type test once conducted shall be applicable (i.e. the requirement of test conducted within last ten years shall not be applicable).
 - a. Temperature rise test (maximum temperature rise allowed is 35°C over 50°C ambient)
 - b. Short time current test
 - c. Corona (dry) and RIV (dry) test
 - d. Resistance test and tensile test

18. Control Cabinets, Junction Boxes, Terminal Boxes & Marshalling Boxes for Outdoor Equipment

- 18.1 All types of boxes, cabinets etc. shall generally conform to & be tested in accordance with IEC-60439, as applicable, and the clauses given below.
- 18.2 Control cabinets, junction boxes, marshalling boxes & terminal boxes shall be made of sheet steel or aluminum enclosure and shall be dust, water and vermin proof. Sheet steel used shall be at least 2.0 mm thick cold rolled or 2.5 mm hot rolled or alternately 1.6 mm thick stainless steel can also be used. The box shall be properly braced to prevent wobbling. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation. In case of aluminum enclosed box the thickness of aluminum shall be such that it provides adequate rigidity and long life as comparable with sheet steel of specified thickness.
- 18.3 A canopy and sealing arrangements for operating rods shall be provided in marshalling boxes / Control cabinets to prevent ingress of rain water.
- 18.4 Cabinet/boxes shall be provided with double hinged doors with padlocking arrangements. The distance between two hinges shall be adequate to ensure uniform

sealing pressure against atmosphere. The quality of the gasket shall be such that it does not get damaged/cracked during the operation of the equipment.

- 18.5 All doors, removable covers and plates shall be gasketed all around with suitably profiled EPDM/Neoprene gaskets. The gasket shall be tested in accordance with approved quality plan, BS: 4255/ Equivalent International Standard. Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh made of brass.
- 18.6 All boxes/cabinets shall be designed for the entry of cables from bottom by means of weather proof and dust-proof connections. Boxes and cabinets shall be designed with generous clearances to avoid interference between the wiring entering from below and any terminal blocks or accessories mounted within the box or cabinet. Suitable cable gland plate above the base of the marshalling kiosk/box shall be provided for this purpose along with the proper blanking plates. Necessary number of cable glands shall be supplied and fitted on this gland plate. Gland plate shall have provision for some future glands to be provided later, if required. The Nickel-plated glands shall be dust proof, screw on & double compression type and made of brass. The gland shall have provision for securing armour of the cable separately and shall be provided with earthing tag. The glands shall conform to BS: 6121.
- 18.7 A 230V, single phase, 50 Hz, 15-amp AC plug and socket shall be provided in the cabinet with ON-OFF switch for connection of hand lamps. Plug and socket shall be of industrial grade.
- 18.8 For illumination, a fluorescent tube, LED tube or LED (low power consumption) of approximately 9 to 15 watts shall be provided. The switching of the fittings shall be controlled by the door switch.

For junction boxes of smaller sizes such as lighting junction box, manual operated earth switch mechanism box etc., plug socket, heater and illumination is not required to be provided.
- 18.9 All control switches shall be of MCB/rotary switch type and Toggle/piano switches shall not be accepted.
- 18.10 Positive earthing of the cabinet shall be ensured by providing two separate earthing pads. The earth wire shall be terminated on to the earthing pad and secured by the use of self-etching washer. Earthing of hinged door shall be done by using a separate earth wire.
- 18.11 The bay marshalling kiosks shall be provided with danger plate and a diagram showing the numbering/connection/feruling by pasting the same on the inside of the door.
- 18.12 The following routine tests along with the routine tests as per IEC 60529/ Equivalent International Standard shall also be conducted:
 - a. Check for wiring
 - b. Visual and dimension check

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

19. Terminal Blocks and Wiring

- 19.1 Control and instrument leads from the switchboards or from other equipment will be brought to terminal boxes or control cabinets in conduits. All inter phase and external connections to equipment or to control cubicles will be made through terminal blocks.
- 19.2 Terminal blocks shall be 650V grade and have continuous rating to carry the maximum expected current on the terminals and non-breakable type. These shall be of moulded

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

- 19.3 Terminal blocks for current transformer and voltage transformer secondary leads shall be provided with test links and isolating facilities. The current transformer secondary leads shall also be provided with short circuiting and earthing facilities.
- 19.4 The terminal shall be such that maximum contact area is achieved when a cable is terminated. The terminal shall have a locking characteristic to prevent cable from escaping from the terminal clamp unless it is done intentionally.
- 19.5 The conducting part in contact with cable shall preferably be tinned or silver plated however Nickel-plated copper or zinc plated steel shall also be acceptable.
- 19.6 The terminal blocks shall be of extensible design.
- 19.7 The terminal blocks shall have locking arrangement to prevent its escape from the mounting rails.
- 19.8 The terminal blocks shall be fully enclosed with removable covers of transparent, non-deteriorating type plastic material. Insulating barriers shall be provided between the terminal blocks. These barriers shall not hinder the operator from carrying out the wiring without removing the barriers.
- 19.9 Unless otherwise specified terminal blocks shall be suitable for connecting the following conductors on each side.
 - a. All circuits except CT/PT Circuits Minimum of 2 nos. of 2.5mm² copper flexible.
 - b. All CT/PT circuits Minimum of 4 nos. of 2.5mm² copper flexible.
- 19.10 The arrangements shall be in such a manner so that it is possible to safely connect or disconnect terminals on live circuits and replace fuse links when the cabinet is live.
- 19.11 At least 20 % spare terminals shall be provided on each panel/cubicle/box and these spare terminals shall be uniformly distributed on all terminal's rows.
- 19.12 There shall be a minimum clearance of 250 mm between the First/bottom row of terminal block and the associated cable gland plate for outdoor ground mounted marshalling box and the clearance between two rows of terminal blocks shall be a minimum of 150 mm.
- 19.13 The Contractor shall furnish all wire, conduits and terminals for the necessary inter phase electrical connections (where applicable) as well as between phases and common terminal boxes or control cabinets.
- 19.14 All input and output terminals of each control cubicle shall be tested for surge withstand capability in accordance with the relevant IEC Publications, in both longitudinal and transverse modes. The Contractor shall also provide all necessary filtering, surge protection, interface relays and any other measures necessary to achieve an impulse withstand level at the cable interfaces of the equipment.

20. Lamps & Sockets

20.1 Sockets

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

20.2 Hand Lamp

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

20.3 Switches and Fuses

- 20.3.1 Each panel shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with miniature circuit breaker / switch fuse units. Selection of the main and Sub-circuit fuse ratings shall be such as to ensure selective clearance of sub-circuit faults. Potential circuits for relaying and metering shall be protected by HRC fuses.
- 20.3.2 All fuses shall be of HRC cartridge type conforming to IS: 9228/ Equivalent International Standard mounted on plug-in type fuse bases. Miniature circuit breakers with thermal protection and alarm contacts will also be accepted. All accessible live connection to fuse bases shall be adequately shrouded. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage.

21. Bushings, Hollow Column Insulators, Support Insulators:

- 21.1 Bushings shall be manufactured and tested in accordance with IEC-60137 while hollow column insulators shall be manufactured and tested in accordance with IEC-62155. The support insulators shall be manufactured and tested as per IEC-60168 and IEC-60273. The insulators shall also conform to IEC-60815 as applicable.
- The bidder may also offer composite hollow insulators, conforming to IEC-61462.
- 21.2 Support insulators, bushings and hollow column insulators shall be manufactured from high quality porcelain. Porcelain used shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified tough and impervious to moisture.
- 21.3 Glazing of the porcelain shall be uniform brown in color, free from blisters, burrs and similar other defects.
- 21.4 Support insulators/bushings/hollow column insulators shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which they will be used.
- 21.5 When operating at normal rated voltage there shall be no electric discharge between the conductors and bushing which would cause corrosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action. No radio interference shall be caused by the insulators/bushings when operating at the normal rated voltage.
- 21.6 Bushing porcelain shall be robust and capable of withstanding the internal pressures likely to occur in service. The design and location of clamps and the shape and the strength of the porcelain flange securing the bushing to the tank shall be such that there is no risk of fracture. All portions of the assembled porcelain enclosures and supports other than gaskets, which may in any way be exposed to the atmosphere shall be composed of completely non hygroscopic material such as metal or glazed porcelain.
- 21.7 All iron parts shall be hot dip galvanized and all joints shall be air tight. Surface of joints shall be trued up porcelain parts by grinding and metal parts by machining. Insulator/bushing design shall be such as to ensure a uniform compressive pressure on the joints.
- 21.8 **Tests**
- In bushing, hollow column insulators and support insulators shall conform to type tests and shall be subjected to routine tests in accordance with IS: 2099 & IS: 2544 & IS : 5621/ Equivalent International Standard .

22. Motors

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

22.2 Enclosures

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

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

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

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

22.3 Operational Features

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

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

22.4 Starting Requirements

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

22.4.2 Motors shall be capable of withstanding the electro dynamic stresses and heating imposed if it is started at a voltage of 110% of the rated value.

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

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

22.4.5 The locked rotor withstand time under hot condition at 110% of rated voltage shall be more than starting time with the driven equipment of minimum permissible voltage by at least two seconds or 15% of the accelerating time whichever is greater. In case it is not possible to meet the above requirement, the Contractor shall offer centrifugal type speed switch mounted on the motor shaft which shall remain closed for speed lower than

20% and open for speeds above 20% of the rated speed. The speed switch shall be capable of withstanding 120% of the rated speed in either direction of rotation.

22.5 Running Requirements

- 22.5.1 The maximum permissible temperature rise over the ambient temperature of 50 degree C shall be within the limits specified in IS: 325/ Equivalent International Standard (for 3 - phase induction motors) after adjustment due to increased ambient temperature specified.
- 22.5.2 The double amplitude of motor vibration shall be within the limits specified in IS: 4729/ Equivalent International Standard. Vibration shall also be within the limits specified by the relevant standard for the driven equipment when measured at the motor bearings.
- 22.5.3 All the induction motors shall be capable of running at 80% of rated voltage for a period of 5 minutes with rated load commencing from hot condition.

22.6 Testing and Commissioning

- 22.6.1 An indicative list of tests is given below. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./Instructions of the equipment Contractor or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates and shall furnish the list of instruments to the Employer for approval.
 - a. Insulation resistance.
 - b. Phase sequence and proper direction of rotation.
 - c. Any motor operating incorrectly shall be checked to determine the cause and the conditions corrected.

23. Technical Requirement of Equipment

23.1 1.1 KV Grade Power & Control Cables

23.1.1 Applicable for PVC Control Cable

The manufacturers, whose PVC control cables are offered, should have designed, manufactured, tested and supplied in a single contract at least 100 Kms of 1.1 KV grade PVC insulated control cables as on the date of bid opening. Further the manufacturer should also have designed, manufactured, tested and supplied at least 1 km of 17C x 2.5 Sq. mm or higher size as on the originally Scheduled date of bid opening.

23.1.2 Applicable for PVC Power Cable

The manufacturer, whose PVC Power Cables are offered, should have designed, manufactured, tested and supplied in a single contract at least 100 Kms of 1.1 KV or higher-grade PVC insulated power cables as on the date of bid opening. Further the manufacturer should also have designed, manufactured, tested and supplied at least 1 km of 1C x 150 Sq. mm or higher size as on the originally Scheduled date of bid opening.

23.1.3 Applicable for XLPE Power Cables

The Manufacturer, whose XLPE Power cables are offered should have designed manufactured, tested and supplied in a single contract at least 25 Kms of 1.1 KV or higher grade XLPE insulated power cables as on the date of bid opening. Further the manufacturer should also have designed, manufactured, tested and supplied at least 1 km of 1C x 400 Sq. mm or higher size as on the originally Scheduled date of bid opening.

23.2 LT Switchgear

- 23.2.1 The Manufacturer whose LT Switchgear is offered should be a manufacturer of LT Switchboards of the type and rating being offered. He should have designed, manufactured, tested and supplied at least 50 nos. draw out circuit breaker panels, out of which at least 5 nos. should have been with relay and protection schemes with current transformer. He should have also manufactured at least 50 nos MCC panels comprising of MCCBs (i.e. Moulded Case Circuit Breakers) modules of the type offered which should be in successful operation as on originally Scheduled date of bid opening.
- 23.2.2 The Switchgear items (such as circuit breakers, fuse switch units, contactors etc.), may be of his own make or shall be procured from reputed manufacturers and of proven design. At least one hundred circuit breakers of the make and type being offered shall be operating satisfactory as on originally Scheduled date of bid opening.

23.3 Fire Fighting System

- 23.3.1 The bidder or his sub-vendor should have designed, supplied, tested and installed the firefighting equipment for fire protection system of each type described in BOQ shall comply with International Standard code (FOC, LONDON or NFPA, USA etc.).

Annexure - A: List of Specifications

GENERAL STANDARDS AND CODES

IEC-60060 (Part 1 to P4)	High Voltage Test Techniques
IEC 60068	Environmental Test
IEC-60117	Graphical Symbols
IEC-60156	Method for the Determination of the Electrical Strength of Insulation Oils.
IEC-60270	Partial Discharge Measurements.
IEC-60376	Specification and Acceptance of New Sulphur Hexafluoride
IEC-60437	Radio Interference Test on High Voltage Insulators.
IEC-60507	Artificial Pollution Tests on High Voltage Insulators to be used on AC Systems.
IEC-62271-1	Common Specification for High Voltage Switchgear & Control gear Standards.
IEC-60815	Guide for the Selection of Insulators in respect of Polluted Conditions.
IEC-60865 (P1 & P2)	Short Circuit Current - Calculation of effects.
ANSI-C.1/NFPA.70	National Electrical Code
ANSI-C37.90A	Guide for Surge Withstand Capability (SWC) Tests
ANSI-C63.21, C63.3, C36.4	Specification for Electromagnetic Noise and Field Strength Instrumentation 10 KHz to 1 GHZ
ANSI-C68.1	Techniques for Dielectric Tests
ANSI-C76.1/EEE21	Standard General Requirements and Test Procedure for Outdoor Apparatus Bushings.
ANSI-SI-4	Specification for Sound Level Meters
ANSI-Y32-2/C337.2	Drawing Symbols
ANSI-Z55.11	Gray Finishes for Industrial Apparatus and Equipment No. 61 Light Gray
NEMA-107T	Methods of Measurements of RIV of High Voltage Apparatus
NEMA-ICS-II	General Standards for Industrial Control and Systems Part ICSI-109
CISPR-1	Specification for CISPR Radio Interference Measuring Apparatus for the frequency range 0.15 MHz to 30 MHz
CSA-Z299.1-1978h	Quality Assurance Program Requirements
CSA-Z299.2-1979h	Quality Control Program Requirements
CSA-Z299.3-1979h	Quality Verification Program Requirements
CSA-Z299.4-1979h	Inspection Program Requirements

TRANSFORMERS AND REACTORS

IEC-60076 (Part 1 to 5)	Power Transformers
IEC-60214	On-Load Tap-Changers.
IEC-60289	Reactors.
IEC- 60354	Loading Guide for Oil - Immersed power transformers
IEC-60076-10	Determination of Transformer and Reactor Sound Levels
ANSI-C571280	General requirements for Distribution, Power and Regulating Transformers

ANSI-C571290	Test Code for Distribution, Power and Regulation Transformers
ANSI-C5716	Terminology & Test Code for Current Limiting Reactors
ANSI-C5721	Requirements, Terminology and Test Code for Shunt Reactors Rated Over 500 KVA
ANSI-C5792	Guide for Loading Oil-Immersed Power Transformers upto and including 100 MVA with 55 deg C or 65 deg C Winding Rise
ANSI-CG, IEEE-4	Standard Techniques for High Voltage Testing

CIRCUIT BREAKERS

IEC-62271-100	High-voltage switchgear and control gear - Part 100: Alternating current circuit-breakers
IEC-62271-101	High-voltage switchgear and control gear - Part 101: Synthetic testing
IEC-62155	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1000V
IEC-62271-110	High-voltage switchgear and control gear - Part 110: Inductive load switching
IEC-62271-109	High-voltage switchgear and control gear - Part 110: Inductive load switching

CURRENT TRANSFORMERS, VOLTAGE TRANSFORMERS AND COUPLING CAPACITOR VOLTAGE TRANSFORMERS

IEC-60044-1	Current transformers.
IEC-60044-2	Inductive Voltage Transformers.
IEC-60044-5	Instrument transformers - Part 5: Capacitor voltage transformers
IEC-60186	Voltage transformers
IEC-60358	Coupling capacitors and capacitor dividers.
IEC-60044-4	Instrument Transformers: Measurement of Partial Discharges
IEC-60481	Coupling Devices for power Line Carrier Systems.
ANSI-C5713	Requirements for Instrument transformers
ANSIC92.2	Power Line coupling voltage Transformers
ANSI-C93.1	Requirements for Power Line Carrier Coupling Capacitors

BUSHING

IEC-60137	Insulated Bushings for Alternating Voltages above 1000V

SURGE ARRESTERS

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

CUBICLES AND PANELS & OTHER RELATED EQUIPMENTS

IEC-60068.2.2	Basic environmental testing procedures Part 2: Test B: Dry heat
IEC-60694	Switchgear and control gear
IEC-60529	Degree of Protection provided by enclosures.

IEC-60947-4-1	Low voltage switchgear and control gear.
IEC-61095	Electromechanical Contactors for household and similar purposes.
IEC-60439 (P1 & 2)	Low Voltage Switchgear and control gear assemblies
ANSI-C37.20	Switchgear Assemblies, including metal enclosed bus.
ANSI-C37.50	Test Procedures for Low Voltage Alternating Current Power Circuit Breakers
ANSI-C39	Electric Measuring instrument
ANSI-C83	Components for Electric Equipment
NEMA-AB	Moulded Case Circuit and Systems
NEMA-CS	Industrial Controls and Systems
NEMA-PB-1	Panel Boards
NEMA-SG-5	Low voltage Power Circuit breakers
NEMA-SG-3	Power Switchgear Assemblies
NEMA-SG-6	Power switching Equipment
NEMA-5E-3	Motor Control Centers
1248 (P1 to P9)	Direct acting indicating analogue electrical measuring instruments & their accessories.

Disconnecting switches

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

Protection and control equipment

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

ANSI-C37.2	Manual and automatic station control, supervisory and associated telemetering equipment
ANSI-C37.2	Relays and relay systems associated with electric power apparatus
ANSI-C39.1	Requirements for electrical analog indicating instruments

Electronic equipment and components

MIL-21B, MIL-833 & MIL-2750

IEC-60068 (P1 to P5)	Environmental testing
IEC-60326 (P1 to P2)	Printed boards

Material and workmanship standards

ASTM	Specification and tests for materials

Clamps & connectors

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

Bus hardware and insulators

IEC-60120	Dimensions of Ball and Socket Couplings of string insulator units.
IEC-60137	Insulated bushings for alternating voltages above 1000 V.
IEC-60168	Tests on indoor and outdoor post insulators of ceramic material or glass for Systems with Nominal Voltages Greater than 1000 V.
IEC-62155	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V
IEC-60273	Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1000V.
IEC-61462	Pressurized and un-pressurized insulator for use in electrical equipment with rated voltage greater than 1000V – Definitions, Test methods, acceptance criteria and design recommendations
IEC-60305	Insulators for overhead lines with nominal voltage above 1000V-ceramic or glass insulator units for a.c. systems Characteristics of String Insulator Units of the cap and pin type.
IEC-60372 (1984)	Locking devices for ball and socket couplings of string insulator units: dimensions and tests.
IEC-60383 (P1 and P2)	Insulators for overhead lines with a nominal voltage above 1000 V.
IEC-60433	Characteristics of string insulator units of the long rod type.
IEC-60471	Dimensions of Clevis and tongue couplings of string insulator units.
ANSI-C29	Wet process porcelain insulators
ANSI-C29.1	Test methods for electrical power insulators
ANSI-C92.2	For insulators, wet-process porcelain and toughened glass suspension type
ANSI-C29.8	For wet-process porcelain insulators apparatus, post-type
ANSI-G.8	Iron and steel hardware
CISPR-7B	Recommendation of the CISPR, tolerances of form and of Position, Part 1

ASTM A-153 Zinc Coating (Hot-Dip) on iron and steel hardware

Strain and rigid bus-conductor

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

Batteries and Batteries charger

Battery

IEC: 60896-21&22 Lead Acid Batteries Valve Regulated types – Methods of Tests & Requirements
 IEC: 60623 Vented type nickel Cadmium Batteries
 IEC: 60622 Secondary Cells & Batteries – Sealed Ni-Cd rechargeable single cell
 IEC: 60623 Secondary Cells & Batteries – Vented Ni-Cd rechargeable single cell
 IEC: 60896-11 Stationary Lead Acid Batteries – Vented Type – General requirements & method of tests
 IEEE-485 Recommended practices for sizing of Lead Acid Batteries
 IEEE-1115 Sizing of Ni-Cd Batteries
 IEEE-1187 Recommended practices for design & installation of VRLA Batteries
 IEEE-1188 Recommended practices for design & installation of VRLA Batteries
 IEEE-1189 Guide for selection of VRLA Batteries

Battery Charger

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

Wires and cables

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

IEC-60332 (P1 to P3)	Tests on electric cables under fire conditions.
IEC-60502	Extruded solid dielectric insulated power cables for rated voltages from 1 kV upto to 30 kV
IEC-754 (P1 and P2)	Tests on gases evolved during combustion of electric cables.

Painting

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

Steel structures

ANSI-B18.2.1	Inch series square and Hexagonal bolts and screws
ANSI-B18.2.2	Square and hexagonal nuts
ANSI-G8.14	Round head bolts
ASTM-A6	Specification for General Requirements for rolled steel plates, shapes, sheet piling and bars of structural use
ASTM-A36	Specifications of structural steel
ASTM-A47	Specification for malleable iron castings
ASTM-A143	Practice for safeguarding against embrittlement of Hot Galvanized structural steel products and procedure for detaching embrittlement
ASTM-A242	Specification for high strength low alloy structural steel
ASTM-A283	Specification for low and intermediate tensile strength carbon steel plates of structural quality
ASTM-A394	Specification for Galvanized steel transmission tower bolts and nuts
ASTM-441	Specification for High strength low alloy structural manganese vanadium steel.
ASTM-A572	Specification for High strength low alloy columbium-Vanadium steel of structural quality
AWS D1-0	Code for welding in building construction welding inspection
AWS D1-1	Structural welding code
AISC	American institute of steel construction
NEMA-CG1	Manufactured graphite electrodes

ACSR CONDUCTOR

IEC: 437-1973	Test on High Voltage Insulators NEMA: 107-1964 CISPR
Part - V	Overhead Transmission Purposes
BS: 215(Part-II)	Aluminum Conductors galvanized IEC: 209-1966 steel reinforced extra high
BS: 215(Part-II)	voltage (400 kV and above)

GALVANISED STEEL EARTHWIRE

P5:1992	overhead transmission purposes.

Annexure - B: List of Drawings/Documents

Drawings are attached as per requirement.

1. Existing Kalanga Substation Layout
2. Substation General Layout
3. Control Room Layout
4. Control Room Tentative Section Plan

NOTE:

The above list of drawing/document is only illustrative and not exhaustive. The Contractor shall submit drawings/documents as per requirement of Technical specification.

Annexure-B

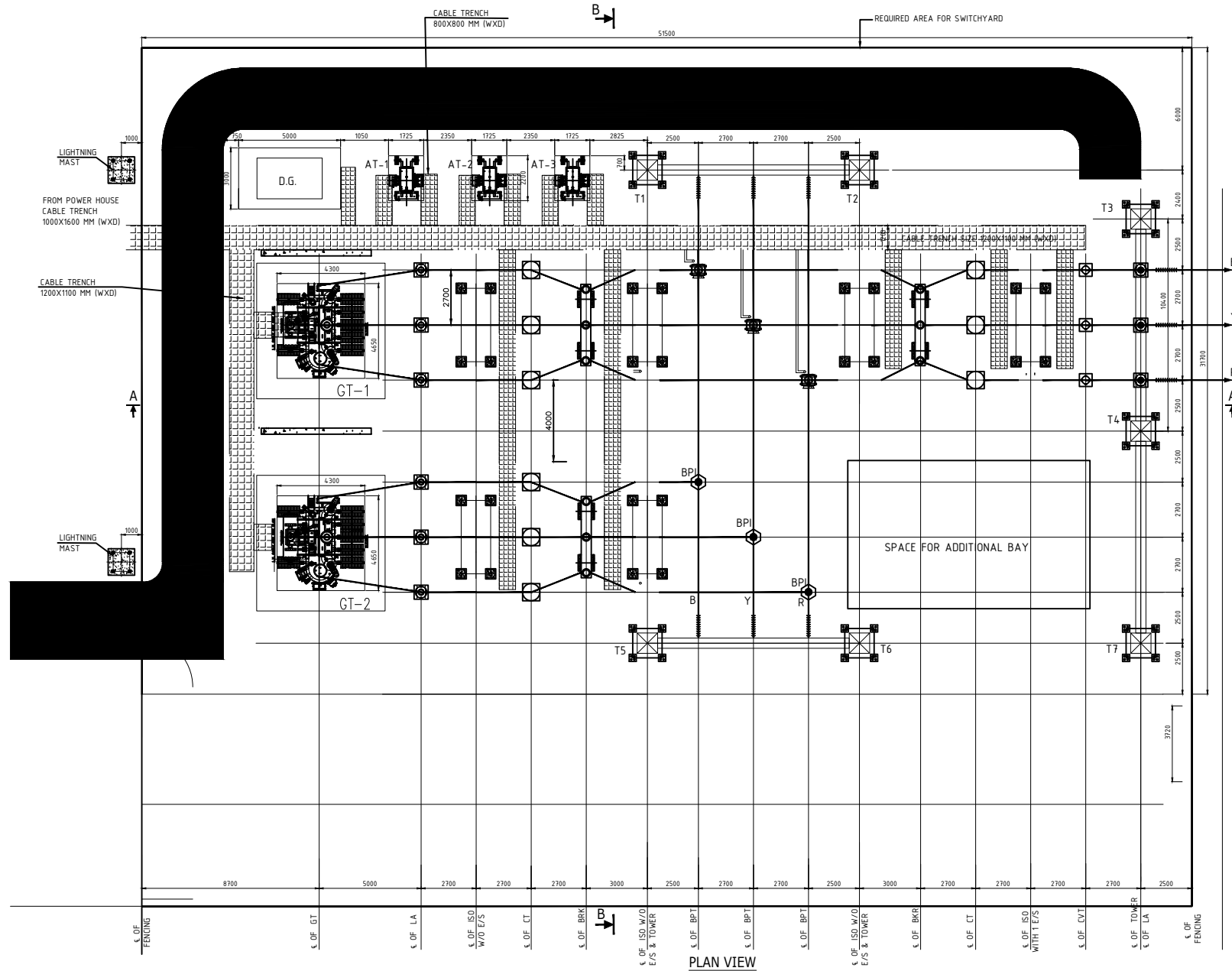


Fig. Existing 33/132 kV Kalanga Substation Layout

Annexure-B

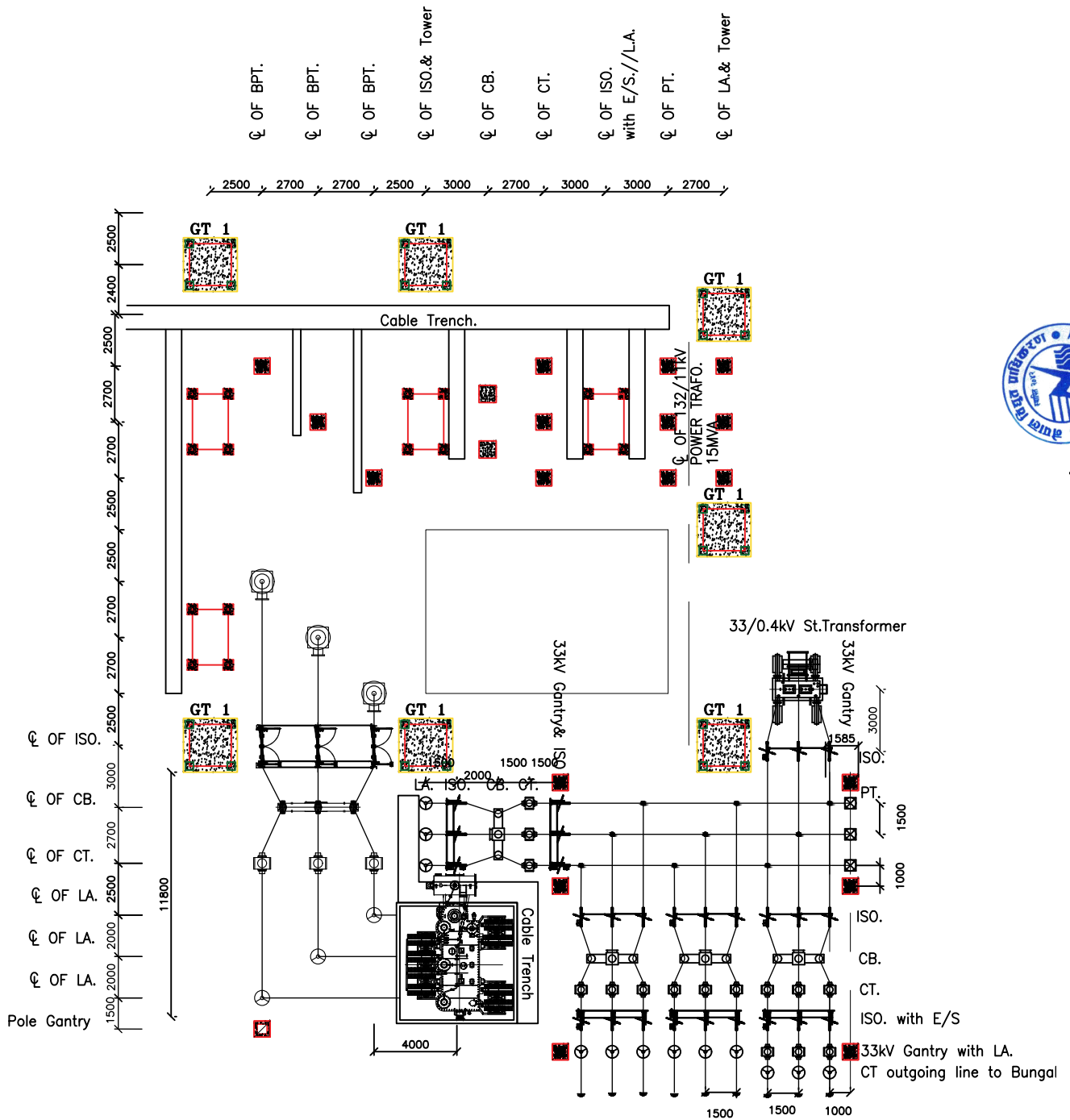
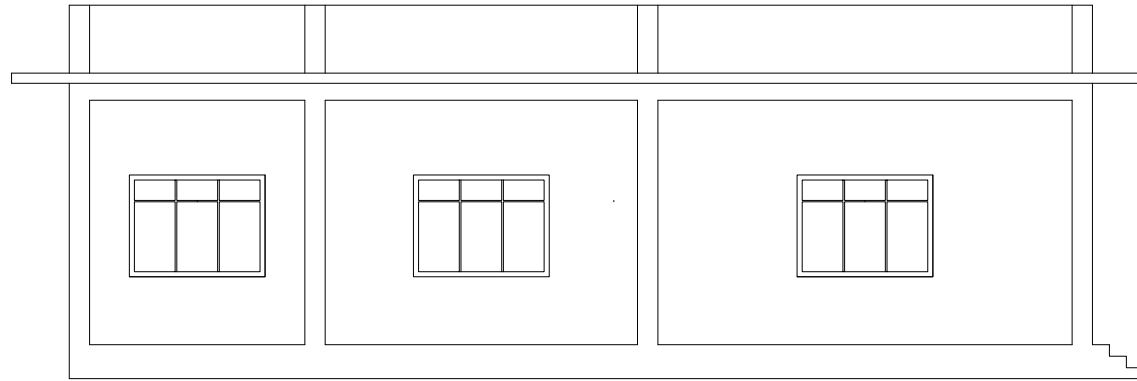
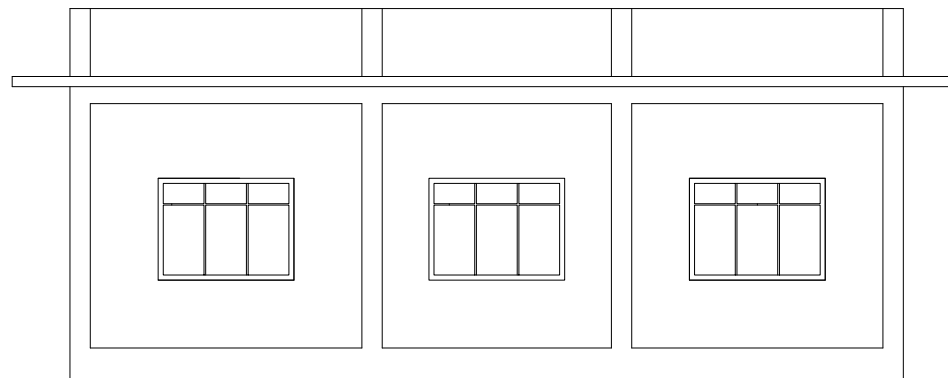


Fig. General Layout of 132/33 kV Kalanga Substation

Annexure-B



SIDE ELEVATION



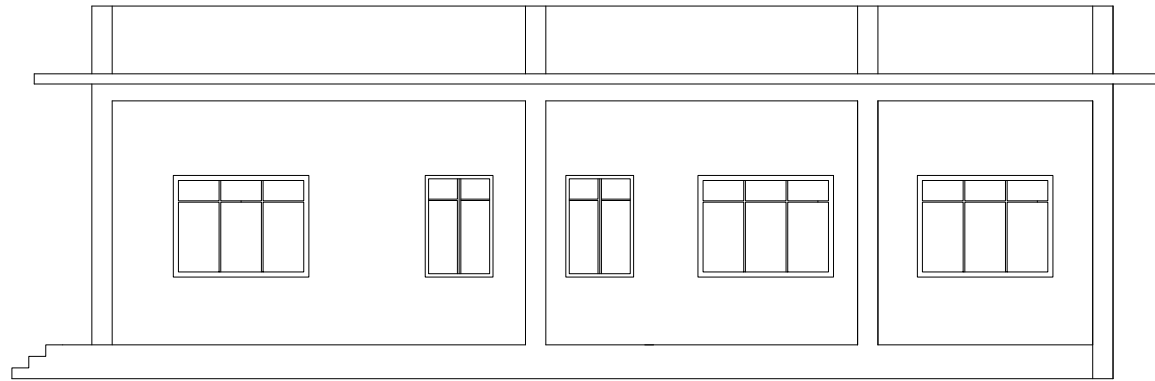
BACK ELEVATION

Fig. Control Room Building Elevation

Annexure-B



[Handwritten signature]



SIDE ELEVATION



FRONT ELEVATION

Fig. Control Room Elevation

Annexure-B

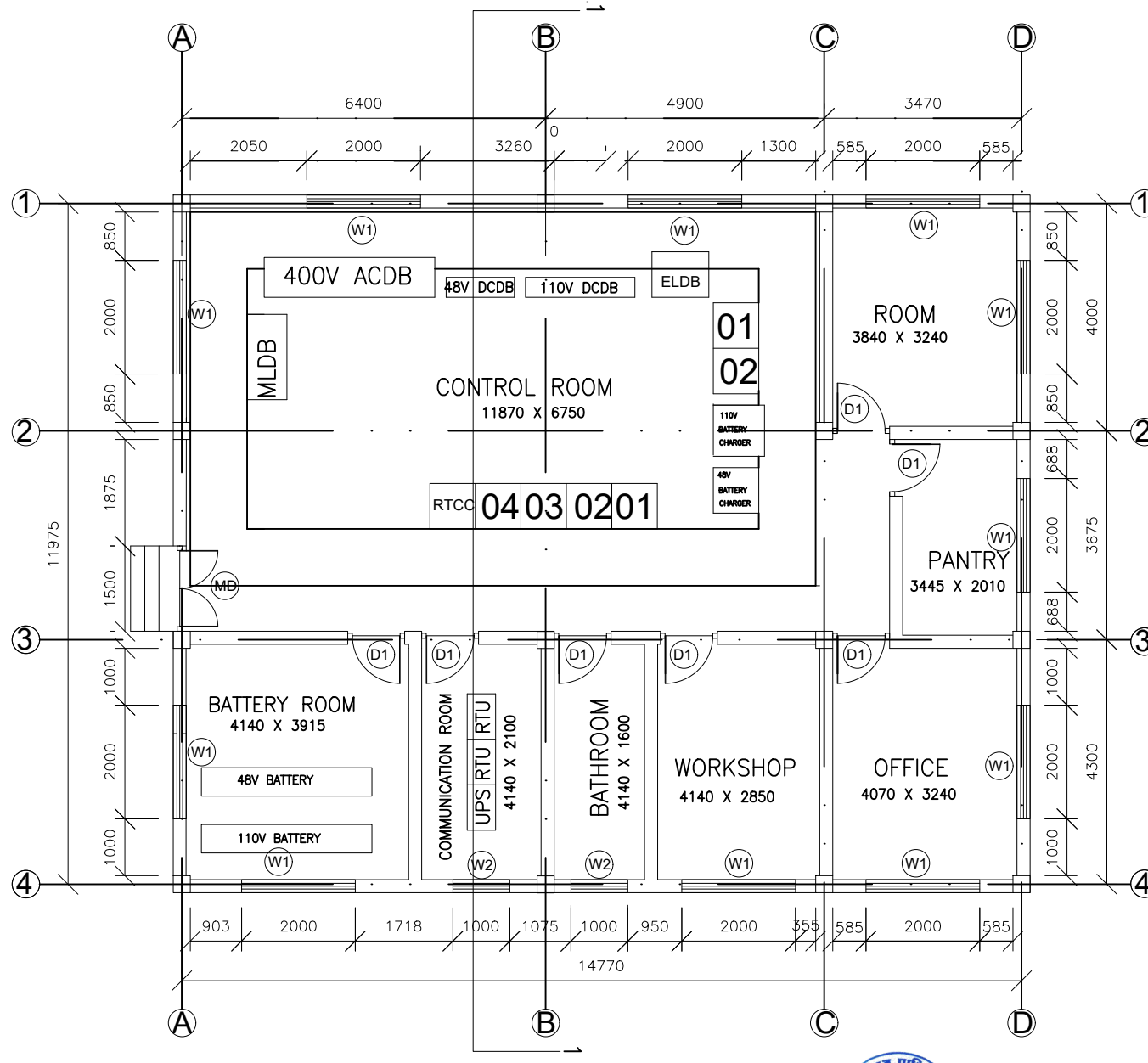


Fig. Control Room Building Layout



Annexure-B

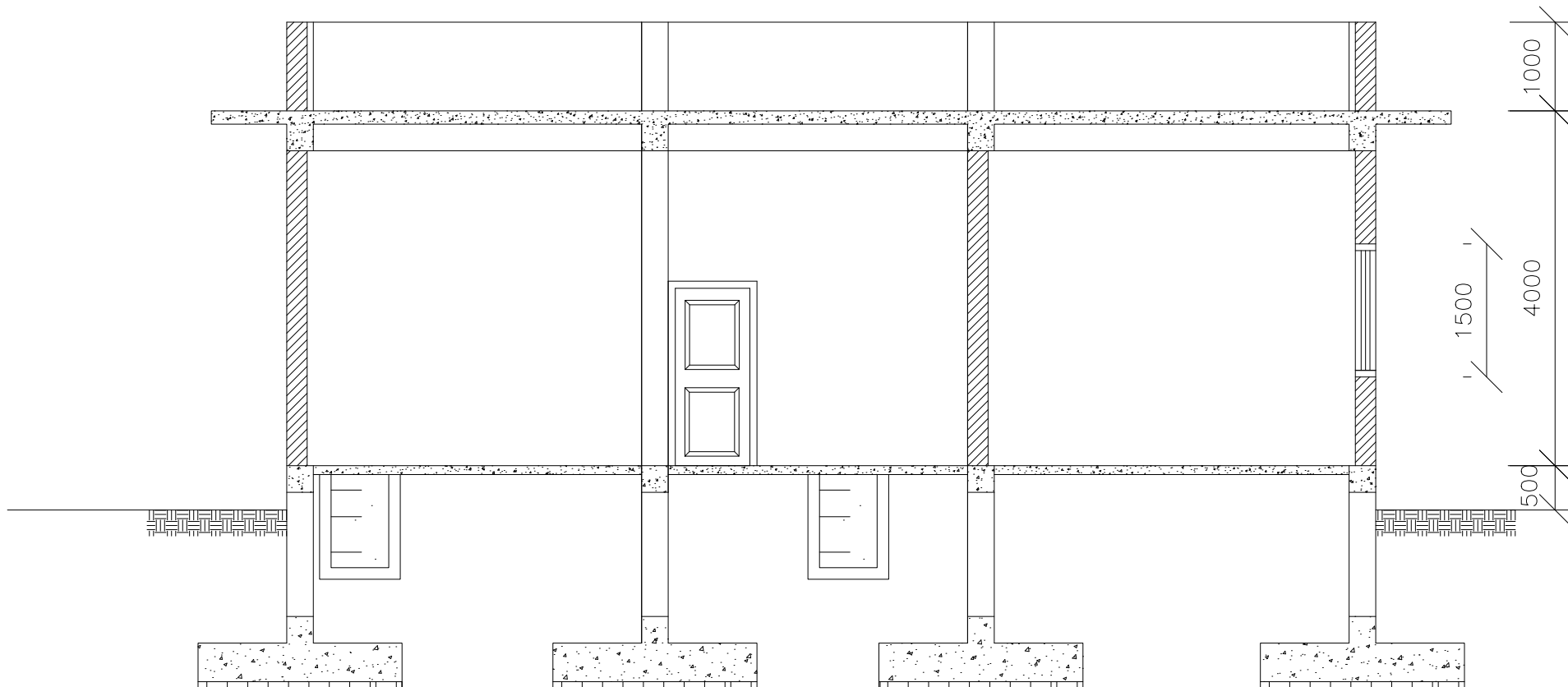


Fig. Control Room Tentative Section Plan

Volume II

Section 6: Employer's Requirements

CHAPTER 3: POWER TRANSFORMER

Table of Contents

1.	General.....	2
2.	Performance.....	3
3.	Construction Details	5
4.	Fittings.....	26
5.	Inspection and Testing	27
6.	Technical Parameters	35
7.	Bushing Current Transformer	37
8.	Tender Evaluation and the Guaranteed Losses	38
9.	Oil Sampling Bottle	39
	Annexure - A.....	40

CHAPTER 3

POWER TRANSFORMER

1. 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.

The Transformer shall have additional features which shall be finalized during design stage, required for Substation Automation System.

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 finalize 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 Contractor.
- 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. 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.
- 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 **Radio Interference and Noise Level**
 - 2.5.1 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.
 - 2.5.2 The noise level of transformer, when energized at normal voltage and frequency with cooler equipment in operation shall not exceed, when measured under standard conditions, the values specified at relevant clause.
- 2.6 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.
- 2.7 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 31.5 kA (sym, rms, 3 phase fault on 132 kV) & 25 kA (sym rms 3 phase fault on 33 kV & 11 kV).
- 2.8 Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any winding.
- 2.9 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
- 2.10 **Dynamic Short Circuit Test requirement**

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 Tender opening and shall enclose the relevant Test Report/ Certificate along with bid. **In case the Manufacturer has not successfully tested 132 kV or above voltage class transformer for Dynamic Short Circuit Test, their Tender 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.
- 2.11 **Design review**
 - 2.11.1 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 provides long life with least maintenance.

- 2.11.2 Design reviews shall be conducted by Employer or an appointed Consultant at different stages of the procurement process for transformer; however, the entire responsibility of design shall be with the manufacturer.
- 2.11.3 The Employer may visit to the manufacturers works to inspect design, manufacturing and test facilities.
- 2.11.4 The design review will commence after placement of award and shall be finalized before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the transformer under scope of this specification.
- 2.11.5 The design review shall be conducted generally following the "Guidelines for conducting design reviews for transformers 100 MVA and 132 kV and above" prepared by Cigre SC 12 Working Group 12.22.
- 2.11.6 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.
- 2.11.7 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.
- 2.11.8 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 localized potentially hot area.
5.	Cooling design
6.	Overload capability
7.	Eddy current losses
8.	Seismic design, as applicable
9.	Insulation co-ordination
10.	Tank and accessories
10.1	Bushings and barrier design
10.2	Tap changers
10.3	Protective devices
10.4	Radiators
10.5	Oil and oil preservation system
11.	Corrosion protection

12.	Electrical and physical Interfaces with substation
13.	Earthing
14.	Processing and assembly
15.	Testing capabilities
16.	Inspection and test plan
17.	Transport and storage
18.	Sensitivity of design to specified parameters
19.	Acoustic Noise
20.	Spares, inter-changeability and standardization
21.	Maintainability

3. Construction Details

3.1 The features and construction details of each power transformer shall be in accordance with the requirement stated hereunder.

3.2 Tank and Tank Accessories

3.2.1 Tank

Tank shall preferably be of welded construction and fabricated from tested quality low carbon steel of adequate thickness.

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.

Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.

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.

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.

The tank shall be designed in such a way that it can be mounted on the rollers.

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.

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°C. The detailed painting procedure shall also be submitted for approval in case of award.

Parts	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thickness (DFT)	Colour
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 80µm	Glossy white 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 aesthetic 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 exterior interior

Note:

- * Indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.
- ** Radiator hot dip galvanized may also be acceptable.

3.2.2 **Tank Cover**

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.

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.

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.

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.

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.

Tank hotspot

The maximum temperature on any metal part shall not exceed 130°Celsius.

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.

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.

3.2.3 **Axles and Wheels**

The transformer shall be mounted on rollers, as per manufacturer's standard practice.

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.

The rail track gauge shall be 1676 mm.

3.2.4 **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.

3.2.5 **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.

OLTC shall have conventional type conservator with prismatic oil level gauge.

3.2.6 **Conservator tank and pipe work**

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 100°C. 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.

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.

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.

Pipe work connections shall be of adequate size for their duty and as short and direct as possible. Only radiused elbows shall be used.

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.

This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degree.

3.2.7 **Oil Preservation Equipment**

The requirements of air cell type oil sealing system are given below.

Contact of the oil with atmosphere is prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth.

The temperature of oil is likely to rise up to 100°C during operation. As such air cell used shall be suitable for operating continuously at 100°C.

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.

The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator.

3.2.8 **Maintenance-free Dehydrating Filter Breather**

Conservator of Main Tank and OLTC each shall be fitted with a maintenance-free dehydrating breather in which only pure silica gel has been filled as dehydrating agent. Connection shall be made to a point in the oil conservator not less than 50 mm above the maximum working oil level by means of a pipe

with a minimum diameter of 25 mm. Breathers and connecting pipes shall be securely clamped and supported to the transformer, or other structure supplied by the contractor, in such a manner so as to eliminate undesirable vibration and noise. The design shall be such that:

- a. Incoming air is directed toward the desiccant (silica gel) and dried.
- b. The desiccant is regenerated/de-humidified by an installed heating element that shall be sensor-controlled and self-regulating.
- c. Silica gel is isolated from atmosphere by an oil seal.
- d. Moisture absorption indicated by a change in color of the crystals.
- e. Breather is mounted approximately 1200mm above rail top level.
- f. The maintenance free dehydrating breathers shall have a humidity and temperature sensor and must have 3 LED for status indication and a data logger to log all important events. The maintenance free breather shall be equipped with a self-learning algorithm alpha control for the OLTC conservator and beta control for main tank conservator. Moving parts such as solenoid valves or fans are not accepted. Additionally an Anti-Condensation heater shall be installed in the control box and test button is required for auto-diagnosis and testing functions.

3.2.9 **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.

3.2.10 **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.

3.2.11 Temperature Indicators

Oil Temperature Indicator (OTI)

All transformers shall be provided with a 150 mm (approx.) dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent ungrounded alarm and trip contacts, maximum reading pointer and resetting device shall be provided in the OTI. A temperature sensing element suitably located in a pocket on top oil shall be furnished. This shall be connected to the OTI by means of capillary tubing. Temperature indicator dials shall have linear gradations to clearly read at least every 2°C. Accuracy of OTI shall be $\pm 3.0^{\circ}\text{C}$ or better. The setting of alarm and tripping contacts shall be adjustable at site.

In addition to the above, the following equipment shall be provided for remote indication of oil temperature:

a. **Signal transmitter**

Signal transmitter shall have additional facility to transmit signal for recording oil temperature at Employer's data acquisition system, for which duplex platinum RTD with nominal resistance of 100 ohms at zero degree centigrade shall be supplied. The RTD shall be three wire ungrounded system. The calibration shall be as per SAMA (USA) standard or equivalent. The RTD may be placed in the pocket containing temperature sensing element and image coil for OTI system which will be used for both remote OTI and DAS. Necessary equipment for sending the signal to remote OTI and DAS shall be provided. In lieu, separate RTD for each of the functions shall be provided.

b. **Remote oil temperature indicator**

It shall be suitable for flush mounting on Employer's/ RTCC panel. This shall not be repeater dial of local OTI and will operate by signal transmitter. Any special cable required for shielding purpose, for connection between cooler control cabinet and remote OTI control circuit, shall be in the scope of Contractor. Only one ROTI with a four point selector switch shall be provided.

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:

- a. Temperature sensing element.
- b. Image coil.
- c. Auxiliary CTs, if required to match the image coil, shall be furnished and mounted in the cooler control cabinet.
- d. 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°C.
- e. Calibration device.
- f. Accuracy of WTI shall be $\pm 3.0^{\circ}\text{C}$ or better.

- g. 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	110°C
Trip	120°C

In addition to the above, the following equipment shall be provided for remote indication of winding temperature for each of the winding:

a. **Signal transmitter for each winding**

Signal transmitter shall have additional facility to transmit signal for recording winding temperature at Employer's data acquisition system, for which duplex platinum RTD with nominal resistance of 100 ohms at zero degree centigrade shall be supplied. The RTD shall be three wire ungrounded system. The calibration shall be as per SAMA (USA) standard or equivalent. The RTD may be placed in the pocket containing temperature sensing element and image coil for WTI system which will be used for both remote WTI and DAS. Necessary equipment for sending the signal to remote WTI and DAS shall be provided. In lieu, separate RTD for each of the functions shall be provided.

b. **Remote winding temperature indicator**

It shall be suitable for flush mounting on Employer's panel. This shall not be repeater dial of local WTI and will operate by signal transmitter.

Any special cable required for shielding purpose, for connection between cooler control cabinet and remote WTI control circuit, shall be in the scope of Contractor. Only one RWTI with a selector switch shall be provided for all the windings (HV and LV).

3.2.12 **Earthing Terminals**

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 galvanized steel grounding flat shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

Two earthing terminals suitable for connection to 75 x 6 mm galvanized steel flat shall also be provided on cooler, marshalling box and any other equipment mounted separately.

3.3 **Core**

- 3.3.1 The core shall be constructed from prime quality, non-ageing, cold rolled, super grain oriented, and silicon steel laminations.

- 3.3.2 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 ° C under normal operating condition and 130 ° C under most extreme operating condition. Adequate temperature margin shall be provided to maintain longer life expectancy for this material.

- 3.3.3 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.
- 3.3.4 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.
- 3.3.5 All steel sections used for supporting the core shall be thoroughly sand blasted after cutting, drilling and welding.
- 3.3.6 Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.
- 3.3.7 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.
- 3.3.8 Adequate lifting lugs will be provided to enable the core and windings to be lifted.
- 3.3.9 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.

3.4 Windings

- 3.4.1 The Contractor shall ensure that windings of all transformers are made in dust proof and conditioned atmosphere.
- 3.4.2 The conductors shall be of electrolytic grade copper free from scales and burrs.
- 3.4.3 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.
- 3.4.4 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.
- 3.4.5 The coils would be made up, shaped and braced to provide for expansion and contraction due to temperature changes.
- 3.4.6 The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalize the distribution of currents and temperature along the winding.

3.5 Unused inhibited Insulating Oil

- 3.5.1 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.

S. No.	Property	Test Method	Limits
A. Function			
1a.	Viscosity at 100°C	ISO 3104 or ASTM D445 or ASTM D7042	(Max.) 3 mm ² /s
1b.	Viscosity at 40°C	ISO 3104 or ASTM D445 or ASTM D7042	(Max.)12 mm ² /s
1c.	Viscosity at -30°C	ISO 3104 or ASTM D445 or ASTM D7042	(Max.)1800 mm ² /s
2.	Appearance	A representative sample of the oil shall be examined in a 100 mm thick layer, at ambient temperature	The oil shall be clear and bright, transparent and free from suspended matter or sediment
3.	Pour point	ISO 3016 or ASTM D97	(Max.)- 40°C
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°C	ISO 3675 or ISO 12185 or ASTM D 4052	0.820 - 0.895 g/ml
7.	Dielectric dissipation factor (tan delta) at 90°C	IEC 60247 or IEC 61620 or ASTM D924	(Max) 0.0025
8.	Resistivity at 90°C	IEC 60247	150 X 10 ¹² Ohm-cm, (Min.) for records only.
9.	Negative impulse testing KVp @ 25°C	ASTM D-3300	145 (Min.)
10.	Carbon type composition (% of Aromatic, Paraffin and Naphthenic compounds.)	IEC 60590 or ASTM D 2140	Max. Aromatic : 4 to 12 % Paraffin: <50% & balance shall be Naphthenic compounds.
B. Refining / Stability			
1.	Acidity	IEC 62021-1 or ASTM D974	(Max) 0.01 mg KOH/g
2.	Interfacial tension at 27°C	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.)
C.	Performance		
1	Oxidation stability - -Total acidity - -Sludge - -Dielectric dissipation factor (tan delta) at 90°C	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.)
D.	Health, safety and environment (HSE)		
1.	Flash point	ISO 2719	(Min.)135°C
2.	PCA content	BS 2000 Part 346	Max 3%
3.	PCB content	IEC 61619 or ASTM D4059	Not detectable (Less than 2 mg/kg)

3.5.2 Prior to filling in main tank at site and shall be tested for

- a. Break Down voltage (BDV) 70kV (min.)
- b. Moisture content 5 ppm (max.)
- c. Tan-delta at 90 °C 0.0025 (max)
- d. Interfacial tension More than 0.004 N/m

3.5.3 Prior to energization at site oil shall be tested for following properties & acceptance norms as per below generally in line with IEC 60422:

- a. Break Down voltage (BDV) 70 kV (min.)
- b. Moisture content 10 ppm (max.)
- c. Tan-delta at 90°C 0.01 (max.)
- d. Resistivity at 90°C 6×10^{12} ohm-cm (min.)
- e. Interfacial tension 0.035 N/m (min.)
- f. Oxidation Stability (Test method as per IEC 61125 method C, Test duration: 500 hour for inhibited oil)*
 - i. Acidity 0.3 (mg KOH /g) (max.)
 - ii. Sludge 0.05 % (max.)
 - iii. Tan delta at 90°C 0.05 (max.)

- g. Total PCB content* Not detectable (2mg/kg)

* For Sr. No. f & g separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning for approval of Consultant.

3.5.4 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. a to e of clause 3.5.3 above. The oil test results shall form part of equipment test report.

3.5.5 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.

3.6 Terminal Arrangements

3.6.1 Bushings

- a. The electrical and mechanical characteristics of bushings shall be in accordance with IEC 60137/ DIN 42530.
- b. Bushing for various voltage rating shall be as follows
 - 52 kV and above Hermetically sealed Oil filled condenser type/ RIP bushing with porcelain or composite insulator.
 - 36 kV and below Solid porcelain or oil communicating type. Dimensions of 11 kV bushing shall conform to IEC
- c. Oil Filled condenser type bushing shall be provided with at least the following fittings:
 - i. Oil level gauge.
 - ii. Tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable.
- d. Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.
- e. Bushings of identical rating shall be interchangeable.
- f. 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.
- g. Clamps and fittings shall be of hot dip galvanized steel.
- h. Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.
- i. No arcing horns shall be provided on the bushings.
- j. Installation procedures for the various voltage class bushings shall be clearly brought out in the Instruction manual.

3.6.2 Terminal Marking

The terminal marking and their physical position shall be as per IEC: 60076.

3.6.3 Neutral Earthing Arrangement

a. For 3-Phase Unit

The neutral of the transformer shall be brought out through bushing. The neutral terminal of 3-phase transformer shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to two (2) 75 x 12 mm galvanised steel flats connected to Employer's grounding mat.

b. 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.

c. Spare Unit connection arrangement (applicable for 1-Phase Transformer)

Connection arrangement of spare unit of transformer with other units shall be made by isolator switching (Isolators are not part of this specification). Neutral formation for spare unit of transformer shall be done by manual connection. The contractor shall make connection arrangement as well as control scheme of OLTC and Cooler in such a way that spare unit of transformer can be connected in place of faulty unit without physically shifting it from its location. For this purpose, HV, LV and Neutral Connections of spare unit are to be extended up to the other unit by forming auxiliary buses and shall be supported by structure mounted bus post insulators at suitable intervals to enable spare unit connection through flexible/rigid conductor and suitable connector in place of existing unit to be replaced. The detail configuration and actual sizes of various items shall be finalized during detailed engineering and shall be subject to Employer's approval. All associated materials like Bus post insulators, Aluminium tube, conductors, clamps & connectors, insulator strings, hardware, cables, support structures, required for the above-mentioned arrangement shall be provided by the contractor.

3.7 Cooling Equipment and its Control

3.7.1 Cooling Equipment

- a. The cooler shall be designed using sufficient number of tank mounted radiators. Design of cooling system shall satisfy the performance requirements.
- b. 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.

- c. Required number of standby fans of approximately 20% capacity shall also be provided with radiators.
- d. Cooling fans shall be directly mounted on radiator. Each fan shall be suitably protected by galvanized wire guard. The exhaust air flow from cooling fan shall not be directed towards the main tank in any case.
- e. 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.
- f. The cooler and its accessories shall preferably be hot dip galvanized or corrosion resistant paint (as per clause 3.1.1.8) should be applied to it.
- g. 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.

3.7.2 Cooling Equipment Control (ONAN/ONAF COOLING)

- a. 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.
- b. Suitable manual control facility for cooler fans shall be provided.
- c. 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.
- d. Indicating Devices
Following lamp indications shall be provided in cooler control cabinet:
 - i. Control Supply failure.
 - ii. Cooling fan failure.
 - iii. 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).

- e. 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.
- f. 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.

- g. 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.

3.7.3 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.

3.7.4 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 up to the terminal board in the cooler control cabinet/Individual Marshalling box. All the CT secondary terminals in the cooler control cabinet shall have provision for shorting to avoid CT open circuit while it is not in use. All the necessary terminations for remote connection to Purchaser's panel shall be wired up to the Common Marshalling box.

3.7.5 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.

3.7.6 Valves

- a. 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.
- b. Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.
- c. Each valve shall be provided with the indicator to show clearly the position of the valve.
- d. All valves flanges shall have machined faces.
- e. All valves in oil line shall be suitable for continuous operation with transformer oil at 115°C.
- f. 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.

- g. 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 finalized during detail engineering stage
- h. 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.
- i. All hardware used shall be cadmium plated/electro galvanized steel.
- j. For estimation purpose of spares one set of valves would mean one valve of each type used in Transformer.

3.8 Tap Changing Equipment

- 3.8.1 Each transformer shall be provided with Off load tap / On Load Tap changing equipment as specified elsewhere.

3.8.2 Off load tap Changer equipment (if applicable)

The off load / Off Circuit tap changer (OCTC) equipment shall be handle operated with a locking arrangement along with tap position indicator. The external handle shall be situated in an unobstructed position. The contacts are positively self-locating in each tapping position without constraint from the operating mechanism. The rating of the contacts shall be suitable to carry maximum current of the transformer. For three phase transformer the tap change switch shall simultaneous switch the similar taps on the three phases. A warning plate indicating that OCTC shall be operated only when the transformer is de-energized, shall be fitted.

3.8.3 ON Load Tap Changing (OLTC) Equipment

The On Load Tap Changer (OLTC) shall be of high speed resistor type with vacuum technology include the following:

a. Main OLTC Gear Mechanism

- i. Each single / three phase transformer shall be provided with voltage control equipment of the tap changing type for varying its effective transformation ratio whilst the transformers are on load.
- ii. OLTC shall be motor operated suitable for local as well as remote operation. The diverter switch or arcing switch shall be designed so as to ensure that its operation once commenced shall be completed independently of the control relays or switches, failure of auxiliary supplies etc. To meet any contingency which may result in incomplete operation of the diverter switch, adequate means shall be provided to safeguard the transformer and its ancillary equipment. The current diverting contacts shall be housed in a separate vacuum interrupter chamber not communicating with the oil in main tank of the transformer. The contacts shall be accessible for inspection without lowering oil level in the main tank and the contacts shall be replaceable. Electrical arcing took place in a vacuum interrupter only.
- iii. Necessary safeguards shall be provided to avoid harmful arcing at the current diverting contacts in the event of operation of the OLTC gear under overload conditions of the transformer.

- iv. Tap changer shall be so mounted that bell cover of transformer can be lifted without removing connections between windings and tap changer

b. Local OLTC Control Cabinet (Drive Mechanism Box)

Each transformer unit of OLTC gear shall have following features:

- i. OLTC shall be suitable for manually handle operated and electrically motor operated. For local manual operation from Local OLTC Control cabinet (Drive Mechanism Box), an external handle shall be provided.
- ii. OLTC's Local control cabinet shall be mounted on the tank in accessible position. The cranking device/handle for manual operation for OLTC gear shall be removable and suitable for operation by a man standing at ground level. The mechanism shall be complete with the following:
 - Mechanical tap position indicator which shall be clearly visible from near the transformer.
 - A mechanical operation counter of at least five digits shall be fitted to indicate the number of operations completed and shall have no provision for resetting. Mechanical stops to prevent over- cranking of the mechanism beyond the extreme tap positions.
 - The manual control considered as backup to the motor operated on load tap changer control shall be interlocked with the motor to block motor start-up during manual operation.
 - The manual operating mechanism shall be labeled to show the direction of operation for raising the voltage and vice-versa.
 - An electrical interlock to cut-off a counter impulse for reverse step change being initiated during a progressing tap change and until the mechanism comes to rest and resets circuits for a fresh position.
- iii. For electrical operation from local as well as remote, motor operated mechanism shall be provided. It shall not be possible to operate the electric drive when the manual operating gear is in use. It shall not be possible for any two controls to be in operation at the same time. Transfer of source in the event of failure of one AC supply shall not affect the tap changer. Thermal device or other means shall be provided to protect the motor and control circuit.
- iv. The Local OLTC Drive Mechanism Box shall house all necessary devices meant for OLTC control and indication. It shall be complete with the followings:
 - A circuit breaker/contactors with thermal overload devices for controlling the AC Auxiliary supply to the OLTC motor
 - Emergency Push Button to stop OLTC operation
 - Cubicle light with door switch
 - Provided with anti-condensation metal clad heaters to prevent condensation of moisture

- Padlocking arrangement for hinged door of cabinet
 - All contactors relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.
 - The cabinet shall be tested at least IP55 protection class.
- v. All relays and operating devices shall operate correctly at any voltage within the limits specified in Chapter-GTR. Incase auxiliary power supply requirement for OLTC DM Box is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor.
 - vi. Operating mechanism for on load tap changer shall be designed to go through one step of tap change per command only, until the control switch is returned to the off position between successive operations/repeat commands.
 - vii. Limit switches shall be provided to prevent over running of the mechanism and shall be directly connected in the control circuit of the operating motor provided that a mechanical de-clutching mechanism is incorporated. In addition, a mechanical stop shall be provided to prevent over-running of the mechanism under any condition. An interlock to cut-out electrical control when it tends to operate the gear beyond either of the extreme tap positions.
 - viii. OLTC local control cabinet shall be provided with tap position indication for the transformer. Drive Mechanism shall be equipped with a fixed resistor network capable of providing discrete voltage steps or provide 4-20mA transducer outputs for tap position indication in CMB (for single phase unit) and input to Digital RTCC/SCADA system.
 - ix. 'Local-remote' selector switch shall be provided in the local OLTC control cabinet. In Local mode, all electrical commands from remote (i.e. from CMB, Digital RTCC, SCADA etc.) shall be cut-off/blocked. Electrical operations to change tap positions shall be possible by using raise/lower push buttons under local mode from DM Box. In remote mode electrical commands from CMB/Digital RTCC/SCADA etc. shall be executed. The remote-local selector switch shall be having at-least two spare contacts per position.
 - x. Following minimum contacts shall be available in DM Box, which shall be wired to CMB for single phase unit. Further these contacts shall be wired to Digital RTCC panel:
 - INCOMPLETE STEP which shall not operate for momentary loss of auxiliary power.
 - OLTC motor overload protection
 - Supply to DM Motor fail
 - OLTC INPROGRESS
 - Local / Remote Selector switch position
 - OLTC upper/lower limits reached
 - xi. All relays, switches, fuses etc. shall be mounted in the OLTC local control cabinet and shall be clearly marked/labeled for the purpose of identification.

- xii. A permanently legible lubrication chart if required shall be fitted within the OLTC local control cabinet.

c. **OLTC Control from Common Marshalling Box (CMB)**

- i. It shall be possible to monitor, control/operate, the OLTC of all the three 1- phase transformers of a transformer bank from Common Marshalling Box. The control and monitoring terminations of a spare transformer unit shall be brought to CMB. The necessary switching arrangement through male-female plug-in TB assembly shall be provided for replacing spare unit with any one of the faulty phase unit for monitoring & control from CMB.
- ii. 'Independent-combined-remote selector switch, raise/lower switch and emergency stop Push Button shall be provided in the common marshalling box for OLTC control.
- iii. When the selector switch is in independent position, the OLTC control shall be possible from individual Local OLTC Control Cabinet (DM Box) only.
- iv. In 'combined position', raise-lower switch (provided in the CMB), shall be used to operate for bank of three single phase transformers from CMB.
- v. In 'remote position' control of OLTC shall be possible from Digital RTCC/SCADA etc.
- vi. From CMB, the operation of OLTC shall be for 3-phases of transformer units without producing phase displacement. Independent operation of each single phase transformer from CMB/Digital RTCC/SCADA will be prevented.
- vii. Following minimum LED indications shall be provided in CMB:
 - INCOMPLETESTEP
 - OLTC motor overload protection
 - Supply to DM Motor fail
 - OLTC IN PROGRESS
 - Local / Remote Selector switch positions of DM
 - OLTC upper/lower limits reached
 - 400V Main AC supply ON
 - 400V Standby AC supply ON

Following contacts shall be wired to TBs in CMB for further wiring to C & R Panels.

- 400V Main AC supply Fail
- 400V Standby AC supply Fail

Following contacts shall be wired to TBs in CMB for further wiring to digital RTCC Panel:

- INCOMPLETE STEP
- OLTC motor overload protection
- Supply to DM Motorfail
- OLTC INPROGRESS

- Local / Remote Selector switch positions of DM
- OLTC upper/lower limits reached
- 'Independent-combined-remote' selector switch positions of CMB

viii. Further, OLTC Tap position Digital indications for all three 1-PhTransformer units either separately or through selector switch shall be provided in CMB. The same shall also be wired to Digital RTCC Panel to display tap positions for all three 1-ph unit separately.

3.8.4 Digital RTCC Panel

- a. The digital RTCC panel shall have Automatic Tap Changer control and monitoring relay with Automatic Voltage Regulating features (referred as Digital RTCC relay) to remotely control and monitor OLTC. The relay shall be offered from the manufacturer who has already supplied Digital RTCC relay, which is in operation for at-least 2 years for transformer OLTC application.
- b. Digital RTCC relay shall be microprocessor based adopting the latest state of the art design & technology within-built large display for ease of programming and viewing. The unit supplied shall be field programmable so that in the event of change in transformer / location, it could be customized to site conditions without sending back to works. The programming shall be menu driven and easily configurable. If it is designed with draw out type modules, it should take care of shorting all CT inputs automatically while drawing out. The CT/VT ratio shall be field programmable and Relay shall display the actual HV Voltage and current considering suitable multiplying factors. The system shall be self-sufficient and shall not require any additional devices like parallel balancing module etc. All Digital RTCC Relays shall be of same make for smooth integration of these relays for parallel operations of all transformers in the substation.
- c. The digital RTCC Panel shall be provided with digital RTCC relay having Raise/Lower push buttons, Manual/ Automatic mode selection features, Master/Follower/Independent/ off mode selection features and emergency stop Push Button for control of OLTC. Touch screen option in the relay, instead of electrical push button/switch is also acceptable.
- d. **In Manual Mode:** In this mode, power system voltage based automatic control from digital RTCC relay shall be blocked and commands shall be executed manually by raise/lower push buttons.
- e. **In Auto Mode:** In Auto mode, digital RTCC relay shall automatically control OLTC taps based on power system voltage and voltage set points. An interlock shall be provided to cut off electrical control automatically upon recourse being taken to the manual control in emergency.
- f. **Master/Follower/Independent/Off mode**
 - i. Master Position: If the selector switch is in master position, it shall be possible to control the OLTC units of other parallel operating transformers in the follower mode by operation from the master unit.

- ii. Follower Position: If the selector switch is in Follower position control of OLTC shall be possible only from panel where master mode is selected.
- iii. Independent Position: In independent position of selector switch, control of OLTC shall be possible only from the panel where independent mode is selected. Suitable interlock arrangement shall be provided to avoid unwanted/ inconsistent operation of OLTC of the transformer
- g. **Raise/Lower control:** The remote OLTC scheme offered shall have provision to raise or lower taps for the complete bank of three 1-phase transformers/3-Phase Transformers. Individual 1-phase OLTC operation shall not be possible from the remote control panel.
- h. Digital RTCC relays shall communicate with SCADA using IEC 61850 protocols to monitor, parameterize & control the OLTC. Any software required for this purpose shall be supplied. The supplied software shall not have restriction in loading on multiple computers for downloading and analyzing the data. Software shall indicate the current overview of all measured parameters of the connected transformer in real time. The digital RTCC Relay shall have multiple selectable set point voltages and it shall be possible to select the set points from SCADA, with a facility to have the possibility of additional set points command from SCADA. Communication between the Digital RTCC relays to execute the commands for parallel operation shall be implemented using required communication protocol. IEC-61850 GOOSE messaging between Digital RTCC relays for OLTC parallel operation is not permitted. Suitable communication hardware shall be provided to communicate up to distance of 1km between digital RTCC relays. Scope shall also include communication cables between digital RTCC relays. Cables as required for parallel operation of OLTCs of all transformers (including existing transformers wherever required) from Digital RTCC relays shall be considered included in the scope of the Contractor.
- i. The Digital RTCC relay shall have programmable Binary Inputs (minimum 7 Nos.) and Binary outputs (minimum 7 Nos.) for Employer's future use. It shall be possible to have additional module for Binary Input/output as well as Analogue input module depending upon requirement.
- j. The relays shall ensure positive completion of lowering/raising of the OLTC tap, once the command is issued from the relay. "Step-by-Step" operation shall be ensured so that only one tap change from each tap changing pulse shall be effected. If the command remains in the "operate" position, lock-out of the mechanism is to be ensured.
- k. Following minimum indications/alarms shall be provided in Digital RTCC relay either through relay display panel or through relay LEDs:
 - i. INCOMPLETE STEP alarm
 - ii. OLTC motor overload protection alarm
 - iii. Supply to DM Motor fail alarm
 - iv. OLTC IN PROGRESS alarm
 - v. Local/Remote Selector switch positions in DM Box
 - vi. OLTC upper/lower limits reached alarm
 - vii. OLTC Tap position indications for transformer units
 - viii. Independent-combined-remote selector switch positions of CMB

- I. In case of parallel operation or 1-Phase Transformer unit banks OLTC out of step alarm shall be generated in the digital RTCC panel for discrepancy in the tap positions.

3.9 Auxiliary Power Supply of OLTC, Cooler Control and Power Circuit

- 3.9.1 Two auxiliary power supplies, 400 volt, three phase four (4) wire shall be provided by the Employer at cooler control cabinet for OLTC and cooler control and power circuit.
- 3.9.2 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.

3.9.3 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.

3.9.4 Power Supply for Cooler Circuits

- a. Control and power supplies are to be given for Cooler circuits after the selection as mentioned above.
- b. The Contractor shall derive AC power for Cooler Control Circuitry by using appropriately rated dry type transformer in case of using supply voltage different from the Employer's auxiliary supply. If the control circuit is operated by DC supply then suitable main and standby convertors shall be provided by the Contractor, to be operated from AC power source.

- 3.9.5 Necessary isolating switches and MCBs/MCCBs shall be provided at suitable points as per Employer's approved scheme.

3.10 Constructional Features of Cooler Control Cabinet/ Individual Marshalling Box/Common Marshalling Box and Digital RTCC Panel

- 3.10.1 Each transformer unit shall be provided with local OLTC Drive Mechanism Box, cooler control cabinet/individual marshalling box. Digital RTCC panel

- and common marshalling (for a bank of three 1-phase units) shall be provided.
- 3.10.2 The cooler control cabinet, Individual Marshalling Box, Common Marshalling Box, shall be made of stainless steel sheet of at least 1.6mm thick. Digital RTCC panel shall be CRCA sheet of minimum thickness of 2.5mm and shall be painted suitably as per the relevant standard.
 - 3.10.3 The degree of protection shall be IP: 55 for outdoor and IP: 43 for indoor in accordance with IS: 13947/IEC: 60947.
 - 3.10.4 All doors, removable covers and plates shall be gasketed all around with suitably profiled. All gasketed surfaces shall be smooth straight and reinforced if necessary to minimize distortion to make a tight seal. For Control cubicle / Marshalling Boxes etc. which are outdoor type, all the sealing gaskets shall be of EPDM rubber or any better approved quality, whereas for all indoor control cabinets /Digital RTCC panel, the sealing gaskets shall be of neoprene rubber or any better approved quality. The gaskets shall be tested in accordance with approved quality plan, IS: 1149 and IS: 3400.
 - 3.10.5 Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh of brass. All the control cabinets shall be provided with suitable lifting arrangement. Thermostat controlled space heater and cubicle lighting with ON-OFF switch shall be provided in each panel.
 - 3.10.6 The size of Common marshalling box shall not be less than 1600mm (front) x 650mm (depth) x 1800mm (height). All the cabinets except common marshalling box & Digital RTCC shall be tank mounted. All the separately mounted cabinets and panels shall be free standing floor mounted type and have domed or sloping roof for outdoor application.

4. Fittings

- 4.1 The following fittings shall be provided with each three phase transformer covered in this specification.
 - a. 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.
 - b. Pressure relief devices with alarm/trip contacts.
 - c. 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.
 - d. Air release plug.
 - e. Inspection openings and covers.
 - f. Bushing with metal parts and gaskets to suit the termination arrangement.
 - g. 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.
 - h. Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs.
 - i. Protected type mercury or alcohol in glass thermometer.
 - j. Bottom and top filter valves with threaded male adaptors, bottom sampling valve and drain valve.

- k. Rating and diagram plates on transformers and auxiliary apparatus.
- l. Flanged bi-directional wheels/Trolley for movement
- m. Cooler cabinet.
- n. Off load / On load tap changing gear.
- o. Cooling equipment
- p. Bushing current transformers.
- q. Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently.
- r. Terminal marking plates.
- s. Valves schedule plates.
- t. Oil temperature indicator for local and remote mounting
- u. Oil flow indicator
- v. Marshalling box/Common Marshalling box
- w. Suitable galvanized iron or stainless steel tray for cabling on main tank for better aesthetics.
- x. Terminal clamp & connector
- y. 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.
- z. One set of hand tools of reputed make packed in a carry bag/box broadly comprising of double ended spanners (open jaws, cranked ring, tubular with Tommy bar each of sizes 9mm to 24mm, one set each), adjustable wrenches (8 & 12 inch one set), gasket punches (of different sizes as used in the reactor one set), pliers (flat nose, round nose & side cutting one of each type), hammer with handle (one), files with handle (two), knife with handle (one), adjustable hacksaw (one), and cold chisel (one) shall be supplied per Substation.

5. Inspection and Testing

- 5.1 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 5.2. 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.

5.2 Inspection

5.2.1 Tank and Conservator

- a. Certification of chemical analysis and material tests of plates.
- b. Check for flatness.
- c. Electrical interconnection of top and bottom by braided tinned copper flexibles.
- d. Welder's qualification and weld procedure.
- e. Testing of electrodes for quality of base materials and coatings.
- f. Inspection of major weld preparation.
- g. Crack detection of major strength weld seams by dye penetration test.
- h. Measurement of film thickness of :

- i. Oil insoluble varnish.
- ii. Zinc chromate paint.
- iii. Finished coat.
- i. Check correct dimensions between wheels, demonstrate turning of wheels through 90°C and further dimensional check.
- j. 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.
- k. Leakage test of the conservator.
- l. Certification of all test results.

5.2.2 Core

- a. Sample testing of core materials for checking specific loss, bend properties, characteristics and thickness.
- b. Check on the quality of varnish if used on the stampings :
 - i. Measurement of thickness and hardness of varnish on stampings.
 - ii. Solvent resistance test to check that varnish does not react in hot oil.
 - iii. Check overall quality of varnish by sampling to ensure uniform shining colour, no bare spots, no over burnt varnish layer and no bubbles on varnished surface.
- c. Check on the amount of burrs.
- d. Bow check on stampings.
- e. Check for the overlapping of stampings. Corners of the sheet are to be part.
- f. Visual and dimensional check during assembly stage.
- g. Check for inter laminar insulation between core sectors before and after pressing.
- h. Visual and dimensional checks for straightness and roundness of core, thickness of limbs and suitability of clamps.
- i. High voltage test (2 kV for one minute) between core and clamps.
- j. Certification of all test results.

5.2.3 Insulation Material

- a. Sample check for physical properties of materials.
- b. Check for dielectric strength.
- c. Visual and dimensional checks.
- d. Check for the reaction of hot oil on insulating materials.
- e. Dimension stability test at high temperature for insulating material.
- f. Tracking resistance test on insulating material
- g. Certification of all test results.

5.2.4 Winding

- a. Sample check on winding conductor for mechanical properties and electrical conductivity.

- b. Visual and dimensional checks on conductor for scratches, dent marks etc.
- c. Sample check on insulating paper for pH value, bursting strength and electric strength.
- d. Check for the reaction of hot oil on insulating paper.
- e. Check for the bonding of the insulating paper with conductor.
- f. Check and ensure that physical condition of all materials taken for windings is satisfactory and free of dust.
- g. Check for absence of short circuit between parallel strands.
- h. Check for brazed joints wherever applicable.
- i. Measurement of voltage ratio to be carried out when core/yoke is completely restacked and all connections are ready.
- j. Conductor enamel test for checking of cracks, leakage and pin holes.
- k. Conductor flexibility test
- l. Heat shrink test for enameled wire.
- m. Certification of all test results.

5.2.5 Checks Before Drying Process

- a. Check condition of insulation on the conductor and between the windings.
- b. Check insulation distance between high voltage connections, cables and earth and other live parts.
- c. Check insulating distances between low voltage connections and earth and other parts.
- d. Insulation of core shall be tested at 2 kV/minute between core to bolts and core to clamp plates.
- e. Check for proper cleanliness and absence of dust etc.
- f. Certification of all test results.

5.2.6 Checks During Drying Process

- a. Measurement and recording of temperature, vacuum and drying time during vacuum treatment.
- b. Check for completeness of drying by periodic monitoring of IR and Tan delta.
- c. Certification of all test results.

5.2.7 Assembled Transformer

- a. Check completed transformer against approved outline drawings, provision for all fittings, finish level etc.
- b. Test to check effective shielding of the tank.
- c. Jacking test with oil on all the assembled transformers.
- d. Dye penetration test shall be carried out after the jacking test.

5.2.8 Bought Out Items

- a. The makes of all major bought out items shall be subject to Employer's approval.

- b. 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:
 - i. Buchholz Relay.
 - ii. Axles and wheels.
 - iii. Winding temperature indicators for local and remote mounting.
 - iv. Oil temperature indicators.
 - v. Bushings.
 - vi. Bushing current transformers.
 - vii. Cooler cabinet.
 - viii. ON Load / Off Load Tap change gear.
 - ix. Oil pumps.
 - x. Terminal connectors.
 - xi. Pressure relief device relay
 - xii. 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.

5.2.9 Pre-Shipment Checks at Manufacturer's Works

- a. Check for interchangeability of components of similar transformers for mounting dimensions.
- b. Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.
- c. Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.
- d. Gas tightness test to confirm tightness and record of dew point of gas inside the tank.
- e. Derivation of leakage rate and ensure the adequate reserve gas capacity.
- f. 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°C. Also the dew point of dry air / nitrogen cylinders attached for make up during transportation should of the order of (-) 50°C.
- g. Functioning of impact recorder(s) at their works before installing on the tank.

5.3 Factory Tests

- 5.3.1 The manufacturer shall be fully equipped to perform all the required tests as specified. The capabilities of the proposed manufacturing plant in this regard shall be confirmed during tendering. 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-A.

- 5.3.2 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
10.	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 Employer after proper scrutiny and signing on each page by the test engineer of the manufacturer.

* Type Test if not carried out on identical unit as per the relevant standards or if not valid, then It shall be carried out at the manufacturing plant.

5.3.3 Measurement of capacitance and tan delta to determine capacitance between winding and earth. Tan delta value shall not be more than 0.5% at ambient temperature.

5.3.4 Measurement of capacitance and tan delta of OIP bushings. Tan delta value shall not be more than 0.4% at ambient temperature.

5.3.5 **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 Chapter 2 – GTR. The list of fittings and the type test requirement is:

- a. Bushing (Type Test as per IEC: 60137, including snap back/seismic test)
- b. Buchholz relay (Type Test as per IEC and IP-55 Test on terminal box)
- c. 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).
- d. Cooling fan and motor assembly – Free air delivery, Temperature rise, sound level, running at reduced voltage, IP-55 degree of protection for terminal box.
- e. Air Cell (Flexible air separator) – Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per BS: 903.
- f. Cooler Control cabinet (IP-55 test)
- g. 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.

- h. Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection
- i. OTI & WTI– Switch setting & operation, switch differential, switch rating

5.3.6 Pre-Shipment Checks at Manufacturer's Works

5.3.7 Check for interchangeability of components of similar transformers for mounting dimensions.

5.3.8 Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

5.3.9 Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

5.3.10 Gas tightness test to confirm tightness and record of dew point of gas inside the tank.

5.3.11 Derivation of leakage rate and ensure the adequate reserve gas capacity.

- 5.3.12 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°C. Also, the dew point of dry air / nitrogen cylinders attached for make up during transportation should be of the order of (-) 50°C.

5.4 Inspection and Testing at Site

- 5.4.1 The Contractor/Manufacturer shall carry out a detailed inspection and testing Programme for field activities covering areas right from the receipt of material stage up to commissioning stage. An indicative programme of inspection as envisaged by the Employer is given below. Pre commissioning Procedures and Formats for equipment shall be contractor's responsibility to draw up and carry out such a programme.

5.4.2 Receipt and Storage Checks

- a. Check and record condition of each package, visible parts of the transformer etc. for any damage.
- b. 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.
- c. Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.

5.4.3 Installation Checks

- a. Inspection and performance testing of accessories like tap changers etc.
- b. Check the direction of rotation of fans.
- c. Check the bearing lubrication.
- d. Check whole assembly for tightness, general appearance etc.
- e. Oil leakage test
- f. Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.
- g. Leakage test on bushing before erection.
- h. 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.
- i. **Oil filling**
 - i. Oil impregnation or drying under vacuum at site shall be done with the transformer and oil at a temperature not exceeding 70°C.
 - ii. 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.
 - iii. 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.

- iv. 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.
- v. Procedures for site drying, oil purification, oil filling etc. shall be submitted for approval and complete instructions shall form part of the manual.

5.4.4 Commissioning Checks

- a. Check the colour of silica gel in silica gel breather.
- b. Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.
- c. Check the bushing for conformity of connection to the lines etc,
- d. 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.
- e. Check for the adequate protection on the electric circuit supplying the accessories.
- f. Check resistance of all windings on all steps of the tap changer. Insulation resistance measurement for the following:
 - i. Control wiring.
 - ii. Main windings.
- g. Check for cleanliness of the transformer and the surroundings.
- h. 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.
- i. Phase out and vector group test.
- j. Ratio test on all taps.
- k. Magnetizing current test.
- l. Capacitance and Tan delta measurement of winding and bushing.
- m. DGA of oil just after 24 hours energization at site.
- n. Frequency response analysis (FRA) at site by the equipment to be provided by the Contractor.
- o. Contractor shall prepare a comprehensive commissioning report including all commissioning test results and forward to Employer for future record.

6. Technical Parameters

6.1 Technical Particulars / Parameters of Transformers

(132/33 kV 3-Phase Power Transformer)

S. No.	Description	Unit	Technical Parameters
1.	Rated Capacity	MVA	12.5/15
2.	Voltage ratio (HV/LV) Line to line	kV	132/33
3.	Single / Three Phase Design		3 (THREE)
4.	Applicable Standard		IEC 60076
5.	Frequency	Hz	50
6.	Cooling		ONAN/ONAF
7.	Type of Transformer		Constant Ohmic impedance type (Refer Note 1)
8.	HV-LV Impedance at 75°C		
a.	Principal tap	%	>11
b.	Tolerance on Impedance	%	As per IEC
9.	Service		Outdoor
10.	Duty		Continuous
11.	Overload Capacity		IEC 60076-7
12.	Temperature rise over 50°C Ambient Temp		
a.	Top oil measured by thermometer	°C	50
b.	Average winding measured by resistance method	°C	55
13.	Windings		
a.	System Fault level		
	HV	kA	31.5
	LV	kA	25
	Neutral	kA	
b.	Lightning Impulse withstand Voltage		
	HV	kV _p	650
	LV		170
	Neutral	kV _p	95
c.	Switching Impulse withstand Voltage		
	HV	kV _p	650
d.	One Minute Power Frequency withstand Voltage		
	HV	kV _{rms}	275
	LV	kV _{rms}	70
e.	Neutral Grounding		Solidly grounded

f.	Insulation		
	HV		GRADED
	LV		UNIFORM
g.	Tan delta of winding	%	<0.5%
14.	Vector Group (3-ph) (unless specified differently elsewhere)		YNynO
15.	Tap Changer		OLTC
a.	Tap Range & No. of steps		-10% to +10% of HV variation in the step of 1.25%, 17 steps
b.	Location of Tap changer		Neutral end of 132 kV/HV winding
c.	Design		Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I
d.	Tap control		Full capacity on load tap changer suitable for group/independent, remote/local electrical and local manual operation and bi-directional power flow.
16.	Bushings		
a.	Rated voltage		
	HV	kV	145
	LV	kV	36
	Neutral	kV	
b.	Rated current (Min.)		
	HV	A	300
	LV	A	1200
c.	Lightning Impulse withstand Voltage		
	HV	kVp	650
	LV	kVp	170
d.	One Minute Power Frequency withstand Voltage		
	HV	kVrms	275
	LV	kVrms	75
	Neutral	kVrms	55/32
e.	Minimum total creepage distances		
	HV	mm	3625
	LV	mm	900
	Neutral	mm	
f.	Tan delta of bushing		
	HV	%	<0.4

g.	Max Partial discharge level at U_m		
	HV	pC	10
17.	Max Partial discharge level at $1.5U_m/V_3$	pC	100
18.	Max Noise level at rated voltage and at principal tap on full load and all cooling active	dB	75

Notes:

- For parallel operation of transformers, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
- No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
- Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.
- The criteria for Transformer losses shall be "Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)".

7. Bushing Current Transformer

- Current transformers shall comply with IEC-60185.
- 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.
- 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.
- 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.
- Technical Parameters for Bushing CT**
 - Technical Parameters of Current Transformers (for 15 MVA, 132/33 kV 3-Ph Transformers)**

Description	Current Transformer Parameters (Transformer)			
	HV Side	HV Neutral Side	LV Side	LV Neutral Side
(a) Ratio				
CORE 1	300/1	300/1	1200/1	1200/1
CORE 2	NA	NA	NA	NA
(b) Minimum knee point voltage or burden and accuracy class				
CORE 1	5P20	5P20	5P20	5P20
CORE 2	0.2 Class 15VA ISF ≤ 5	-	0.2 Class 15VA ISF ≤ 5	
(c) Maximum CT Secondary Resistance				
CORE 1	1.5 Ohm	1.5 Ohm	1.5 Ohm	1.5 Ohm
CORE 2		-		

(d) Application				
CORE 1	Protection	Protection	Protection	Protection
CORE 2	NA			
(e) Maximum magnetization current (at knee point voltage)				
CORE 1	100mA	100 mA	100mA	100 mA
CORE 2		-		

NOTE:

1. 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.
2. Rated continuous thermal current rating shall be 200% of rated primary current.
3. Parameters of WTI CT for each winding shall be provided by the contractor.
4. For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.
5. 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.
6. The CT ratio and ratings will be reviewed during detail engineering. The Contractor shall suggest the employer.

8. Tender Evaluation and the Guaranteed Losses**8.1 Capitalization of Transformer Losses**

When evaluating the individual Tender received from various Tenderers, the loss of transformer shall be capitalized and evaluated Tender Price shall be calculated as below:

$$P_E = P_b + K_L L_L + K_{NL} L_{NL} + K_{CL} L_{CL}$$

where,

P_E	Evaluated price
P_b	Tender price
K_L	Value of load loss
L_L	Guaranteed load losses at rated current
K_{NL}	Value of no-load loss
L_{NL}	Guaranteed no-load losses
K_{CL}	Value of Cooler Loss
L_{CL}	Guaranteed Cooler losses for full load operation on max MVA base.

The Transformer Losses capitalization rate shall be:

K_{NL}	Value of no-load loss	USD 4,684 / kW
K_L	Value of load loss	USD 1180 / kW
K_{CL}	Value of Cooler loss	USD 393/ kW

8.2 Evaluation of Transformer Losses

If the Tenderers quote unrealistic and unachievable guaranteed transformer loss values (no-load or load losses), then the Employer may ask the Tenderer to submit technical justifications to substantiate such guaranteed losses. The technical

justifications shall be in the form of type test reports performed on the similar type of power transformers. If the justifications are not satisfactory, the proposed transformers shall be rejected and the bid shall be considered non-responsive.

8.3 **Guaranteed Values Not Reached**

If the individual losses of a power transformer as measured during test exceeds the values guaranteed in the Tender/Contract, then for each kilowatt of losses in excess of the losses guaranteed, an amount at the rates of twice the rates of specified in clause 8.1 for No-load Loss, Load Loss and Cooler Loss shall be deducted from the Contract Price.

8.4 **Performance Guarantee**

The performance figures quoted on Technical Data Sheet shall be guaranteed within the tolerances permitted by relevant standards listed under Chapter of General Technical Specifications, and shall become a part of the Contract. In case of loss capitalization, no tolerance shall be permitted for the guaranteed value. The measured no-load and load losses (excluding fan loss) should not exceed the guaranteed value by over 15 % provided that the total losses do not exceed 10% as specified. In case the loss figures are not inside this tolerance, NEA has the right to reject the proposed transformer during factory test.

9. **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 liter.
- 9.3 Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.
- 9.4 The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.
- 9.5 An impermeable oil-proof, transparent plastic or rubber tube of about 5 mm diameter, and of sufficient length shall also be provided with each bottle along with suitable connectors to fit the tube on to the oil sampling valve of the equipment and the oil collecting bottles respectively.

Annexure - A

All Tests shall be carried out as per IEC 60076 on transformer

1. **Magnetic Circuit Test**

After assembly each core shall be tested for 1 minute at 2000 Volts between all bolts, side plates and structural steel work.

2. **Tank Tests**

a. **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.

b. **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:

<u>Horizontal Length of flat plate (in mm)</u>	<u>Permanent deflection (in mm)</u>
Up to 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

c. **Pressure Test**

All transformer tank of each size, its radiator, conservator vessel and other fittings together or separately shall be subjected to an air pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 KN/m² whichever is lower measured at the base of the tank and maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified above for vacuum test.

3. Measurement of capacitance and tan delta to determine capacitance between winding and earth. Tan delta value shall not be more than 0.5% corrected at 20deg C. Temperature correction factor table shall be given by the Contractor and shall form the part of test results.

4. **Temp. Rise Test (as per IEC 60076)**

Gas chromatographic analysis on oil shall also be conducted before and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC 60567. For the evaluation of the gas analysis in temperature rise test the procedure shall be as IEC: 60567 and results will be interpreted as per IEC -61181. The DGA results shall generally conform to IEC/IEEE guidelines.

The temperature rise test shall be conducted at a tap for the worst combination of loading on the three windings of the transformer. The Contractor before carrying out such test shall submit detailed calculations showing alternatives possible, on various taps of the transformer and shall recommend the combination that result in highest temperature rise for the test.

5. Type Tests on fittings:

6. 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 Employer (MOEP-2). Contractor shall submit a detailed procedure for Testing & Commissioning at site including receipt, storage & installation checks as mentioned below.

a. Receipt and Storage Checks

Check and record condition of each package, visible parts of the transformer etc. for any damage.

Check and record the gas pressure in the transformer tank as well as in the gas cylinder.

Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.

Check and record reading of impact recorder at receipt and verify the allowable limits as per manufacturer's recommendations.

b. Installation Checks

Check whole assembly for tightness, general appearance etc.

Oil leakage test

Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.

Leakage check on bushing before erection.

Measure and record the dew point of nitrogen/dry air in the main tank before assembly. Manufacturer shall submit dew point acceptable limits along with temperature correction factor and shall form part of instruction manual. In case dew point values are not within permissible limit suitable drying out process shall be applied for dry out of active part in consultation with the Manufacturer.

c. **Oil filling**

Oil impregnation or drying under vacuum at site shall be done with the transformer and oil at a temperature not exceeding 70°C.

The duration of the vacuum treatment shall be demonstrated as adequate by means of water measurement with a cold trap or other suitable method but shall generally not be less than 72 hours. The vacuum shall be measured on the top of the transformer tank and should be less than 1mbar.

Vacuum shall not be broken until the transformer is oil filled up to the Buchholz relay. Whenever the active insulation or any paper insulated HV connections, especially those from the windings to the bushings are exposed, these shall be re-impregnated under vacuum along with the complete transformer. For this purpose the transformer shall first be drained to expose all insulation material.

The minimum safe level of oil filling (if different from the Buchholz level) to which the transformer shall be oil filled under vacuum, shall be indicated in the manual.

Procedures for site drying, oil purification, oil filling etc shall be submitted for approval and complete instructions shall form part of the manual.

d. **Commissioning Checks**

Check the color of silica gel in silica gel 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:

- Buchholz relay.
- Excessive winding temperature.
- Excessive oil temperature.
- 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:

- Control wiring.
- 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.

Magnetizing current test.

Capacitance and Tan delta measurement of winding and bushing.

DGA of oil just after 24 hours energization at site.

Volume II

Section 6: Employer's Requirements

CHAPTER 4: STATION TRANSFORMER

Table of Contents

1.	General.....	2
2.	Scope of Work	2
3.	General Information	2
4.	Technical Requirements	2
5.	Inspection and Testing	3
6.	Inspection	3
7.	Factory Test	4
8.	Fittings.....	5
9.	Spare Parts	6
10.	Technical Specification	6

CHAPTER 4

STATION TRANSFORMER

1. 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 Outdoor Type Oil filled 33/0.4 kV, 100 kVA Station Transformer.

2. Scope of Work

2.1 Scope of Supply

- a. Transformers as listed above, with insulating oil, current limiting fuse, all materials and accessories, and complete in all respects.
- b. Gland plates, power cable, lugs, anchor bolts and hardware.
- c. Mandatory & optional spares and special maintenance equipment if any.

2.2 Scope of Service

The scope includes but is not limited to the following items of work to be performed for all equipment and materials furnished under this chapter:

- a. Design, manufacturing, shop testing, packing & dispatch
- b. Transportation inclusive of insurance and delivery, FOR site basis
- c. Unloading, handling, storing, transportation at site up to foundations, oil filling and treatment, erection, testing and commissioning
- d. Civil Works
- e. Supply of external cables and termination as required.

3. General Information

- 3.1 All temperature indicators, Buchholz relays and other auxiliary devices shall be suitable for 110 V DC Control Supply. All alarm and Trip Contacts shall also be suitable for connection in 110 V DC Circuits.
- 3.2 All accessories and station supply system shall be suitable for Unmanned Substation and shall be compatible with Substation Automation System (SAS).
- 3.3 The Transformer offered shall confirm to dynamic short circuit test and dielectric test as per IEC 60076. Test report for the same shall be submitted during detail engineering for approval.

4. Technical Requirements

4.1 Core

The core shall be constructed from high grade, non-aging, cold rolled grain-oriented silicon steel laminations. The maximum flux density in any part of the cores and yoke at normal voltage and frequency shall be such that the flux density at any tap position with 10% voltage variation from the voltage corresponding to the tap shall not exceed 1.9 Wb/Sq.m.

4.2 Windings

The conductor shall be of electrolytic copper, free from scales and burrs.

4.3 Insulating Oil

The oil supplied with transformer shall be unused and have the parameters for unused new oil conforming to IEC: 60296 while tested at oil Contractor's premises, no

inhibitors shall be used in oil. Ten percent extra oil shall be supplied for topping up after commissioning in non-returnable containers suitable for outdoor storage.

4.4 Terminal Arrangement

Bushing terminals shall be provided with suitable terminal connectors of approved type and size for cable/overhead conductor's termination of HV side and cable termination on LV side.

The neutral terminals of 400V winding shall be brought out on a bushing along with the 400 volt phase terminals to form a 4 wire system for the 400 volt. Additional neutral bushing shall also be provided for earthing.

4.5 Off Circuit Tap Changing Equipment

The tap change switch shall be three phase, hand operated for simultaneous switching of similar taps on the three phases by operating an external hand wheel.

4.6 Marshalling Box

A metal enclosed, weather, vermin & dust proof marshalling box shall be provided with each transformer to accommodate temperature indicators, terminal blocks etc. It shall have a degree of protection of IP 55 as per IEC: 60947 Part-1.

4.7 Cable boxes

Whenever cable connections are required, suitable cable boxes shall be provided and shall be air insulated. They shall be of sufficient size to accommodate Employer's cables and shall have suitable removable side/top cover to facilitate cable termination and inspection. Cable boxes shall be dust & vermin proof.

5. Inspection and Testing

5.1 The Contractor shall draw up and carry out a comprehensive inspection and testing program during manufacture and commissioning of the transformer. The program shall be duly approved by the Employer.

5.2 The Contractor shall carryout all routine tests on the entire transformer as per relevant standards. Type test report shall be submitted for approval during detail engineering.

6. Inspection

6.1 Tank and Accessories

- a. Physical and dimensional check of transformer tank and accessories.
- b. Crack detection of major strength weld seams by dye penetration test.

6.2 Core

- a. Physical inspection and check of quality of varnish, if used.
- b. Sample testing of core material for checking specific loss, bend properties, magnetization, characteristics and thickness.
- c. Check on completed core for measurement of iron loss and check for any hot spot by exciting the core so as to induce the designed value of flux density in the core.
- d. HV Test

6.3 Insulating Material

- a. Sample checks for physical properties of the material
- b. Check for dielectric strength
- c. Check for the reaction of hot oil on insulating material

6.4 Winding

- a. Sample check on winding conductor for mechanical properties and electrical conductivity and on installation covering.
- b. Sample check on insulation paper for pH value, Bursting strength, Electric strength.

6.5 Assembled Transformer

- a. Check complete transformer against approved outline drawing provision for all fittings, finish etc.
- b. Jacking test on all the assembled transformers.

6.6 Oil

All Standard tests in accordance with relevant Standards shall be carried out on oil samples taken from the transformer before and after testing of the transformer.

The contractor shall also prepare a comprehensive inspection and testing program for all bought out sub-contracted items and shall submit the same to the Employer for approval. Such program shall include the following components:

- a. Buchholz Relay
- b. Winding temperature Indicator
- c. Bushings
- d. Marshaling Box
- e. Tap changer switch
- f. Oil temperature indicator

7. Factory Test

7.1 All standard routine tests in accordance with latest issue of IEC: 60076 shall be carried out on each transformer.

7.2 The transformer shall conform to all the type tests in accordance with latest issues of IEC: 60076. The manufacturer shall submit type tests & additional test reports as listed above as already carried out on transformers of identical design for Employer's acceptance. In such a case validity of type test reports shall be in line with **clause 9.2 of Chapter 2-GTR** of technical specifications. Following parameters in general shall be ensured for establishment of identical design as per IEC 60076, Part-V.

- a. Same Voltage ratio, KVA rating, vector group & impedance.
- b. Same conceptual design of core and winding.
- c. Same arrangement and geometrical sequence of the main windings.
- d. Same type of winding conductors.
- e. Same type of main windings.
- f. Absorbed power at short circuit (i.e. rated power/per unit short circuit impedance) between 30% and 130% of that relating to the reference transformer.
- g. Axial forces and winding stresses occurring at short circuit not exceeding 120% of those relating to the reference transformer.
- h. Same manufacturing process.
- i. Same Clamping and winding support arrangement.

7.3 In addition to all type and routine tests, transformer shall also conform to following additional type tests as per IEC: 60076.

- a. Measurement of zero sequence impedance

- b. Short circuit test
 - c. Measurement of acoustic noise level. This shall conform to NEMA standard publication TR-1.
 - d. Measurement of capacitance and tan delta of transformer winding.
 - e. Test on oil samples as per IS 60296
- 7.4 All auxiliary equipment shall be tested as per the relevant IS Test Certificates shall be submitted for bought out items.
- 7.5 High voltage withstand test shall be performed on auxiliary equipment and wiring after complete assembly.
- 7.6 **Tank Tests:**
 - a. Routine Tests: As per IEC: 60076 Part-1 including
 - b. Vacuum Tests: As per IEC: 60076 Part-1
 - c. Pressure Test: As per IEC: 60076 Part-1
- 7.7 In addition to the above, the following checks should be carried out at manufacturer's works before dispatch for all transformers:
 - a. Check for interchangeability of components of similar transformers and for mounting dimensions.
 - b. Check for proper packing and preservation of accessories like radiators, bushings explosion vent, dehydrating breather, Buchholz relay, conservator etc.
 - c. Check for proper provision of bracings to arrest the movements of core and winding assembly inside the tank.
 - d. Test for gas tightness and derivation of leakage rate. To ensure adequate reserve gas capacity during transit and storage.
- 7.8 The Contractor shall submit a detailed inspection and testing program for field activities, covering areas right from the receipt of material stage up to commissioning stage as per IS : 1886 - Code of practice for installation and maintenance of transformers. The indicative checks and tests are given below.
 - a. Physical checks on each transformer on receipt at site for any damage or short supply.
 - b. Tests on oil samples
 - c. Oil leakage test
 - d. Physical checks for Colour of silica in breather
 - e. Check for oil level in breather housing, conservator tank, etc.
 - f. Check for correct operation of all protections and alarms.
 - g. Insulation Resistance Measurement for Main Winding, control wiring etc.
 - h. Continuously observe the transformer operation at no load for 24 hours.
- 8. **Fittings**
 - 8.1 The following fittings shall be provided with each transformer covered under this specification.
 - a. Conservator with drain plug and oil filling hole with blanking plate
 - b. Plain oil Gauge
 - c. Silica gel Breather
 - d. Pressure Relief vent
 - e. Pocket on tank cover for Thermometer

- f. Valves
- g. Earthing Terminals
- h. Rating & Terminal Marking Plates
- i. Lifting Lugs
- j. Rollers
- k. Air Release Plug

8.2 The fittings listed above are only indicative and any other fittings which generally are required for satisfactory operation of transformer are deemed to be included.

9. Spare Parts

- 9.1 The list of spares for outdoor type transformers covered under this chapter shall be as specified in Chapter 1- PSR
- 9.2 In addition, the Bidder shall also recommend optional spare parts and maintenance equipment necessary for three (3) years of successful operation of the equipment. The prices of these shall be indicated in respective schedules and these shall not be considered for the purpose of evaluation.

10. Technical Specification

S. No.	Description	Unit	Parameters
1	Rated Capacity	KVA	200
2	Rated Voltage		
a.	HV	kV	33
b.	LV	kV	0.4
3	Type of Winding		Two Winding
4	Service		Outdoor
5	No of Phases	No.	Three
6	Frequency	Hz	50
7	Type of Cooling		ONAN
8	Impedance at 75°C	%	0.05
9	Tolerance on Impedance	%	±10
10	Duty		Continuous
11	Overload		IEC: 60076-7
12	Max. Temp. Rise over an ambient of 50°C		
a.	Oil (Temperature rise measurement by thermometer)	°C	35
b.	Winding Temperature rise measurement by resistance method)	°C	40
13	Windings		
a.	System Apparent Short circuit level (kA)		As per IEC: 60076-Part 1
b.	Winding Connection		
	HV		Delta
	LV		Star

S. No.	Description	Unit	Parameters
14	Vector Group		Dyn11
15	Insulation		Uniform
16	Insulation Level	kV _{rms}	
a.	Power Frequency Test Level		
	HV	kV _{rms}	95
	LV	kV _{rms}	2
b.	Basic Impulse Level		
	HV	kV _p	250
	LV	kV _p	-
17	Highest voltage (kV) for each winding	kV	52
18	Method of earthing		Solidly earthed
19	Tap Changer		
a.	Tap Change		+5% to -10% in step of 2.5% on HV side
b.	Tap control		Off Circuit Tap Change Switch
21	HV Bushing		
a.	Rated Voltage	kV	52
b.	Rated current	A	100
c.	Basic Impulse Level (kVp)	kV _p	250
d.	Wet & Dry Power frequency Withstand Voltage	kV _{rms}	95
e.	Min. Total Creepage Distance	mm	1300
f.	Mounting		Tank / Transformer Body
22	LV & Neutral Bushing		
a.	Rated Voltage	kV	1.1
b.	Rated current	A	1000
c.	Basic Impulse Level (kVp)	kV _p	-
d.	Wet & Dry Power frequency Withstand Voltage	kV _{rms}	2
e.	Mounting		Tank / Transformer Body
23	Terminal Detail		
a.	HV		Suitable for 33 kV Cable or Over Head Conductor
b.	LV & Neutral		Cable Box
24	Min. Clearance in Air	mm	
a.	Ph-Ph (HV/LV)	mm	530/25
b.	Ph-Earth (HV/LV)	mm	480/25

Volume II

Section 6: Employer's Requirements

CHAPTER 5: DISCONNECTING SWITCH

Table of Contents

Chapter 5.....	2
DISCONNECTING SWITCH.....	2
1. General.....	2
2. Duty Requirements.....	2
3. Constructional Features	3
4. Earthing Switches	4
5. Operating Mechanism.....	4
6. Operation.....	5
7. Terminal Connector Stud/Pad	6
8. Support Structure.....	6
9. Tests.....	6
10. Pre-Commissioning Tests.....	7
11. Spare Parts and Maintenance Equipment	7
12. Technical Parameters.....	7

CHAPTER 5

DISCONNECTING SWITCH

1. General

- 1.1 The Disconnecting Switches and accessories shall conform in general to IEC: 62271-102 except to the extent explicitly modified in specification and shall be in accordance with requirement of Chapter 2-GTR.
- 1.2 Disconnecting Switches shall be outdoor, off-load type. Earth switches shall be provided on Disconnecting Switches wherever called for, with possibility of being mounted on any side of the Disconnecting Switch. The Disconnecting Switches shall be double break type, unless specified otherwise.
- 1.3 Complete Disconnecting Switch with all the necessary items for successful operation shall be supplied including but not limited to the following:
 - a. Disconnecting Switch assembled with complete Support Insulators, operating rod insulator, base frame, linkages, operating mechanism, control cabinet, interlocks etc.
 - b. All necessary parts to provide a complete and operable Disconnecting Switch installation, control parts and other devices whether specifically called for herein or not.
 - c. The Disconnecting Switch shall be designed for use in the geographic and meteorological conditions as given in Chapter 2-GTR.

2. Duty Requirements

- 2.1 Disconnecting Switches and earth switches shall be capable of withstanding the dynamic and thermal effects of the maximum possible short circuit current of the systems in their closed position. They shall be constructed such that they do not open under influence of short circuit current.
- 2.2 The earth switches, wherever provided, shall be constructionally interlocked so that the earth switches can be operated only when the Disconnecting Switch is open and vice versa. The constructional interlocks shall be built in construction of Disconnecting Switch and shall be in addition to the electrical interlocks. Suitable mechanical arrangement shall also be provided for delinking electrical drive for manual operation.
- 2.3 In addition to the constructional interlock, Disconnecting Switch and earth switches shall have provision to prevent their electrical and manual operation unless the associated and other interlocking conditions are met. All these interlocks shall be of fail-safe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from DC supply and within a variation range as stipulated in **Section 2-GTR**.
- 2.4 The earthing switches shall be capable of discharging trapped charges of the associated lines.
- 2.5 The Disconnecting Switch shall be capable of making/breaking normal currents when no significant change in voltage occurs across the terminals of each pole of Disconnecting Switch on account of make/break operation.
- 2.6 Disconnecting Switch rated for above 72.5 kV shall be of extended mechanical endurance class - M2 as per IEC-62271-102. Disconnecting Switch rated for 72.5 kV and below shall be of extended mechanical endurance class - M1 as per IEC-62271-102. All earth switches shall be of M0 duty.

3. Constructional Features

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

3.1.1 Contacts

- a. The contacts shall be self-aligning and self-cleaning and so designed that binding cannot occur after remaining closed for prolonged periods of time in a heavily polluted atmosphere.
- b. No undue wear or scuffing shall be evident during the mechanical endurance tests. Contacts and spring shall be designed so that readjustments in contact pressure shall not be necessary throughout the life of the Disconnecting Switch or earthing switch. Each contact or pair of contacts shall be independently sprung so that full pressure is maintained on all contacts at all time.
- c. Contact springs shall not carry any current and shall not lose their characteristics due to heating effects.
- d. The moving contact of double break Disconnecting Switch shall have turn-and-twist type or other suitable type of locking arrangement to ensure adequate contact pressure.

3.1.2 Base

Each single pole of the Disconnecting Switch shall be provided with a complete galvanized steel base provided with holes and designed for mounting on a supporting structure.

3.1.3 Blades

- a. All metal parts shall be of non-rusting and non-corroding material. All current carrying parts shall be made from high conductivity electrolytic copper/aluminium. Bolts, screws and pins shall be provided with lock washers. Keys or equivalent locking facilities if provided on current carrying parts, shall be made of copper silicon alloy or stainless steel or equivalent. The bolts or pins used in current carrying parts shall be made of non-corroding material. Ferrous parts, other than stainless steel shall not be used in close proximity of main current path. All ferrous castings, if used elsewhere shall be made of malleable cast iron or cast-steel. No grey iron shall be used in the manufacture of any part of the Disconnecting Switch.
- b. The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces, where this is impracticable adequate corona rings shall be provided. Corona shields are not acceptable. Corona rings shall be made up of aluminum/aluminum alloy.
- c. Disconnecting Switches and earthing switches including their operating parts shall be such that they cannot be dislodged from their open or closed positions by short circuit forces, gravity, wind pressure, vibrations, shocks, or accidental touching of the connecting rods of the operating mechanism.
- d. The switch shall be designed such that no lubrication of any part is required except at very infrequent intervals. i. e. after every 1000 operations or after 5 years whichever is earlier.

3.1.4 Insulator

- a. The insulator shall conform to or IEC-60168. The porcelain of the insulator shall conform to the requirements stipulated under Section 2-

GTR and shall have a minimum cantilever strength of 600 Kgs. for 145 kV insulators respectively.

- b. Pressure due to the contact shall not be transferred to the insulators after the main blades are fully closed.
- c. The parameters of the insulators shall meet the requirements specified under Section 2-GTR.
- d. Insulator shall be type and routine tested as per IEC-60168.
- e. For 145 kV Insulator: (For Disconnecting Switch)

- Top PCD	127 mm
- No. of holes	4 x M16
- Bottom PCD	254 mm
- No. of holes	8 x 18 dia

3.1.5 Name Plate

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

4. Earthing Switches

- 4.1 Where earthing switches are specified these shall include the complete operating mechanism and auxiliary contacts.
- 4.2 The earthing switches shall form an integral part of the Disconnecting Switch and shall be mounted on the base frame of the Disconnecting Switch.
- 4.3 Earthing switches shall be only locally operated.
- 4.4 The earthing switches shall be constructionally interlocked with the Disconnecting Switch so that the earthing switches can be operated only when the Disconnecting Switch is open and vice versa. The constructional interlocks shall be built in construction of Disconnecting Switch and shall be in addition to the electrical interlocks. Suitable mechanical arrangement shall be provided for de-linking electrical drive for manual operation.
- 4.5 Each earth switch shall be provided with flexible copper/aluminum braids for connection to earth terminal. These braids shall have the same short time current carrying capacity as the earth blade. The transfer of fault current through swivel connection will not be accepted.
- 4.6 The plane of movement and final position of the earth blades shall be such that adequate electrical clearances are obtained from adjacent live parts in the course of its movement between ON and OFF position.
- 4.7 The frame of each Disconnecting Switch and earthing switches shall be provided with two reliable earth terminals for connection to the earth mat.
- 4.8 Disconnecting Switch design shall be such as to permit addition of earth switches at a future date. It should be possible to interchange position of earth switch to either side.
- 4.9 The earth switch should be able to carry the same fault current as the main blades of the Disconnecting Switch and shall withstand dynamic stresses.

5. Operating Mechanism

- 5.1 The Manufacturer shall offer motor operated Disconnecting Switch and earth switches.
- 5.2 Control cabinet/operating mechanism box shall conform to the requirement stipulated in Chapter 2-GTR and shall be made of cast aluminium/aluminum sheet of adequate thickness (minimum 3 mm).

- 5.3 A "Local/Remote" selector switch and a set of open/close push buttons shall be provided on the control cabinet of the Disconnecting Switch to permit its operation through local or remote push buttons.
- 5.4 Provision shall be made in the control cabinet to disconnect power supply to prevent local/remote power operation.
- 5.5 Motor shall be an AC motor and conform to the requirements of Chapter 2-GTR.
- 5.6 Suitable reduction gearing shall be provided between the motor and the drive shaft of the Disconnecting Switch. The mechanism shall stop immediately when motor supply is switched off. If necessary a quick electromechanical brake shall be fitted on the higher speed shaft to effect rapid braking.
- 5.7 Manual operation facility (with handle) should be provided with necessary interlock to disconnect motor.
- 5.8 Gear should be of forged material suitably chosen to avoid bending/jamming on operation after a prolonged period of non-operation. Also all gear and connected material should be so chosen/surface treated to avoid rusting.
- 5.9 The test report for blocked rotor test of motor shall be submitted as per the requirement of **clause 23.0 of Chapter 2: GTR of Technical Specification**.
- 5.10 Only stranded conductor shall be used for wiring. Minimum size of the conductor for control circuit wiring shall be 1.5 sq.mm. (Copper).
- 5.11 The operating mechanism shall be located such that it can be directly mounted on any one of the support structure.

6. Operation

- 6.1 The Disconnecting Switch and earth switches shall be gang operated.
- 6.2 The design shall be such as to provide maximum reliability under all service conditions. All operating linkages carrying mechanical loads shall be designed for negligible deflection. The length of inter insulator and interpole operating rods shall be capable of adjustments, by means of screw thread which can be locked with a lock nut after an adjustment has been made. The Disconnecting Switch and earth switches shall be provided with "over center" device in the operating mechanism to prevent accidental opening by wind, vibration, short circuit forces or movement of the support structures.
- 6.3 Each Disconnecting Switch/pole of Disconnecting Switch and earth switch shall be provided with a manual operating handle enabling one man to open or close the Disconnecting Switch with ease in one movement while standing at ground level. Non-detachable type manual operating handle shall have provision for padlocking. For detachable type manual operating handles, suitable provision shall be made inside the operating mechanism box for parking the detached handles. The provision of manual operation shall be located at a convenient operating height from the base of Disconnecting Switch support structure.
- 6.4 The Disconnecting Switch shall be provided with positive continuous control throughout the entire cycle of operation. The operating pipes and rods shall be sufficiently rigid to maintain positive control under the most adverse conditions and when operated in tension or compression for Disconnecting Switch closing. They shall also be capable of withstanding all torsional and bending stresses due to operation of the Disconnecting Switch. Wherever supported the operating rods shall be provided with bearings on either ends. The operating rods/ pipes shall be provided with suitable universal couplings to account for any angular misalignment.
- 6.5 All rotating parts shall be provided with grease packed roller or ball bearings in sealed housings designed to prevent the ingress of moisture, dirt or other foreign matter.

Bearings pressure shall be kept low to ensure long life and ease of operation. Locking pins wherever used shall be rustproof.

- 6.6 Signaling of closed position shall not take place unless it is certain that the movable contacts, have reached a position in which rated normal current, peak withstand current and short time withstand current can be carried safely. Signaling of open position shall not take place unless movable contacts have reached a position such that clearance between contacts is at least 80% of the isolating distance.
- 6.7 The position of movable contact system (main blades) of each of the Disconnecting Switches and earthing switches shall be indicated by a mechanical indicator at the lower end of the vertical rod of shaft for the Disconnecting Switches and earthing switch. The indicator shall be of metal and shall be visible from operating level.
- 6.8 The contractor shall furnish the following details along with quality norms, during detailed engineering stage:
 - a. Current transfer arrangement from main blades of Disconnecting Switch along with milli volt drop immediately across transfer point.
 - b. Details to demonstrate smooth transfer of rotary motion from motor shaft to the insulator along with stoppers to prevent over travel.

7. Terminal Connector Stud/Pad

- 7.1 The Disconnecting Switch terminal pads/studs shall be made of high quality copper or aluminium and shall be conforming to Australian standard AS-2935 for rated current. The terminal pad shall have protective covers which shall be removed before interconnections.

8. Support Structure

- 8.1 Disconnecting Switches shall be suitable for mounting on support structures to be supplied in accordance with stipulations of Section 2-GTR.

9. Tests

- 9.1 In continuation to the requirements stipulated under Section 2-GTR the Disconnecting Switch along with its earthing switch and operating mechanism should have been type tested as per IEC and shall be subjected to routine tests in accordance with IEC-62271-102. Minimum 1000 Nos. mechanical operations in line with mechanical endurance test, M0 duty, shall be carried out on 1 (one) Disconnecting Switch out of every lot of Disconnecting Switches, assembled completely with all accessories, as acceptance test for the lot. The travel characteristics measured at a suitable location in the base of insulator along with motor current/power drawn, during the entire travel duration are to be recorded at the start and completion and shall not vary by more than $\pm 10\%$ after completion of 1000 cycles of operation. After completion of test, mechanical interlock operation to be checked.
- 9.2 The test reports of the type tests and the following additional type tests (additional type tests are required for Disconnecting Switches rated above 72.5 kV only) shall also be submitted for the Purchaser's review.
 - a. Radio interference voltage test.
 - b. Seismic withstand test on Disconnecting Switch mounted on Support structure. The test shall be performed in the following position :
 - Disconnecting Switch open E/S Closed
 - Disconnecting Switch open E/S Open
 - Disconnecting Switch Closed E/S Open

10. Pre-Commissioning Tests

- 10.1 An indicative list of tests on Disconnecting Switch and earth switch is given below. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./instructions of the equipment Supplier or Purchaser without any extra cost to the Purchaser. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates and shall furnish the list of instruments to the Purchaser for approval.
- Insulation resistance of each pole.
 - Manual and electrical operation and interlocks.
 - Insulation resistance of control circuits and motors.
 - Ground connections.
 - Contact resistance.
 - Proper alignment so as to minimize vibration during operation.
 - Measurement of operating Torque for Disconnecting Switch and Earth switch.
 - Resistance of operating and interlocks coils.
 - Functional check of the control schematic and electrical & mechanical interlocks.
 - 50 operations test on Disconnecting Switch and earth switch.
- 10.2 The contractor shall ensure that erection, testing and commissioning of Disconnecting Switches above 72.5 kV class shall be carried out under the supervision of the Disconnecting Switch manufacturer's representative. The commissioning report shall be signed by the manufacturer's representative.

11. Spare Parts and Maintenance Equipment

- 11.1 Bidder shall include in his proposal mandatory spare parts in accordance with the requirements stipulated in Section 1 - PSR.

12. Technical Parameters

(In addition to those specified under Section 2-GTR)

12.1 145 kV Disconnecting Switches

S. No.	Description	Parameters
1	Type	Outdoor
2	Rated Current at 50°C ambient temperature	1250 A
3	Rated short time withstand current of disconnecting switch and earth switch	31.5 kA for 1 Sec
4	Rated dynamic short circuit withstand current of disconnecting switch and earth switch	80 kA _p
5	Temperature rise over design ambient temperature	As per table V of IEC-694
6	Rated Mechanical Terminal Load	As per table III of IEC-62271-102 or as per value calculated in Section 2-GTR whichever is higher
7	Operating Mechanism of Disconnecting Switch/Earth Switch	AC Motor operated
8	No. of Auxiliary contacts on each Disconnecting Switch	Besides requirement of this spec. 5 NO + 5 NC wired to

S. No.	Description	Parameters
		terminal block exclusively for Employer's use in future
9	No. of Auxiliary contacts on each Earthing Switch	Besides requirement of this spec. 3 NO + 3 NC wired to terminal block exclusively for Employer's use in future
10	Operating Time	15 sec or less
11	Number of Terminal in Control Cabinet (Inter pole cabling shall be supplied by the Contractor)	All contacts and control circuits are to be wired to control cabinet plus 24 spare terminals evenly distributed

12.2 33 kV Disconnecting Switches

S. No.	Description	Parameters
1	Type	Outdoor
2	Rated Current at 50°C ambient temperature	1600/1250/800/400 A (as applicable)
3	Rated short time withstand current of disconnecting switch and earth switch	25 kA for 3 Sec
4	Rated dynamic short circuit withstand current of disconnecting switch and earth switch	As per IEC
5	Temperature rise over design ambient temperature	As per table V of IEC-694
6	Rated Mechanical Terminal Load	As per table III of IEC-62271-102 or as per value calculated in Section 2-GTR whichever is higher.
7	Operating Mechanism of Disconnecting Switch/Earth Switch	AC Motor operated
8	No. of Auxiliary contacts on each Disconnecting Switch	Besides requirement of this spec. 5 NO + 5 NC wired to terminal block exclusively for Employer's use in future.
9	No. of Auxiliary contacts on each Earthing Switch	Besides requirement of this spec. 3 NO + 3 NC wired to terminal block exclusively for Employer's use in future.
10	Operating Time	15 sec or less
11	Number of Terminal in Control Cabinet (Inter pole cabling shall be supplied by the Contractor)	All contacts and control circuits are to be wired to control cabinet plus 24 spare terminals evenly distributed

The Porcelain of the 36 kV insulators shall have minimum cantilever strength of 450 kgs.

Volume II

Section 6: Employer's Requirements

CHAPTER 6: SURGE ARRESTOR

Table of Contents

1.	General.....	2
2.	Duty Requirements	2
3.	Constructional Features	2
4.	Fittings and Accessories	3
5.	Spare Parts and Maintenance Equipment.....	4
6.	Tests	4
7.	Pre-Commissioning Tests	5
8.	Technical Parameters	5

CHAPTER 6

SURGE ARRESTOR

1. General

- 1.1 The Surge arresters shall conform to IEC: 60099-4 except to the extent modified in the specification and shall also be in accordance with requirements under Chapter 2 -GTR.
- 1.2 Arresters shall be of hermetically sealed units, self-supporting construction, suitable for mounting on tubular support structures to be supplied by the Contractor.
- 1.3 The Surge Arrestors shall be designed for use in the geographic and meteorological conditions as given in the Chapter 2 -GTR.

2. Duty Requirements

- 2.1 The surge arresters shall be of heavy duty station class and gapless type without any series or shunt gaps.
- 2.2 The surge arresters shall be capable of discharging over-voltages occurring during switching of unloaded transformers, reactors and long lines.
- 2.3 145/36 kV class arrester shall be capable for discharging energy equivalent to class 3 of IEC for 145/36 kV system on two successive operations.
- 2.4 The surge arresters shall be suitable for withstanding forces as defined in Chapter 2-GTR.
- 2.5 The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.
- 2.6 The surge arresters are being provided to protect the following equipment whose insulation levels are indicated in the table given below:-

Equipment to be protected	Lightning Surge for 145 kV System
Power transformer	± 550
Instrument Transformer	± 650
Reactor	--
CB/Isolator Phase to ground	± 650
CB/Isolator Across open contacts	± 750

- 2.7 The duty cycle of CB installed in 145 and 36 kV System of the Employer shall be O-0.3 sec-CO-3 min-CO. The Surge Arrester shall be suitable for such circuit breaker duties in the system.

3. Constructional Features

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

- 3.3 The arresters shall not fail due to arrester porcelain contamination.
- 3.4 Seals shall be provided in such a way that these are always effectively maintained even when discharging rated lightning current.
- 3.5 Outer insulator shall be porcelain/ polymer conforming to requirements stipulated in Chapter 2-GTR. Terminal connectors shall conform to requirements stipulated under Chapter 2-GTR. The outer insulator housing shall be so coordinated that external flashover will not occur due to application of any impulse or switching surge voltage up to the maximum design value for arrester.
- 3.6 The end fittings shall be made of corrosion proof material and preferably be nonmagnetic.
- 3.7 The name plate shall conform to the requirements of IEC incorporating the year of manufacture.
- 3.8 The heat treatment cycle details along with necessary quality checks used for individual blocks along with insulation layer formed across each block are to be furnished. Metalizing coating thickness for reduced resistance between adjacent discs is to be furnished with additional information schedule of bid proposal sheets along with procedure for checking the same. Details of thermal stability test for uniform distribution of current on individual disc is to be furnished.
- 3.9 The manufacturer will submit Data for rejection rate of Zinc oxide (ZnO) blocks during manufacturing/operation for the past three years.
- 3.10 The sealing arrangement of the Surge Arrester stacks shall be done incorporating grooved flanges with the O-rings/elliptical cross-section gaskets of Neoprene or Butyl rubber.
- 3.11 The Surge arrester with porcelain housing shall have a cantilever strength of not less than 350 kg for 120 kV surge arresters respectively or as per the value obtained vide Chapter 2-GTR, whichever is higher. For Surge arrester with polymer housing, the cantilever strength shall not be less than 150 kg.

4. Fittings and Accessories

- 4.1 120/30 kV Arresters shall be complete with insulating base and Surge monitor having provision for bolting to flat surface of structure.
- 4.2 Self-contained discharge counters, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole unit along with necessary connection. Suitable leakage current meters should also be provided. The reading of millimeter and counters shall be visible through an inspection glass panel. The terminals shall be robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends.
- 4.3 Surge monitor consisting of discharge counters and millimeters should be suitable to be mounted on support structure of the arrester and should be tested for IP66 degree of protection. The standard supporting structure for surge arrester should be provided with a mounting pad, for fixing the surge monitor. The surge monitor should be suitable for mounting on this standard mounting pad. Also all nuts, bolts, washers etc. required for fixing the surge monitor shall have to be supplied by the Contractor.

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

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

5. Spare Parts and Maintenance Equipment

- 5.1 Bidder shall include in his proposal spare parts and maintenance equipment, as mentioned in Chapter 1-PSR.

6. Tests

- 6.1 In accordance with the requirements stipulated under Chapter 2-GTR, the surge arresters should have been type tested as per IEC and shall be subjected to routine and acceptance tests in accordance with IEC document. For contamination test, procedures outlined in 60099-3 shall be followed.

- 6.2 The test reports of the type tests and the following additional type tests (additional type tests are required for Surge Arresters above 72.5 kV class only) shall also be submitted for the Employer's review.

- a. Radio interference voltage test as per IEC 60099-4.
- b. Seismic withstand test.
- c. Contamination test.
- d. Test to verify the Power frequency versus time characteristics. Temporary over voltage profile for arresters are to be mutually agreed.

- 6.3 Each metal oxide block of surge arresters shall be tested for the guaranteed specific energy capability in addition to the routine/acceptance test as per IEC: 60099-4.

6.4 Acceptance Tests:

- a. Measurement of power frequency reference voltage of the arrester units.
- b. Lightning Impulse Residual voltage on arrester units. (IEC clause 6.3.2).
- c. Internal Ionization or partial Discharge test.

6.5 Special Acceptance Test:

- a. Thermal stability test on three sections. (IEC Clause 7.2.2).
- b. Aging & Energy Capability test on blocks (procedure to be mutually agreed).
- c. Watt loss test.

6.6 Routine Tests:

- a. Sealing test: Water dip test at 1.5 m depth from top of Surge Arrestor for 30 minutes shall be performed during assembly of Surge Arrester stacks (followed by other routine tests, i.e. P.D. Measurement, Reference Voltage, Residual Voltage & IR measurement).
- b. Measurement of reference voltage.
- c. Residual voltage test of arrester unit.
- d. Internal Ionization test or partial discharge test.
- e. Verticality check on completely assembled Surge arresters as a sample test on each lot.

6.7 Test on Surge Monitors:

- a. The Surge monitors shall also be connected in series with the test specimens during residual voltage and current impulses withstand tests to verify efficacy of the same. Additional routine/ functional tests with one 100A and 10kA current impulse (8/20 micro sec.) shall also be performed on the Surge monitor.

- b. Surge monitors shall be routinely tested for water dip test at 1.5m for 30 minutes. No water vapors shall be visible on the monitor glass.

6.8 Test on insulators

- a. All routine tests shall be conducted on the hollow column insulators as per IEC 62155. Polymer housing shall be tested in accordance to IEC-61462.

7. Pre-Commissioning Tests

7.1 An indicative list of tests is given below:

- a. Operation check of LA counter.
- b. Insulation resistance measurement
- c. Capacitance and Tan delta measurement of individual stacks.
- d. Third harmonic resistive current measurement (to be conducted after energization).

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

8. Technical Parameters

(In addition to those specified under Chapter 2-GTR)

8.1 145 kV Class Surge Arrester

S. No.	Description	Parameters
1	Rated Arrester Voltage	120 kV
2	Nominal Discharge Current	10 kA of 8/20 μ sec wave
3	Minimum Discharge Capability	5kJ/kV (referred to rated arrester voltage corresponding to minimum discharge characteristics.
4	Continuous Operating Voltage at 50°C	102 kV _{rms}
5	Maximum switching surge residual voltage (1kA)	280 kV _p
6	Maximum Residual Voltage at a. 5 kA b. 10 kA nominal discharge current	310 kV _p 330 kV _p
7	Long Duration Discharge class	3
8	High current short duration test value (4/10 μ sec wave)	100 kA _p
9	Current for pressure relief test	40 kA _{rms}
10	Low current long duration test value (2400 μ sec wave)	As per IEC
11	Pressure Relief Class	31.5 kA

8.2 36 kV Surge Arrester

S. No.	Description	Parameters
1	Rated Arrester Voltage	30 kV
2	Nominal Discharge Current	10 kA of 8/20 μ sec wave
3	Minimum Discharge Capability	5kJ/kV (referred to rated arrester voltage corresponding to minimum discharge characteristics.
4	Continuous Operating Voltage at 50°C	24 kV _{rms}
5	Maximum switching surge residual voltage (1kA)	63 kV _p
6	Maximum Residual Voltage at a. 5 kA b. 10 kA nominal discharge current	80 kV _p 85 kV _p
7	Long Duration Discharge class	2
8	High current short duration test value (4/10 μ sec wave)	100 kA _p
9	Current for pressure relief test	40 kA _{rms}
10	Low current long duration test value (2400 μ sec wave)	As per IEC
11	Pressure Relief Class as per IEC 60099-1	A

Volume II

Section 6: Employer's Requirements

CHAPTER 7: INSTRUMENT TRANSFORMERS

Table of Contents

1.	General.....	2
2.	Construction Features.....	2
3.	Current Transformers.....	3
4.	Voltage Transformers.....	4
5.	Terminal Connectors	5
6.	Tests	5
7.	Spare Parts and Maintenance Equipment.....	7
8.	Pre-Commissioning Tests	7
9.	Technical Parameters	8

CHAPTER 7

INSTRUMENT TRANSFORMERS

1. General

- 1.1 The instrument transformers and accessories shall conform to the latest version of the standards specified below except to the extent explicitly modified in the specification and shall be in accordance with the requirements in Chapter 2-GTR.
 - a. Current Transformers IEC: 60044-1
 - b. Capacitive Voltage Transformers IEC: 60044-5 / IEC-60358
 - c. Inductive Voltage Transformers IEC: 60044-2
- 1.2 The instrument transformers shall be complete with its terminal box and a common marshalling box for a set of 3 instrument transformers.
- 1.3 The external surface of instrument transformer, if made of steel, shall be hot dip galvanized or painted as per Chapter 2-GTR. External surface of aluminium can have natural finish.
- 1.4 The impregnation details along with tests/checks to ensure successful completion of impregnation cycle shall be furnished for approval.
- 1.5 The instrument transformers shall be designed for use in geographic and meteorological conditions as given in Chapter 2-GTR.

2. Construction Features

- 2.1 The features and constructional details of instrument transformers shall be in accordance with requirements stipulated hereunder:
 - 2.1.1 Instrument transformers shall be of 145 kV class, oil filled/ SF₆ gas filled, suitable for outdoor service and upright mounting on steel structures. 145 kV Instrument transformers shall be with shedded porcelain/ polymer bushings/Insulators.
 - 2.1.2 Bushings/Insulators shall conform to requirements stipulated in Chapter 2-GTR. The bushing/insulator for CT shall be one piece without any metallic flange joint.
 - 2.1.3 Oil filling and drain plugs, oil sight glass shall be provided for CT and for electromagnetic unit of CVT etc. The Instrument Transformer shall have cantilever strength of not less than 350 kg for 145 kV Instrument transformers. For CVT with polymer housing, the cantilever strength shall not be less than 150 kg. Oil filling and drain plugs are not required with SF₆ gas filled CT.
 - 2.1.4 Instruments transformers shall be hermetically sealed units. Manufacturer shall furnish details of the arrangements made for the sealing of instrument transformers during detailed engineering.

Manufacturer shall also furnish the details of site tests to check the effectiveness of hermetic sealing for approval.
 - 2.1.5 Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.
 - 2.1.6 In case of SF₆ filled CTs/Inductive VTs, it shall be provided with a suitable SF₆ gas density monitoring device, with NO/NC contacts to facilitate the remote annunciation and tripping in case of SF₆ leakage. Provisions shall be made for online gas filling. Suitable rupture disc shall be provided to prevent explosion.

2.2 Terminal Box/Marshalling Box

Terminal box shall conform to the requirements of Chapter 2-GTR.

2.3 Insulating Oil

2.3.1 Insulating oil to be used for instrument transformers shall be of EHV grade and shall conform to IEC - 60296 (required for first filling). Non-PCB based synthetic insulating oil conforming to IEC 60867 can also be used in the capacitor units of CVT with specific approval from the owner, the proposal for which shall be submitted during detailed engineering stage.

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

2.4 Name Plate

2.4.1 Name plate shall conform to the requirements of IEC incorporating the year of manufacture. The rated current, extended current rating in case of current transformers and rated voltage, voltage factor in case of voltage transformers shall be clearly indicated on the name plate. The rated thermal current in case of CT shall also be marked on the name plate.

2.4.2 The intermediate voltage in case of capacitor voltage transformer shall be indicated on the name plate.

3. Current Transformers

3.1 Current transformers shall have single primary either ring type, or hair pin type and suitably designed for bringing out the secondary terminals in a weather proof (IP 55) terminal box at the bottom. PF Terminal for measurement of tan delta and capacitance of the unit shall be provided. These secondary terminals shall be terminated to stud type non disconnecting terminal blocks inside the terminal box. In case "Bar primary" inverted type current transformers are offered the manufacturer will meet following additional requirements:

3.1.1 The secondaries shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution.

3.1.2 The lowest part of the insulation assembly shall be properly secured to avoid any risk of damage due to transportation stresses.

3.1.3 The upper part of insulation assembly resting on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly & top dome.

3.1.4 Nitrogen if used for hermetic sealing (in case of live tank design) should not come in direct contact with oil.

3.1.5 Manufacturer shall recommend whether any special storage facility is required for spare CT.

3.2 Different ratios specified shall be achieved by secondary taps only and primary reconnection shall not be accepted.

3.3 Core lamination shall be of cold rolled grain oriented silicon steel or other equivalent alloys. The cores used for protection shall produce undistorted secondary current under transient conditions at all ratios with specified CT parameters.

3.4 The expansion chamber at the top of the porcelain insulators should be suitable for expansion of oil.

3.5 Facilities shall be provided at terminal blocks in the marshalling box for star delta formation, short circuiting and grounding of CT secondary terminals.

- 3.6 Current transformer's guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.
- 3.7 For 145 kV class CTs, the rated extended primary current shall be 120% (or 150% if applicable) on all cores of the CTs as specified in the Chapter 1 – GTR.
- 3.8 For 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.
- 3.9 The current transformer shall be suitable for horizontal transportation. It shall be ensured that the CT is able to withstand all the stresses imposed on it while transporting and there shall be no damage in transit. The Contractor shall submit the details of packing design to the Purchaser for review.
- 3.10 For 145 kV CTs the instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be inbuilt construction of the CTs. In case these are to be mounted separately these shall be mounted in the central marshalling box suitably wired up to the terminal blocks.
- 3.11 The wiring diagram plate for the interconnections of the three single phase CTs shall be provided inside the marshalling box.
- 3.12 The current transformers should be suitable for mounting on lattice support structure or pipe structure to be provided by the Contractor in accordance with stipulations of Chapter 2-GTR.
- 3.13 The CT shall be so designed as to achieve the minimum risks of explosion in service. Manufacturer shall bring out in his offer, the measures taken to achieve this.

4. Voltage Transformers

- 4.1 145 kV Voltage transformers shall be capacitor voltage divider type with electromagnetic units and shall be suitable for carrier coupling. And the 36kV Voltage transformers shall be Inductive Type.
- 4.2 Voltage transformers secondaries shall be protected by HRC cartridge type fuses or MCBs for all the windings. In addition fuses/MCBs shall be provided for the protection and metering windings for fuse monitoring scheme. The secondary terminals of the VTs shall be terminated to the stud type non - disconnecting terminal blocks in the individual phase secondary boxes via the fuse/MCB.
- 4.3 VTs shall be suitable for high frequency (HF) coupling required for power line carrier communication. Carrier signal must be prevented from flowing into potential transformer (EMU) circuit by means of a RF choke/reactor suitable for effectively blocking the carrier signals over the entire carrier frequency range i.e. 40 to 500 KHz. Details of the arrangement shall be furnished along with the Tender. H.F. terminal of the VT shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling filters of the carrier communication equipment, when utilized. Further, earthing link with fastener to be provided for HF terminal.
- 4.4 The electromagnetic unit comprising compensating reactor, intermediate transformer and protective and damping devices should have separate terminal box with all the secondary terminals brought out.
- 4.5 The damping device, which should be permanently connected to one of the secondary windings, should be capable of suppressing the Ferro resonance oscillations.

- 4.6 The accuracy of 0.2 on secondary III for all VTs should be maintained throughout the entire burden range up to 50 VA on all the windings without any adjustments during operation.
- 4.7 145 kV CVTs shall be suitable for mounting on tubular GI pipe in accordance with stipulations of Chapter 2-GTR.
- 4.8 It should be ensured that access to secondary terminals is without any danger of access to high voltage circuit.
- 4.9 A protective surge arrester shall be provided if required, to prevent breakdown of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor/primary winding, tuning reactor/RF choke etc. due to short circuit in transformer secondaries. In case of an alternate arrangement, Manufacturer shall bring out the details in the Tender.
- 4.10 The wiring diagram for the interconnection of the three single phase VTs shall be provided inside the marshalling box in such a manner that it does not deteriorate with time.

5. Terminal Connectors

- 5.1 The terminal connectors shall meet the requirements as given in Chapter 2-GTR.

6. Tests

- 6.1 In accordance with the requirements in Chapter 2-GTR, Current and Voltage Transformers should have been type tested and shall be subjected to routine tests in accordance with IEC:60044-1 and IEC: 60044-5/60044-2 respectively.
- 6.2 The test reports of the type tests and the following additional type tests (additional type tests are required for Instrument Transformers, rated above 72.5 kV only) shall also be submitted for the Employer's review.

6.2.1 Current Transformers

- a. Radio interference voltage test as per IEC 60044-1.
- b. Seismic withstand test.
- c. Thermal stability test, i.e. application of rated voltage and rated extended thermal current simultaneously by synthetic test circuit. (not applicable for SF₆ filled CT)
- d. Thermal co-efficient test i.e. measurement of tan delta as a function of temperature (at ambient and between 80°C & 90°C) and voltage (at 0.3, 0.7, 1.0 and 1.1 Um/V3) (not applicable for SF₆ filled CT)
- e. The current transformer shall be subjected to Multiple chopped impulse test (not applicable for SF₆ filled CT) by any one of the following two methods given below to assess the CT performance in service to withstand the high frequency over voltage generated due to closing & opening operation of isolators. Alternatively, method as per IEC:60044-1 may be followed:

Method I

600 negative polarity lightning impulses chopped on crest will be applied to current transformer. The opposite polarity amplitude must be limited to 50% of crest value when the wave is chopped. One impulse per minute shall be applied and every 50 impulse high frequency currents from the windings and total current to earth will be recorded and be compared

with reference currents recorded applying one or more (max 20) reduced chopped impulses of 50% of test value.

Oil samples will be taken before and 3 days after the test. Gas analysis must not show appreciable rate of increase in various gases related with the results of the analysis performed before test.

Total sum of crest values of current through secondaries must not exceed 5% of the crest value of total current to earth.

CT must withstand dielectric tests after this test to pass the test.

Method II

100 negative polarity impulses with a rise and fall time of less than 0.25 microsecond corrected to atmospheric condition shall be applied at one minute interval and total current through insulation of earth will be recorded. The amplitude of first opposite polarity should be limited to 50% of the chopped impulse crest value. Voltage and total current wave shapes shall be recorded after every 10 impulses, and will be compared with reference wave shapes recorded before test at 50% of test values.

Oil sample shall be taken before and 3 days after the test and CT shall be deemed to have passed the test if the increase in gas content before and after test is not appreciable.

6.2.2 Voltage transformers

- a. High frequency capacitance and equivalent series resistance measurement (as per IEC-60358) for VT.
- b. Seismic withstand test.
- c. Stray capacitance and stray conductance measurement of the low voltage terminal (as per IEC-60358) for VT.
- d. Determination of temperature coefficient test (as per IEC-60358).
- e. Radio interference voltage test as per IEC-60044-5/IEC-60044-2. However the RIV level shall be as specified in clause Major Technical Parameters in Chapter 2-GTR.
- f. Apart from the above, report of all special tests mentioned in IEC-60044 for voltage transformer shall also be submitted for approval.

- 6.3 The current and voltage transformer shall be subjected to the following routine tests in addition to routine tests as per IEC.

6.3.1 Current Transformers

- a. For Oil filled CTs
 - Measurement of Capacitance.
 - Oil leakage test.
 - Measurement of tan delta at 0.3, 0.7, 1.0 and 1.1 Um/V3.
- b. For SF₆ filled CTs
 - Dew point measurement
 - SF₆ alarm/ lockout check.
 - SF₆ leakage test. Gas leakage rate shall be maintained within 0.2% per annum.

6.3.2 Voltage Transformers

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

7. Spare Parts and Maintenance Equipment

7.1 The Manufacturer shall include in his proposal spare parts equipment in accordance with Chapter 1-PSR.

8. Pre-Commissioning Tests

8.1 An indicative list of tests is given below:

8.1.1 Current Transformers

- a. Insulation Resistance Test for primary and secondary
- b. Polarity test
- c. Ratio identification test - checking of all ratios on all cores by primary injection of current
- d. Dielectric test of oil (wherever applicable)
- e. Magnetizing characteristics test
- f. Tan delta and capacitance measurement
- g. Secondary winding resistance measurement
- h. Contact resistance measurement (wherever possible/accessible)
- i. Test for SF₆ (for SF₆ filled CTs) – Dew point measurement, SF₆ alarm/lockout check
- j. **DGA test of oil**

Dissolved gas analysis to be carried out at the time of commissioning. CTs must have adequate provision for taking oil samples from the bottom of the CT without exposure to atmosphere. The Manufacturer shall recommend the frequency at which oil samples should be taken and norms for various gases in oil after being in operation for different durations. The Manufacturer should also indicate the total quantity of oil which can be withdrawn from CT for gas analysis before refilling or further treatment of CT becomes necessary.

8.1.2 Voltage Transformers/Capacitive Voltage Transformers

- a. Insulation Resistance test for primary (if applicable) and secondary winding
- b. Polarity test
- c. Ratio test
- d. Dielectric test of oil (wherever applicable).
- e. Tan delta and capacitance measurement of individual capacitor stacks.
- f. Secondary winding resistance measurement.

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

9. Technical Parameters

(In addition to those specified under Chapter 2-GTR)

9.1 145 kV Current Transformers

S. No.	Description	Parameters
1	Rated Primary Current	200/100 A
2	Continuous Thermal Rating	120% of rated current (on all cores)
3	Rated Short Time Thermal Current	31.5 kA for 1 Sec
4	Rated Dynamic Current	80 kA (peak)
5	Maximum Temperature rise over design ambient temperature	As per IEC 60044-1
6	One minute Power Frequency Withstand Voltage secondary terminal and earth	5 kV
7	Number of Terminals	All terminals of control circuits are to be wired up to marshaling box plus 20% spare terminals evenly distributed on all TBS
8	Type of Insulation	Class A

Current Transformers shall also comply with requirements of Table I A as applicable.

9.2 33 kV Current Transformers

S. No.	Description	Parameters
1	Rated Primary Current	600/400/200/100 A
2	Continuous Thermal Rating	120% of rated current (on all cores)
3	Rated Short Time Thermal Current	25 kA for 3 Sec
4	Rated Dynamic Current	As per IEC
5	Maximum Temperature rise over design ambient temperature	As per IEC 60044-1
6	One minute Power Frequency Withstand Voltage secondary terminal and earth	5 kV
7	Number of Terminals	All terminals of control circuits are to be wired up to marshaling box plus 20% spare terminals evenly distributed on all TBS
8	Type of Insulation	Class A

Current Transformers shall also comply with requirements of Table I B as applicable.

9.3 145 kV Voltage Transformers

S. No.	Description	Parameters
1	System Fault Level	31.5 kA for 1 Sec
2	Standard Reference Range of Frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement
3	High frequency capacitance for entire carrier frequency range	Within 80% to 150% of rated capacitance (for CVT only)
4	Equivalent series resistance over the entire carrier frequency range	Less than 40Ω (for CVT only)
5	Stray capacitance and stray conductance of the LV terminal over entire carrier frequency range	As per IEC 358 (for CVT only)
6	One Minute Power Frequency withstand voltage a. Between LV (HF) terminal and earth terminal enclosed in a weather proof box. b. For secondary winding	10 kV _{rms} for exposed terminals and 4 kV _{rms} for terminals 3 kV _{rms}
7	Maximum Temperature rise over design ambient temperature	As per IEC 60044-2 or 60044-5
8	Number of Terminals in control cabinet	All terminals of control circuits are to be wired up to marshaling box plus 20% spare terminals evenly distributed on all TBS
9	Rated Total Thermal Burden (VA)	150 (50VA/winding)

Voltage Transformers shall also comply with requirements of Table II A as applicable.

9.4 33 kV Voltage Transformers

S. No.	Description	Parameters
1	System Fault Level	25 kA for 3 Sec
2	Standard Reference Range of Frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement
3	High frequency capacitance for entire carrier frequency range	Within 80% to 150% of rated capacitance (for CVT only)
4	Equivalent series resistance over the entire carrier frequency range	Less than 40Ω (for CVT only)
5	Stray capacitance and stray conductance of the LV terminal over entire carrier frequency range	As per IEC 358 (for CVT only)

S. No.	Description	Parameters
6	One Minute Power Frequency withstand voltage a. Between LV (HF) terminal and earth terminal enclosed in a weather proof box. b. For secondary winding	10 kV _{rms} for exposed terminals and 4 kV _{rms} for terminals 2 kV _{rms}
7	Maximum Temperature rise over design ambient temperature	As per IEC
8	Number of Terminals in control cabinet	All terminals of control circuits are to be wired up to marshaling box plus 20% spare terminals evenly distributed on all TBS
9	Rated Total Thermal Burden (VA)	90 (30VA/winding)

Voltage Transformers shall also comply with requirements of Table II B as applicable.

- 9.5 Rating of the CTs and VTs may subject to change based on Detail Engineering Design and the Contractor shall propose and get approval of the Employer for this provision but in no case size should be below the size indicated in the Tender Documents. In case of need of higher rating, no extra cost shall be paid to the Contractor.

Table – I A
Requirements for 145 kV Current Transformers

DESCRIPTION		UNIT	REQUIREMENT
1	Type		<i>Outdoor oil immersed</i>
2	Number of phases	No.	single
3	Number of cores in each CT	No.	5
4	Frequency	Hz	50
5	Rated Primary Voltage	kV	132
6	Insulation level		
a	Impulse withstand voltage	kV, (crest)	650
b	Power frequency withstand voltage (1 min. rms)	kV	275
7	Rated peak withstand current	kA	
8	Creepage distance	mm	
9	Short time thermal rating (1 Sec)	kA	25
10	Ratings		
a	Current ratio	A	<i>200-100/1 A (Power Transformer, 132 kV side)</i>
b	Rated VA burden for each core	VA	50
11	Accuracy class / No. of Cores		5P20 – 2 Nos. for Protection CL:0.2 – 2 Nos. for Tariff Metering CL 0.5 – 1 Nos. for Measurement
12	Dimension (L x W x H)	mm	
13	Weight	kg	

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

Table – I B
Requirements for 33 kV Current Transformers

DESCRIPTION		UNIT	REQUIREMENT
1	Type		Outdoor Epoxy resin encapsulated
2	Number of phases	No.	single
3	Number of cores in each CT	No.	3 (for Incomer) 2 (for Feeder)
4	Frequency	Hz	50
5	Rated Primary Voltage	kV	33
6	Temperature rise above 40°C ambient	°C	As per IEC
7	Insulation level		
a	Impulse withstand voltage	kV, (crest)	170
b	Power frequency withstand voltage (1 min. rms)	kV	75
8	Rated peak withstand current	kA	
9	Creepage distance	mm	
10	Short time thermal rating (1 Sec)	kA	25
11	Ratings		
a	Current ratio:	A	600-400-200/1 A (for Incomer) 400-200-100/1 A (for Feeder)
b	Rated VA burden for each core	VA	30
12	Accuracy class / No. of Cores		<u>For Incomer</u> 5P20 – 2 Nos. for Protection CL 0.5 – 1 Nos. for Measurement <u>For Feeder</u> 5P20 – 1 Nos. for Protection CL 0.5 – 1 Nos. for Measurement
13	Dimension (L x W x H)	mm	
14	Weight	kg	

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

Table – II A
Requirements for 145 kV Voltage Transformers

DESCRIPTION		UNIT	REQUIREMENT		
1	Type		Single Phase VT		
2	Number of Secondary	No.	3		
3	Frequency	Hz	50		
4	Rated Primary Voltage	kV	145		
5	Rated Voltage Factor		1.2 times– Continuous 1.5 times for 30 seconds		
6	Phase angle error		± 10 minutes (for metering core)		
			<u>Sec I</u>	<u>Sec II</u>	<u>Sec III</u>
7	Rated Secondary Voltage	V	110/√3	110/√3	110/√3
8	Application		Protection	Metering	Tariff
9	Accuracy		3P	0.2	0.2
10	Rated VA burden for each core	VA	50	50	50

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

Table – II B
Requirements for 33 kV Voltage Transformers

DESCRIPTION		UNIT	REQUIREMENT		
1	Type		Single Phase VT		
2	Number of Secondary	No.	3		
3	Frequency	Hz	50		
4	Rated Primary Voltage	kV	36		
5	Rated Voltage Factor		1.2 times– Continuous 1.5 times for 30 seconds		
6	Phase angle error		± 10 minutes (for metering core)		
			<u>Sec I</u>	<u>Sec II</u>	<u>Sec III</u>
7	Rated Secondary Voltage	V	110/√3	110/√3	110/√3
8	Application		Protection	Metering	Tariff
9	Accuracy		3P	0.2	0.2
10	Rated VA burden for each core	VA	30	30	30

Volume II

Section 6: Employer's Requirements

CHAPTER 8: SWITCHGEAR

Table of Contents

1.	General.....	2
2.	Duty Requirements	2
3.	Total Break Time	2
4.	Constructional Features	3
5.	Sulphur Hexafluoride Gas (SF ₆).....	4
6.	Insulators.....	4
7.	Spare Parts and Maintenance Equipment.....	4
8.	Operating Mechanism and Control	4
9.	Support Structure.....	6
10.	Terminal Connector Pad.....	6
11.	Interpole Cabling (if applicable)	6
12.	Fittings and Accessories	6
13.	Additional Data to be furnished	7
14.	Tests	7
15.	Pre-Commissioning Tests	8
16.	Technical Parameters	9

CHAPTER 8 SWITCHGEAR

1. General

- 1.1 The circuit breakers and accessories shall conform to IEC: 62271-100, IEC: 62271-01 and other relevant IEC standards except to the extent explicitly modified in the specification and shall also be in accordance with requirements specified in Chapter 2-GTR.
- 1.2 145 kV live tank type circuit breakers offered would be of sulphur hexafluoride (SF₆) type only and of class C2-M2 as per IEC.
- 1.3 The circuit breaker shall be complete with terminal connectors, operating mechanism, control cabinets, piping, interpole cable (if applicable), cable accessories like glands, terminal blocks, marking ferrules, lugs, pressure gauges, density monitors (with graduated scale), galvanized support structure for CB and control cabinets, their foundation bolts and all other circuit breaker accessories required for carrying out all the functions the CB is required to perform.
- 1.4 All necessary parts to provide a complete and operable circuit breaker installation such as main equipment, terminals, control parts, connectors and other devices whether specifically called for herein or not shall be provided.
- 1.5 Painting shall be done in line with Chapter 2 –GTR. REL-5032 or similar shades can be used for painting. The support structure of circuit breaker shall be hot dip galvanized. Exposed hardware items shall be hot dip galvanized or Electro-galvanized.
- 1.6 The circuit breakers shall be designed for use in the geographic and meteorological conditions as given in Chapter 2--GTR.

2. Duty Requirements

- 2.1 The circuit breakers shall be capable of performing their duties without opening resistors.
- 2.2 The circuit breaker shall meet the duty requirements for any type of fault or fault location also for line switching when used on a 145 kV effectively grounded system, and perform make and break operations as per the stipulated duty cycles satisfactorily.
- 2.3 The breaker shall be capable of interrupting the steady state and transient magnetizing current corresponding of power transformers.
- 2.4 The circuit breaker shall also be capable of:
 - a. Interrupting line/cable charging current as per IEC without use of opening resistors.
 - b. Clearing short line fault (Kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.
 - c. Breaking 25% of the rated fault current at twice rated voltage under phase opposition condition.
- 2.5 The Breaker shall satisfactorily withstand the high stresses imposed on them during fault clearing, load rejection and re-energization of lines with trapped charges. The breaker shall also withstand the voltages specified under Clause 16 of this Chapter.

3. Total Break Time

- 3.1 The total break time as specified under this Chapter shall not be exceeded under any of the following duties:
 - a. Test duties T10, T30, T60, T100a, T100s (TRV as per IEC: 62271-100)

- b. Short line fault L75, L90 (TRV as per IEC: 62271-100)
 - 3.2 The Manufacturer may please note that total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage, (70-110%) and arc extinguishing medium pressure etc. While furnishing the proof of the total break time of complete circuit breaker, the Manufacturers may specifically bring out the effect of non-simultaneity between contacts between poles and show how it is covered in the guaranteed total break time.
 - 3.3 The values guaranteed shall be supported with the type test reports.
- 4. **Constructional Features**
 - 4.1 The features and constructional details of circuit breakers shall be in accordance with requirements stated hereunder.
 - 4.2 **Contacts**

The gap between the open contacts shall be such that it can withstand at least the rated phase to ground voltage for 8 hours at zero gauge pressure of SF₆ gas due to the leakage. The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. 2 p.u. across the breaker continuously, for validation of which a power frequency dielectric with stand test conducted for a duration of at least 15 minutes is acceptable).
 - 4.3 The SF₆ Circuit Breaker shall meet the following additional requirements:
 - 4.3.1 The circuit breaker shall be single pressure type. The design and construction of the circuit breaker shall be such that there is a minimum possibility of gas leakage and entry of moisture. There should not be any condensation of SF₆ gas on the internal insulating surfaces of the circuit breaker.
 - 4.3.2 All gasketed surfaces shall be smooth, straight and reinforced, if necessary, to minimize distortion and to make a tight seal, the operating rod connecting the operating mechanism to the arc chamber (SF₆ media) shall have adequate seals. The SF₆ gas leakage should not exceed 0.5% per year and the leakage rate shall be guaranteed for at least 10 years. In case the leakage under the specified conditions is found to be greater than 0.5% after one year of commissioning of circuit breaker, the manufacturer will have to supply free of cost, the total gas requirement for subsequent ten (10) years, based on actual leakage observed during first year of operation after commissioning.
 - 4.3.3 In the interrupter assembly there shall be an absorbing product box to minimize the effect of SF₆ decomposition products and moisture. The material used in the construction of the circuit breakers shall be fully compatible with SF₆ gas decomposition products.
 - 4.3.4 A common SF₆ scheme/density monitor shall be provided.
 - 4.3.5 The dial type SF₆ density monitor shall be adequately temperature compensated to model the pressure changes due to variations in ambient temperature within the body of circuit breaker as a whole. The density monitor shall have graduated scale and shall meet the following requirements:
 - a. It shall be possible to dismantle the density monitor for checking/replacement without draining the SF₆ gas by providing suitable interlocked non return valve coupling.
 - 4.3.6 Each Circuit Breaker shall be capable of withstanding a vacuum of minimum 8 millibars without distortion or failure of any part.
 - 4.3.7 Sufficient SF₆ gas including that will be required for gas analysis during filling shall be provided to fill all the circuit breakers installed. In addition spare gas

shall be supplied in separate unused cylinders as per requirement specified in Chapter 1-PSR.

- 4.4 Provisions shall be made for attaching an operational analyzer to record contact travel, speed and making measurement of operating timings, pre-insertion timings of closing resistors if used, synchronization of contacts in one pole.

5. Sulphur Hexafluoride Gas (SF₆)

- 5.1 The SF₆ gas shall comply with IEC 60376, 60376A and 60376B and shall be suitable in all respects for use in the switchgear under the operating conditions.
- 5.2 The high pressure cylinders in which the SF₆ gas is shipped and stored at site shall comply with requirements of the relevant standards and regulations.

5.3 Test

SF₆ gas shall be tested for purity, dew point, air, hydrolysable fluorides and water content as per IEC 60376, 60376A and 60376B and test certificates shall be furnished to Employer indicating all the tests as per IEC 60376 for each lot of SF₆ gas in stipulated copies as indicated in Chapter-GTR 2. Gas bottles should be tested for leakage during receipt at site.

6. Insulators

- 6.1 The porcelain of the insulators shall conform to the requirements stipulated under Chapter 2-GTR.
- 6.2 The mechanical characteristics of insulators shall match with the requirements specified under this Chapter.
- 6.3 All hollow insulators shall conform to IEC-62155.
- 6.4 Hollow Porcelain for pressurized columns/chambers should be in one integral piece in green and fired stage.

7. Spare Parts and Maintenance Equipment

- 7.1 The Manufacturer shall include in his proposal spare parts and maintenance equipment in accordance with Chapter 1-PSR. Calibration certificates of each maintenance equipment shall be supplied along with the equipment.

8. Operating Mechanism and Control

8.1 General Requirements

- 8.1.1 Circuit breaker shall be operated by spring charged mechanism or hydraulic mechanism or a combination of these. The mechanism shall be housed in a weather proof and dust proof control cabinet as stipulated in Chapter 2-GTR.
- 8.1.2 The operating mechanism shall be strong, rigid, not subject to rebound.
- 8.1.3 The mechanism shall be anti-pumping and trip free (as per IEC definition) under every method of closing.
- 8.1.4 The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause trip or closing operation of the power operating devices.
- 8.1.5 A mechanical indicator shall be provided to show open and close position of the breaker. It shall be located in a position where it will be visible to a man standing on the ground level with the mechanism housing closed. An operation counter shall also be provided in the central control cabinet.
- 8.1.6 Working parts of the mechanism shall be corrosion resisting material, bearings which require grease shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned or locked

to prevent loosening or changing adjustment with repeated operation of the breaker.

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

8.2 Control

- 8.2.1 The close and trip circuits shall be designed to permit use of momentary contact switches and push buttons.
- 8.2.2 Each breaker shall be provided with two (2) independent tripping circuits, pressure switches and coils each to be fed from separate DC sources and connected to a different set of protective relays.
- 8.2.3 The breaker shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. However, provisions shall be made for local electrical control. For this purpose a local/remote selector switch and close and trip control switch/push buttons shall be provided in the Breaker central control cabinet.
- 8.2.4 The trip coils shall be suitable for trip circuit supervision during both open and close position of breaker. The trip circuit supervision relay would be provided on relay panels.
- 8.2.5 Closing coil and associated circuits shall operate correctly at all values of voltage between 85% and 110% of the rated voltage. Shunt trip coil and associated circuits shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage. However, even at 50% of rated voltage the breaker shall be able to open. If additional elements are introduced in the trip coil circuit their successful operation and reliability for similar applications on outdoor circuit breakers shall be clearly brought out in the additional information schedules.
- 8.2.6 Density Monitor contacts and pressure switch contact shall be suitable for direct use as permissive in closing and tripping circuits. The density monitor shall be placed suitably inclined in such a way so that the readings are visible from ground level with or without using binoculars. Separate contacts have to be used for each of tripping and closing circuits. If contacts are not suitably rated and multiplying relays are used then fail safe logic/schemes are to be employed. DC supplies for all auxiliary circuits shall be monitored and provision shall be made for remote annunciations and operation lockout in case of D.C. failures. Density monitors are to be so mounted that the contacts do not change on vibration during operation of circuit Breaker.
- 8.2.7 The auxiliary switch of the breaker shall be positively driven by the breaker operating rod.

8.3 Spring Operated Mechanism

- 8.3.1 Spring operated mechanism shall be complete with motor in accordance with Chapter 2-GTR. Opening spring and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit shall also be provided.
- 8.3.2 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.

- 8.3.3 After failure of power supply to the motor one close open operation shall be possible with the energy contained in the operating mechanism.
- 8.3.4 Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring shall also be provided. The motor rating shall be such that it requires not more than 30 seconds for full charging of the closing spring.
- 8.3.5 Closing action of circuit breaker shall compress the opening spring ready for tripping.
- 8.3.6 When closing springs are discharged after closing a breaker, closing springs shall be automatically charged for the next operation and an indication of this shall be provided in the local and remote control cabinet.
- 8.3.7 Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition. Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is already in the closed position.
- 8.3.8 The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

9. Support Structure

- 9.1 The structure design shall be such that during operation of circuit breaker vibrations are reduced to minimum.

10. Terminal Connector Pad

- 10.1 The circuit breaker terminal pads shall be made up of high quality electrolytic copper or aluminium and shall be conforming to Australian standard AS-2935 for rated current. The terminal pad shall have protective covers which shall be removed before interconnections.

11. Interpole Cabling (if applicable)

- 11.1 All cables to be used by contractor shall be armoured and shall be as per IEC-502 (1100 Volts Grade). All cables within & between circuit breaker poles shall be supplied by the CB manufacturer.
- 11.2 Only stranded conductor shall be used. Minimum size of the conductor for interpole control wiring shall be 1.5 sq.mm. (Copper).
- 11.3 The cables shall be with oxygen index Min-29 and temperature index as 250°C as per relevant standards.

12. Fittings and Accessories

- 12.1 Following is a partial list of some of the major fittings and accessories to be furnished by the Manufacturer in the Central Control cabinet. Number and exact location of these parts shall be indicated in the Tender.
 - a. Cable glands (Double compression type), Lugs, Ferrules etc.
 - b. Local/remote changeover switch
 - c. Operation Counter
 - d. Control switches to cut off control power supply
 - e. Fuses as required

- f. The number of terminals provided shall be adequate enough to wire out all contacts and control circuits plus 24 terminals spare for future use
- g. Antipumping relay
- h. Pole discrepancy relay (for electrically ganged CBs), if applicable
- i. D.C. Supervision relays
- j. Rating and diagram plate in accordance with IEC incorporating year of manufacture

13. Additional Data to be furnished

- a. Drawing, showing contacts in close, arc initiation, full arcing, arc extinction and open position.
- b. The temperature v/s pressure curves for each setting of density monitor along with details of density monitor.
- c. Data on capabilities of circuit breakers in terms of time and number of operations at duties ranging from 100% fault currents to load currents of the lowest possible value without requiring any maintenance or checks.
- d. The effect of non-simultaneity between contacts between poles and also show how it is covered in the guaranteed total break time.
- e. Sectional view of non-return couplings if used for SF₆ pipes.
- f. Details & type of filters used in interrupter assembly and also the operating experience with such filters.
- g. Details of SF₆ gas:
 - i. The test methods used in controlling the quality of gas used in the circuit breakers particularly purity and moisture content.
 - ii. Proposed tests to assess the conditions of the SF₆ within a circuit breaker after a period of service particularly with regard to moisture contents of the gas.
- h. All duty requirements as applicable to 145 kV CBs specified under Clause 2.0 of this Chapter shall be provided with the support of adequate test reports.

14. Tests

- 14.1 In accordance with the requirements stipulated under Chapter 2 -GTR the circuit breaker along with its operating mechanism shall conform to IEC: 62271-100.

14.2 Type Test

- 14.2.1 The test reports of the type tests and the following additional type tests shall also be submitted for Purchaser's review:
 - a. Out of phase closing test as per IEC: 62271-100
 - b. Line charging breaking current for proving parameters as per the table of Technical Parameters of this Chapter
 - c. Test to demonstrate the Power Frequency withstand capability of breaker in open condition at Zero Gauge pressure and at lockout pressure (Ref. Clause 4.2)
 - d. Seismic withstand test in unpressurised condition
 - e. Verification of the degree of protection.
 - f. Static Terminal Load test.
 - g. Critical Currents test (if applicable).

14.3 Routine Tests

- 14.3.1 Routine tests as per IEC: 62271-100 shall be performed on all circuit breakers.
- 14.3.2 In addition to the mechanical and electrical tests specified by IEC, the following tests shall also be performed.
- 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 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. where included in scope of supply shall be furnished and utilized. In case of substations where operation analyzer is existing the Contractor shall utilize the same. However necessary adopter and transducers etc. if required shall have to be supplied by the Contractor.
 - Measurement of Dynamic Contact resistance measurement for arcing & main contacts. Signature of Dynamic contact resistance measurements shall be taken as reference for comparing the same during operation and maintenance in order to ascertain the healthiness of contacts.

15. Pre-Commissioning Tests

- 15.1 An indicative list of tests is given below. All routine tests except power frequency voltage dry withstand test on main circuit breaker shall be repeated on the completely assembled breaker at site. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates and shall furnish the list of instruments to the Employer for approval.
- Insulation resistance of each pole.
 - Check adjustments, if any suggested by manufacturer.
 - Breaker closing and opening time.
 - Slow and Power closing operation and opening.
 - Trip free and anti-pumping operation.
 - Minimum pick-up voltage of coils.
 - Dynamic Contact resistance measurement.
 - Functional checking of control circuits interlocks, tripping through protective relays and auto reclose operation.
 - Insulation resistance of control circuits, motor etc.
 - Resistance of closing and tripping coils.
 - SF₆ gas leakage check.
 - Dew Point Measurement
 - Operation check of pressure switches and gas density monitor during gas filling.
 - Checking of mechanical 'CLOSE' interlock, wherever applicable.

- o. Resistance measurement of main circuit.
- p. Checking of operating mechanisms
- q. Check for annunciations in control room.

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

16. Technical Parameters

(In addition to those specified under Chapter 2-GTR)

16.1 145 kV Circuit Breaker

S. No.	Description	Parameters
1.	Rated continuous current (A) at design ambient temperature	1250
2.	Rated short circuit current breaking capacity at rated voltage	31.5 kA with percentage DC component at per IEC: 62271-100 corresponding to minimum opening time under operating conditions specified
3.	Symmetrical interrupting capability (kA rms)	31.5
4.	Rated short circuit making current (kAp)	80
5.	Short time current carrying capability for one second (kA rms)	31.5
6.	Out of phase breaking current capacity (kA rms)	As per IEC
7.	Rated Operating Duty Cycle	O-0.3 sec-CO-3 min-CO
8.	Reclosing	Three Phase Auto reclosing
9.	First pole to clear factor	1.3
10.	Rated Line/Cable Charging interrupting current at 90° leading power factor angle (A rms) (The breaker shall be able to interrupt the rated line/cable charging current with test voltage immediately before opening equal to the product of $U/\sqrt{3}$ and 1.4 as per IEC: 62271-100).	As per IEC
11.	Temperature rise over the design ambient temperature.	As per IEC: 62271-100
12.	Total break time (ms)	65
13.	Rated break time as per IEC (ms)	60
14.	Total closing time (ms)	Not more than 150

S. No.	Description	Parameters
15.	Operating Mechanism	Spring
16.	Maximum difference in the instants of closing/opening of contacts (ms) between poles at rated control voltage and rated operating and quenching media pressures.	3.3
17.	Trip coil and Closing coil voltage	220 V DC with variations as specified
18.	Noise level at base and up to 50 m (distance from base of breaker)	140 dB (Max.)
19.	Rated terminal load	As per IEC or as per the value calculated by Chapter-GTR whichever is higher.
20.	Auxiliary contacts	Besides requirement of specification, the manufacturer shall wire up to 5 NO + 5 NC contacts for future use.
21.	No. of Terminals in common control Cabinet	All contacts and control circuits to be wired out up to common control cabinet plus 24 terminals exclusively for Purchaser's use.

16.2 33 kV Vacuum Circuit Breaker

S. No.	Description	Parameters
1.	Rated Operating Duty Cycle	0-3 min – CO – 3 min - CO
2.	First pole to clear factor	1.3
3.	Rated Line/Cable Charging interrupting current at 90° leading power factor angle (A rms) (The breaker shall be able to interrupt the rated line/cable charging current with test voltage immediately before opening equal to the product of $U/\sqrt{3}$ and 1.4 as per IEC: 62271-100).	As per IEC
4.	Rated break time as per IEC (ms)	45
5.	Total closing time (ms)	Not more than 80
6.	Operating Mechanism	Pneumatic / Spring / Hydraulic or a combination of these.
7.	Maximum difference in the instants of closing/opening of contacts (ms) between poles at rated control voltage and rated operating and quenching media pressures.	3.3
8.	Trip coil and Closing coil voltage	220 V DC with variations as specified

S. No.	Description	Parameters
9.	Noise level at base and up to 50 m (distance from base of breaker)	140 dB (Max.)
10.	Rated terminal load	As per IEC or as per the value calculated by Chapter-GTR whichever is higher.
11.	Auxiliary contacts	Besides requirement of specification, the manufacturer shall wire up to 5 NO + 5 NC contacts for future use.
12.	No. of Terminals in common control Cabinet	All contacts and control circuits to be wired out up to common control cabinet plus 24 terminals exclusively for Purchaser's use.
13.	Rated continuous current at design ambient temperature (amp).	1250/800 (as applicable)
14.	Rated short circuit current breaking capacity at total voltage.	25 kA with percentage DC component as per IEC: 62271-100 corresponding to minimum opening time and operating conditions specified.
15.	Symmetrical interrupting capability (kA rms)	25
16.	Rated short circuit making current (kA peak)	As per IEC
17.	Short time current carrying capability for 3 sec (kA rms)	25
18.	Reclosing	Three phase auto reclosing

Volume II

Section 6: Employer's Requirements

CHAPTER 9: CONTROL, RELAY AND PROTECTION PANELS

Table of Contents

1.	General.....	2
2.	Type of Panels	2
3.	Construction Features.....	3
4.	Mounting.....	4
5.	Panel Internal Wiring.....	4
6.	Terminal Blocks	5
7.	Painting	6
8.	Mimic Diagram	6
9.	Name Plates and Markings.....	7
10.	Miscellaneous Accessories	7
11.	Earthing.....	7
12.	Indicating Instruments & Transducers for Control Panel	8
13.	Annunciation System for Control Panel.....	9
14.	Switches	11
15.	Indicating Lamps	12
16.	Position Indicators (if Applicable).....	12
17.	Synchronizing Equipment (if Applicable).....	13
18.	Test Block	13
19.	DC, AC Auxiliary Supply and VT Secondary Supply Distribution Scheme	13
20.	Relays	15
21.	Transformer Protection.....	17
22.	33 kV Feeder Protection.....	19
23.	Trip Circuit Supervision Relay	20
24.	Tripping Relay.....	20
25.	DC Supply Supervision Relay	20
26.	Weather Proof Relay Panels (If Applicable).....	20
27.	Fault Recorder	21
28.	Time Synchronization Equipment.....	23
29.	Type Tests	24
30.	Configuration of Relay and Protection Panels	24
31.	Erection and Maintenance Tool Equipment.....	26
32.	Tropicalisation	26

CHAPTER 9

CONTROL, RELAY AND PROTECTION PANELS

1. General

- 1.1 This specification covers study, design, manufacture, assembly, factory test, supply, delivery, installation, field test and commissioning of control and relay panels as specified herein under.
- 1.2 It is not the intent to specify completely herein all details of design and construction of equipment to be supplied. The major equipment to be supplied is specified in Appendix, Bill of Material. However, the equipment supplied shall conform, in all respects, to high standards of engineering, design and workmanship and be capable of performing in continuous commercial operation up to Manufacturers' guarantee.
- 1.3 The equipment shall be designed to be fail-safe for the possible failure of any major circuit during the operation and shall provide a safeguard against possible surges, fail-safe against disrupted signals due to outside interference that would normally be associated with the cable communication lines and any other provisions necessary for the different operation of the equipment.
- 1.4 The relays specified in the following articles are based on standard protection schemes generally adopted in 33 kV and 132 kV substations of Employer's Integrated Power System. However, the Contractor shall carry out detail system study of protection system of Integrated Power System with special regard to existing substations in the vicinity of the proposed works. Based on this study, the Contractor shall design a relaying scheme for the substations, prepare a detail relay schedule and recommend relay-setting values for relay co-ordination with existing ones and make all necessary adjustments in the relay settings of neighboring substations as well.
- 1.5 The indication and annunciation schemes intended for existing substations shall be compatible with the existing system as far as possible.
- 1.6 All major protection relays shall be of static/numeric type. Relays and energy meters supplied under this package shall be only from reputed short listed manufacturers for which short list of any government owned entity shall be submitted.
- 1.7 Equipment to be furnished:
 - a. 132/33 kV Transformer Control and Relay Panel
 - b. 33 kV Line Control and Protection Panel
- 1.8 The following control and protective equipment shall be supplied and installed at following substations:
 - a. One (1) sets of 132/33 kV Duplex type Transformer circuit control and relay panel.
 - b. Three (3) sets of 33 kV Simplex type Line control and relays panels panel.

2. Type of Panels

2.1 Simplex Panel

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

2.2 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.

3. Construction Features

- 3.1 The 132/33 kV Transformer circuit control and relay panel shall be duplex type design. 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.
- 3.2 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-43 in accordance with IEC 60529 (Part-1).
- 3.3 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 2.0 mm for sides, door, top and bottom portions. There shall be sufficient reinforcement to provide level transportation and installation.
- 3.4 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.
- 3.5 Design, materials selection and workmanship shall be such as to result in neat appearance, inside and outside with no welds, rivets or bolt head apparent from outside, with all exterior surfaces tune and smooth.
- 3.6 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.
- 3.7 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.
- 3.8 Control/Relay panels required to incorporate the provisions for SCADA/SAS as specified in the relevant Chapter, shall be completely equipped and wired with necessary devices/equipment for control and other signals to be used for such systems. The detail requirements for SCADA/SAS system are furnished in the relevant Chapters of these Specifications.

4. Mounting

- 4.1 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.
- 4.2 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 and of permanent nature.
- 4.3 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.
- 4.4 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. However, the same shall be finalized during Detail Engineering.
- 4.5 The centre lines of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Likewise the top lines of all meters, relays and recorders etc. shall be in one line.
- 4.6 The control switches for circuit breakers and isolators shall be located on the mimic diagram corresponding to their exact position of the controlled equipment in the single line drawing. The location of the switches shall be within working height from the floor level for easy and comfortable operation.
- 4.7 No equipment shall be mounted on the doors.
- 4.8 All the panels in the control room shall be matched with the other panels of the same C&R board in respect of dimension, color and appearance. Control equipment on front side of the panel shall be similarly placed.
- 4.9 All the equipment connections and cabling shall be designed and arranged to minimize the risk of fire and damage.

5. Panel Internal Wiring

- 5.1 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
- 5.2 All wiring shall be carried out with 1100V grade, single core, and stranded copper conductor wires with PVC insulation.
- 5.3 The minimum size of the multi-stranded copper conductor used for internal wiring shall be as follows:
 - a. All current transformer circuits One 2.5 sq. mm per lead
 - b. Voltage transformer circuit (for energy meters) Two 2.5 mm sq. per lead
 - c. All other circuits One 1.5mm sq. per lead
- 5.4 The following color scheme shall be used for the wiring:

S. No.	Description	Color of the wire
a.	R-Y-B phase of Instrument Transformer Circuit	Red, Yellow and Blue
b.	Neutral of the Instrument Transformer Circuit	Black

c.	Earthing Connection	Green
d.	AC control wiring circuit for auxiliary AC supply	Black
e.	DC control wiring circuit using DC Battery supply	Grey

- 5.5 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. The position of the PVC carrying troughs and having bunch of wires shall not give any hindrance for fixing or removing relay casing, switches etc.
- 5.6 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.
- 5.7 Wire termination shall be made with solder less crimping type and tinned copper lugs, which firmly grip the conductor. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wire and shall not fall off when the wire is disconnected from terminal blocks. Termination shall be such that no strand of a conductor shall left loose or overhanging. Conductor termination shall be secured to the holding nuts/screws, terminal blocks etc. with washers interposed between the terminals/holding nuts/screws heads. The terminals shall be so connected that no conductor ferrule code gets masked due to overlay of conductors.
- 5.8 Interconnection to adjacent panels shall be brought to a separate set of terminal blocks located near to the slots or holes meant for taking the interconnecting wire to be provided at the top of the panel. The terminal blocks for the wires shall be with isolating links. Arrangements shall be made for easy connections to adjacent panels at site and wires for this purpose shall be provided and bunched inside the panel.
- 5.9 All wiring interconnecting the front cubicles with the rear cubicles of duplex type panel over the access corridor shall be wired in gutters held against the ceiling of the corridor by means of screws and the interconnection shall be made through suitable terminal connectors securely fixed on the panel.
- 5.10 All wires directly connected to trip circuit breaker or device shall be distinguished by the addition of red colored unlettered ferrule.
- 5.11 Wiring connected to the space heaters in the cubicles shall have porcelain beaded insulation over a safe length from the heater terminals.
- 5.12 Longitudinal troughs extending throughout the full length of the panel shall be preferred for inter panel wiring. All bus wiring for inter-panel connection shall be provided near the top of the panels running throughout the entire length of the panels.
- 5.13 All spare contacts of relays shall be wired up to terminal blocks.
- 5.14 Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.

6. Terminal Blocks

- 6.1 All internal wiring to be connected to external equipment shall terminate on terminal blocks. Terminal blocks shall be 1100V grade and have 10 Amp continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts, inserts. The stud, washers, nuts, locknuts, inserts shall be tin plated Brass/Brass. Terminal block design shall include markings of terminals and the terminals shall be provided with transparent plastic, slip on/clip on terminal covers. 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.
- 6.2 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.
 - 6.3 At least 20% spare terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks.
 - 6.4 In case of duplex panels, separate set of terminal blocks shall be provided with separate internal cable entries for the front (control) and rear (relay) sections.
 - 6.5 Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors of external cable on each side

a. All CT circuits	Two of 4.0 sq. mm. copper
b. All PT circuits	Four of 2.5 sq. mm. copper
c. AC/DC Power Supply Circuits	Four of 2.5 sq. mm. copper
d. All other circuits	Four of 1.5 sq. mm. copper
 - 6.6 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.
 - 6.7 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.
 - 6.8 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.
7. **Painting**
- 7.1 The painting shall be carried out as detailed in Chapter 2–GTR.
8. **Mimic Diagram**
- 8.1 Colored mimic diagram and symbols showing the exact representation of the system shall be provided in the front of control panels.
 - 8.2 Mimic diagram shall be made preferably of anodized aluminium or plastic of approved fast color material, which shall be screwed on to the panel and can be easily cleaned. The mimic bus shall be 2 mm thick. The width of the mimic bus shall be 10 mm for bus bars and 7 mm for other connections. Painted overlaid mimic is also acceptable.
 - 8.3 Mimic bus color will be decided during detailed Engineering.
 - 8.4 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.
 - 8.5 Indicating lamp, one for each phase, for each bus shall be provided on the mimic to indicate bus charged condition.

9. Name Plates and Markings

- 9.1 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.
- 9.2 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.
- 9.3 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.
- 9.4 Name Plates shall be made of non-rusting metal or 3 ply lamicaid. Name plates shall be black with white engraving lettering.
- 9.5 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.
- 9.6 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.

10. Miscellaneous Accessories

- 10.1 **Plug Point:** 230 V, Single phase 50 Hz, 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.
- 10.2 **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.
- 10.3 **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'.
- 10.4 **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.

11. Earthing

- 11.1 All panels shall be equipped with an earth bus securely fixed along with the inside base of the panel extended throughout the length of the C&R board formation. 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 mm x 6 mm copper with threaded holes at a gap of 50 mm with provision of bolts and nuts for connection with cable armors 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.

- 11.2 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.
- 11.3 All metallic cases of relays, instruments and other panel mounted equipment including gland plate, shall be connected to the earth bus by copper wires of size not less than 2.5 sq. mm. The color code of earthing wires shall be green.
- 11.4 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.
- 11.5 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.
- 11.6 An electrostatic discharge arrangement shall be provided in each panel so as to discharge human body before he handles the equipment inside the panels.

12. Indicating Instruments & Transducers for Control Panel

- 12.1 All instruments, meters and transducers shall be enclosed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. All megawatt, megavar, Bus voltage and frequency indicating instruments shall be provided with individual transducers and these shall be calibrated along with transducers to read directly the primary quantities. They shall be accurately adjusted and calibrated at works and shall have means of calibration check and adjustment at site. The manufacturer shall submit calibration certificates at the time of delivery. However no separate transducers are envisaged for digital bus voltmeters and digital frequency meters and the indicating meters provided in the synchronizing equipment.

12.2 Indicating Instruments

- 12.2.1 Unless otherwise specified, all electrical indicating instruments shall be of digital type suitable for flush mounting.
- 12.2.2 Instruments shall have 4-digit display; display height being not less than 25 mm.
- 12.2.3 Instrument shall conform to relevant IEC and shall have an accuracy class of 0.5 or better. Watt and VAR meters shall have an indication of (+) and (-) to indicate EXPORT and IMPORT respectively.
- 12.2.4 Digital voltage and frequency meters shall be of class: 0.5 and shall have digital display of 5 and 4 digits respectively, with display size, not less than 25mm (height).
- 12.2.5 All indicating instruments shall preferably of size 72mm x 144mm

12.3 Transducers

- 12.2.1 Transducers (for use with Indicating Instruments and Telemetry/Data Communication application) shall in general conform to IEC: 688-1.

- 12.2.2 The transducers shall be suitable for measurement of active power, reactive power, voltage, current and frequency in three phase four wire unbalanced system.
- 12.2.3 The input to the transducers will be from Substation 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.
- 12.2.4 The transducer characteristic shall be linear throughout the measuring range.
- 12.2.5 The transducer output shall be load independent and be suitable for load resistance of 1000-1500Ω. And it shall have dual output.
- 12.2.6 The input & output of the transducer shall be galvanically isolated.
- 12.2.7 Each transducer shall be housed in a separate compact case and have suitable terminals for inputs & outputs.
- 12.2.8 The transducers shall be suitably protected against transient high peaks of voltage & current.
- 12.2.9 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.
- 12.2.10 All the transducers shall have an output of 4-20 mA.
- 12.2.11 The response time of the transducers shall be less than 1 second.
- 12.2.12 The accuracy class of transducers shall be 0.5 or better for voltage/current transducer, 0.5 or better for watt/VAR transducer and 0.2 or better for frequency transducer.
- 12.2.13 The transducers shall have a low AC ripple on output less than 1%.

13. Annunciation System for Control Panel

- 13.1 Facia 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 shall be divided into the following categories:
 - a. Trip Annunciation
 - b. Non-trip Annunciation
- 13.2 The annunciation equipment shall be suitable for operation with the substation AC/DC voltage and potential free initiation contract is to be provided. The Annunciator shall have communication port, suitable for SCADA/SAS operation, and this connection is to be established during commissioning.
- 13.3 The visual annunciation shall be provided by annunciation facia, mounted flush on the top of the control panels and necessary switching relays for the same shall be mounted inside the panel or at the relay side of the panel.
- 13.4 The annunciator facia shall be provided with translucent glass or plastic cover plates of white color with inscription in black color. The size of facia window shall be 70mm x 35mm in general and the size of the lettering shall not less than 5 mm. Alarm inscription shall be engraved not more than three line of in each facia window and the same shall be prominently visible when facia light is ON. The cover plates of the facia window shall be easily removable to facilitate replacement of lamp when required. Annunciator of each bay must have minimum 5-6 nos. spare windows available.
- 13.5 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.

- 13.6 All Trip facia shall have red color and all Non-trip facia shall have white color.
- 13.7 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

- 13.8 Annunciator should have in-built Accept, Reset and lamp Test push buttons for acknowledgment of alarm, reset of visual indication and for checking perfectness of the lamps shall be provided below the facia window in each panel. These push buttons shall be common for both trip and warning annunciation. Sequence of operation of the annunciator shall be as follows:

S. 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 Open	Steady On Steady On	OFF OFF
4.	Reset Push Button Pressed	Close Open	On Off	OFF OFF
5.	Lamp Test Push Button Pressed	Open	Steady On	OFF

- 13.9 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.
- 13.10 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.
- 13.11 The annunciation system described above shall meet the following additional requirements:
- 13.11.1 The annunciation system shall be capable of catering to at least 20 simultaneous signals at a time.
- 13.11.2 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
- 13.11.3 One set of the following items shall be provided common for all the control

panel (not applicable for extension of substation) :

- a. Flasher relay for annunciation system
- b. Push button for Flasher test
- c. Three Push buttons for test of all audible alarm systems

- 13.11.4 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.
- 13.11.5 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.
- 13.11.6 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 neighboring 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.

- 13.12 The annunciation system to be supplied for existing Substations shall be engineered as an extension to the existing scheme.

14. Switches

- 14.1 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.
- 14.2 The selection of operating handles for the different types of switches shall be as follows:
- | | |
|------------------------------------|---|
| Breaker, Isolator control switches | Discrepancy Type |
| Synchronizing switches | Oval, Black, Keyed handle (one common removable handle for a group of switches or locking facility having common key) |
| Synchronizing Selector switches | Oval or knob, black |
| Instrument switches | Round, knurled, black |
| Protection Transfer switch | Pistol grip, lockable and black |
- 14.3 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.
- 14.4 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.
- 14.5 Synchronizing switches shall be of maintained contact (stay put) type having a common removable handle for a group of switches. The handle shall be removable only in the OFF position and it shall be coordinated to fit into all the synchronizing switches. These switches shall be arranged to connect the synchronizing equipment when turned to the 'ON' position. One contact of each switch shall be connected in the closing circuit

of the respective breaker so that the breaker cannot be closed until the switch is turned to the 'ON' position.

- 14.6 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.
- 14.7 The contacts of all switches shall preferably open and close with snap action to minimize arcing. Contacts of switches shall be spring assisted and contact faces shall be with rivets of pure silver or silver alloy. Springs shall not be used as current carrying parts
- 14.8 The contact combination and their operation shall be such as to give completeness to the interlock and function of the scheme.
- 14.9 The contact rating of the switches shall be as follows :

S. No.	Description	Contact Rating in Amps		
		110 V DC	50 V DC	230 V AC
1.	Make and Carry Continuously	10	10	10
2.	Make and Carry for 0.5 Sec	30	30	30
3.	Break for Resistive Load	3	20	7
4.	Break for Inductive Load with L/R = 40msec	0.2	-	-

15. Indicating Lamps

- 15.1 Indicating lamps shall be of cluster LED type suitable for panel mounting with rear terminal connections. Lamps shall be provided with series connected resistors preferably built in the lamp assembly. Lamps shall have translucent lamp covers to diffuse lights colored red, green, amber, clear white or blue as specified. The lamp cover shall be preferably of screwed type, unbreakable and moulded from heat resisting material.
- 15.2 The lamps shall be provided with suitable resistors.
- 15.3 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.
- 15.4 The indicating lamps with resistors shall withstand 120% of rated voltage on a continuous basis.

16. Position Indicators (if Applicable)

- 16.1 Position indicators of "SEMAPHORE" type shall be provided when specified as part of the mimic diagrams on panels for indicating the position of circuit breakers, isolating/earthing switches etc. The indicator shall be suitable for semi-flush mounting with only the front disc projecting out and with terminal connection from the rear. Their strips shall be of the same color as the associated mimic.
- 16.2 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.
- 16.3 The rating of the indicator shall not exceed 2.5 W.
- 16.4 The position indicators shall withstand 120% of rated voltage on a continuous basis.

17. Synchronizing Equipment (if Applicable)

- 17.1 For Substation equipped with Substation Automation system, the requirement of synchronization is specified in Chapter 10 Substation Automation System and the same shall prevail. For other Substation which is not equipped with substation automation system following shall be applicable as per requirement.
- 17.2 The synchronizing instruments shall be mounted either on a synchronizing trolley or on a synchronizing panel. The panel/ trolley shall be equipped with double analog voltmeters and double analog frequency meters, synchroscope and lamps fully wired. The size of voltmeters and frequency meters provided in the synchronizing panel shall not be less than 144 x 144 sq.mm. Suitable auxiliary voltage transformers wherever necessary shall also be provided for synchronizing condition. In case the synchroscope is not continuously rated, a synchroscope cut-off switch shall be provided and an indicating lamp to indicate that the synchroscope is energized, shall also be provided.
- 17.3 Synchronizing check relay with necessary ancillary equipment's shall be provided which shall permit breakers to close after checking the requirements of synchronizing of incoming and running supply. The phase angle setting shall not exceed 35 degree and have voltage difference setting not exceeding 10%. This relay shall have a response time of less than 200 milliseconds when the two system conditions are met within present limits and with the timer disconnected. The relay shall have a frequency difference setting not exceeding 0.45% at rated value and at the minimum time setting. The relay shall have an adjustable time setting range of 0.5-20 seconds. A guard relay shall be provided to prevent the closing attempt by means of synchronizing check relay when control switch is kept in closed position long before the two systems are in synchronism.
- 17.4 The synchronizing panel shall be draw out and swing type which can be swiveled in left and right direction. The synchronizing panel shall be placed along with control panels and the number of synchronizing panel shall be as indicated in 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 synchronizing panel for synchronization of circuit breakers. The selector switch provided for each circuit breaker in respective control panels shall be lockable type with a common key so that only one selector switch is kept in synchronizing mode at a time.
- 17.5 Alternatively, the trolley shall be of mobile type with four rubber-padding wheels capable of rotating in 360 degree around the vertical axis. Suitable bumpers with rubber padding shall be provided all around the trolley to prevent any accidental damage to any panel in the control room while the trolley is in movement. The trolley shall have two meter long flexible cord fully wired to the instruments and terminated in a plug in order to facilitate connecting the trolley to any of the panels. The receptacle to accept the plug shall be provided on the panel.

18. Test Block

- 18.1 Switch Board type, back connected, test blocks with contacts shall be provided with links or other devices for shorting terminals of CT leads before interrupting the normal circuit for injection from external source or for inserting testing instruments in the circuit without causing open circuit of the CT. The potential testing studs shall preferably be housed in block molding insulation and partition shall be provided to prevent accidental short circuit across the studs. Test blocks for meters, relays shall be placed in front and rear panel respectively.

19. DC, AC Auxiliary Supply and VT Secondary Supply Distribution Scheme

19.1 DC System

- 19.1.1 DC distribution in CRP panels shall be designed with the consideration of

Battery Bank, Battery Charger and DC Distribution Boards and shall be used for DC Supply for the Substation.

- 19.1.2 For DC Incomer, only suitable rated HRC fuse unit both at +ve and –ve side shall be provided and it shall run continuously in the panel board. Individual panel DC supply shall be teed off in each panel from the DC bus.
- 19.1.3 Necessary arrangement for supervision of the incoming DC supplies shall be made in each panel.
- 19.1.4 Power Supply for VT Selection Circuit, Circuit Breaker Aux. relay circuit and CT supervision circuit (only for SF6 CTs), Isolator Control Circuit and Transformer Supervision Circuit shall be through MCB. While other circuit like circuit of individual IED, DC emergency lamp circuit, Metering Circuit, Synchronizing circuit, CB Closing and Tripping Circuit and Indication circuit shall be through separate suitable HRC fuses.
- 19.1.5 **Annunciation DC Circuit:** There shall be DC incomer from DCDB to each panel through 16A HRC fuse (both +ve and –ve) as Annunciation DC supply. Necessary arrangement for supervision of the incoming supply shall be made. DC annunciation bus shall be teed off from the panel and the same shall run continuously through the entire C&R board for facia annunciation.

19.2 AC System

- 19.2.1 230V, single phase 50Hz AC auxiliary supply to the control, relay and protection panel board of each system voltage of 132KV and 33KV will be fed from AC distribution board through separate 32 Amp switch fuse units provided there.
- 19.2.2 The supply shall be provided in Panel for each voltage class. One 16 Amp rated HRC fuse unit shall be provided for the AC incomer. AC incoming bus shall run continuously in each voltage class panel board.
- 19.2.3 Individual panel AC supply shall be teed off in each panel from the AC bus. A set of fuse and link rated for 10 Amp for 3 pin plug circuit, cubicle lamp circuit, and space heater circuit shall also be provided in each control, relay and protection panel.
- 19.2.4 Door operated corridor illumination lamp circuit of duplex type panel shall be arranged from the above incoming AC bus through suitably rated fuse and link.
- 19.2.5 AC circuit for incoming DC fail and Annunciation DC fail alarm scheme shall be provided in panel for each voltage class. The above circuit shall be teed off from the above respective panel AC bus through suitably rated fuse and link.
- 19.2.6 One supervision relay for incoming AC fail with test P.B. and reverse flag indication shall be provided for monitoring of AC supply healthiness through D.C. operated facia annunciation in panel for each voltage class.

19.3 VT Secondary Supply Distribution Scheme

- 19.3.1 PT kiosk at switchyard may be considered with sufficient terminals, fuses, links etc. for protection PT secondary supply and for metering PT secondary supply to bus coupler panel through individual cable for all voltage class in a substation.
- 19.3.2 The panel shall receive protection VT secondary volts through fuses and links provided in the respective VT kiosk. The protection VT supply shall run throughout entire board for each panel through VT supply selection scheme.

- 19.3.3 The panel shall also receive Metering VT Secondary volts by at least 25 Sqmm Copper/equivalent Aluminum per phase/neutral through fuses and links provided in the respective VT kiosk. The Metering VT supply shall also run throughout entire board for each panel through VT supply selection scheme.
- 19.3.4 VT secondary volts from all Protection cores and Metering core shall be first terminated to de-linked type TBs in each bay panel before wiring to the VT selection scheme.
- 19.3.5 Selected VT secondary supply to the protective relays of each panel shall be fed through individual fuses in individual phases and link in neutral in each panel. Necessary arrangement for supervision of VT secondary supply shall be provided in numeric relay.
- 19.3.6 Selected VT secondary supply to metering and indicating instruments of each panel shall be fed through MCB. Proper arrangement of supervision through MCB shall also be provided.
- 19.3.7 In 132KV C&R panel, where more than one set of 132KV PT is available or not, necessary 132KV PT selection scheme shall be adopted and made ready for future use. Where more than one set of 33KV bus PT is available, necessary 33KV PT selection scheme shall be adopted through switch at 33KV C&R panel.

20. Relays

- 20.1 The main numerical protective relays shall be of Panel manufacturer's own make or their principal company's make. However, panel manufacturer who are authorized by the relay manufacturer to supply their relay may also be considered for supply of C&R if the panel manufacturer provide document/certificate of guarantee from the relay manufacturer.
- 20.2 All relays shall latest conforming to the requirements of IS: 3231/IEC-60255/IEC 61000 or other applicable standards and shall easily interface without third party system to Substation Automation System.
- 20.3 Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear, protected with dust tight cases for tropical use and with transparent cover removal from the front.
- 20.4 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.
- 20.5 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.
- 20.6 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 70% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.
- 20.7 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.
- 20.8 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.
- 20.9 The sub-stations may be required to run without air-conditioning plant. Therefore, the static relays shall be designed for operating satisfactorily under the climatic conditions of ambient temperature and relative humidity variation from 0°C to 55°C and 50% to 95% respectively. The static relays should be capable to withstand the test voltages as stated in the relevant standard. Stringent measures including shielding of long internal wiring should be taken to make the relays insensitive to the voltage spikes. Insulation barriers shall be provided to ensure that transients present in CT & VT connection due to extraneous sources do not cause damage to static circuits.
- 20.10 No control relay, which shall trip the power circuit breaker when the relay is de-energized, shall be employed in the circuits.
- 20.11 Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
- 20.12 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:
- 20.12.1 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.
- 20.12.2 Seal-in-unit shall obtain adequate current for operation when one or more relays operate simultaneously.
- 20.12.3 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.
- 20.12.4 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.
- 20.12.5 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).
- 20.12.6 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.
- 20.12.7 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).

- 20.13 The setting ranges of the relays offered, if different from the ones specified shall also be acceptable if they meet the functional requirements.
- 20.14 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.
- 20.15 All relays and their drawings shall have phase indications as R-Red, Y-yellow, B-blue
- 20.16 For numerical relays, the scope shall include the following:
 - 20.16.1 Necessary software and hardware to up/down load the data to/from the relay from/to the personal computer installed in the substation (SAS). However, the supply of PC is not covered under this clause.
 - 20.16.2 The relay shall have suitable communication facility for connectivity to SCADA. The relay shall be capable of supporting IEC 61850 protocol.
 - 20.16.3 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. 25.
- 20.17 The contractor shall provide one number of laptop computers with latest Intel processor or at least Intel core i7, 10th generation-8076K processor, relay programming software and necessary probes & cables for setting the numeric relays. No separate payment for laptop, software, probes cables etc. shall be made and all cost involved for these items shall be included in the cost of relay and control panels.

21. Transformer Protection

- 21.1 All transformer protection functions may be grouped into Group-I and Group-II protections in the following manner:
 - 21.1.1 **Group-I Protection:** Following protection functions may be provided in Group-I Transformer protection relay:
 - a. Differential Protection as per clause no. 21.3
 - b. Over fluxing Protection for HV side as per clause no. 21.4
 - c. Direction Over current and earth fault protection for HV side as per clause no. 21.6
 - d. Over Load Protection as per clause no. 21.7
 - 21.1.2 **Group-II Protection:** Following protection functions may be provided in Group-II Transformer protection relay:
 - a. REF Protection as per clause no. 21.5
 - b. Over fluxing Protection for IV/LV side as per clause no. 21.4
 - c. Direction Over current and earth fault protection for IV/LV side as per clause no. 21.6
- 21.2 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. 21.3 to 21.8 are met otherwise separate protection relay(s) shall be offered.

21.3 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. Magnetizing 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 during faults and disturbances for the pre fault and post fault period to record graphic form of instantaneous values of Current in all windings in 6 analogue channels 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:

- i. REF protection operated
- ii. HV Breaker status (Main and tie)
- iii. IV Breaker status
- iv. Buchholz /OLTC Buchholz alarm / trip etc.
- v. 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.

21.4 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

21.5 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

21.6 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**
 - i. 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
 - ii. have low transient, over reach high set instantaneous unit of continuously variable setting range 500-2000 % of rated current
 - iii. have a characteristic angle of 30/45 degree lead
 - iv. include hand reset flag indicators or LEDs
- d. **Earth fault relay shall**
 - i. 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
 - ii. have low transient, over reach high set instantaneous unit of continuously variable setting range 200-800 % of rated current
 - iii. have a characteristic angle of 45/60 degree lag
 - iv. include hand reset flag indicators or LEDs
 - v. include necessary separate interposing voltage transformers or have internal feature in the relay for open delta voltage to the relay

21.7 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%

21.8 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. 33 kV Feeder Protection

22.1 The protection scheme of 33 kV Feeder shall have the following:

- a. If Bay control and Protection Unit (BCPU) is considered, so over current protection feature of BCPU shall be used. Else one no. of Numerical relay shall be considered for Directional, IDMT, three over current protection with high set instantaneous unit.
- b. Directional, definite time sensitive earth fault protection
- c. Under frequency relay operated CB tripping scheme

- d. One no. 96 relay along with 95/96 relay for phase overcurrent LBB protection (if applicable)

23. Trip Circuit Supervision Relay

- 23.1 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.
- 23.2 The relay shall have adequate contacts for providing connection to alarm and event logger.
- 23.3 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

24.1 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

- 25.1 The relay shall be capable of monitoring the failure of D.C. supply to which, it is connected.
- 25.2 It shall have adequate potential free contacts to meet the scheme requirement.
- 25.3 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. Weather Proof Relay Panels (If Applicable)

- 26.1 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.
- 26.2 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.
- 26.3 The enclosures of the panel shall provide a degree of protection of not less than IP-55 (as per IEC-60529).
- 26.4 The panel shall be of free standing floor mounting type or pedestal mounting type as per requirement.
- 26.5 The panel shall be provided with double hinged doors with padlocking arrangement.
- 26.6 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
- 26.7 Cable entries shall be from bottom. Suitable removable cable gland plate shall be provided on the cabinet for this purpose.
- 26.8 All sheet steel work shall be degreased, pickled, phosphated and then applied with two

coats of zinc chromates primer and two coats of finishing synthetic enamel paint, both inside and outside. The color of the finishing paint shall be light grey.

- 26.9 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.
- 26.10 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. Fault Recorder

27.1 The fault recorder shall be provided for feeder line.

- 27.2 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.
- 27.3 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.
- 27.4 The acquisition unit is connected with evaluation unit being supplied as described in **Chapter 10** Substation Automation through bus conforming to IEC 61850. In case of extension Substation which is equipped with Substation 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 including hardware if any shall be in the scope of the contractor.
- 27.5 The evaluation unit hardware, for substations having SAS, shall be as described in **clause no. 4.0** of **Chapter 10 Substation Automation System**.
- 27.6 Fault recorder shall have at least 8 analogue and 16 digital channels for each feeder.
- 27.7 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.
- 27.8 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.
- 27.9 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.
- 27.10 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.

- 27.11 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).
- 27.12 The Evaluation unit shall be connected to the printer to obtain the graphic form of disturbances whenever desired by the operator.
- 27.13 Fault recorder acquisition units shall be suitable to operate from 220V DC or 110V DC as available at Substation. 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 10 Substation Automation System clause no. 8.0** and DR evaluation unit.
- 27.14 The acquisition unit shall have the following features
 - 24.15.1 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.
 - 24.15.2 The frequency response shall be 5 Hz on lower side and 250 Hz or better on upper side.
 - 24.15.3 Scan rate shall be 1000 Hz/channel or better.
 - 24.15.4 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
 - 24.15.5 The open delta voltage and neutral current shall be derived either through software or externally by providing necessary auxiliary transformers.
 - 24.15.6 In case the Fault recorder is in-built part of line distance protection, above digital channels may be interfaced either externally or internally.
 - 24.15.7 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.
- 27.15 The color laser printer shall be provided which shall be compatible with the desktop PC and shall use Plain paper. The print out shall contain the Feeder identity, Date and time (in hour, minute and second up to 100th of a second), identity of trigger source and Graphic form of analogue and digital signals of all the channels. Two packets of A4 size paper (500 sheets in each packet) suitable for printer shall be supplied.
- 27.16 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 +0.5 seconds/day, if allowed to run without synchronization. Further, Fault recorder shall have facility to synchronize its

time generator from Time Synchronization Equipment having output of following types:

- a. Voltage signal (0-5V continuously settable, with 50ms minimum pulse duration)
- b. Potential free contact (Minimum pulse duration of 50 m Sec.)
- c. IRIG-B
- d. RS232C

The recorder shall give annunciation in case of absence of synchronizing within a specified time.

- 27.17 Substations where Time Synchronization Equipment is not available, time generator of any one of the Fault recorders can be taken as master and time generators of other Fault recorders and Event loggers in that station shall be synchronized to follow the master.

28. Time Synchronization Equipment

- 28.1 The Time synchronization equipment shall receive the coordinated Universal Time (UTC) transmitted through Geo Positioning Satellite System (GPS) and synchronize equipment to the Nepal Standard Time in a substation.
- 28.2 Time synchronization equipment shall include antenna, all special cables and processing equipment etc.
- 28.3 It shall be compatible for synchronization of Event Loggers, Disturbance recorders and SCADA at a substation through individual port or through Ethernet realized through optic fibre bus.
- 28.4 Equipment shall operate up to the ambient temperature of 50 degree centigrade and 80% humidity.
- 28.5 The synchronization equipment shall have 2 micro-second accuracy. Equipment shall give real time corresponding to IST (taking into consideration all factors like voltage, & temperature variations, propagation & processing delays etc.).
- 28.6 Equipment shall meet the requirement of IEC 60255 for storage & operation.
- 28.7 The system shall be able to track the satellites to ensure no interruption of synchronization signal.
- 28.8 The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse, as per requirement.
- 28.9 The equipment offered shall have six (6) output ports. Various combinations of output ports shall be selected by the customer, during detailed engineering, from the following :
 - a. Potential free contact (Minimum pulse duration of 50 milli Seconds.)
 - b. IRIG-B
 - c. RS232C
 - d. SNTP Port
- 28.10 The equipment shall have a periodic time correction facility of one second periodicity.
- 28.11 Time synchronization equipment shall be suitable to operate from 220V DC or 110V DC as available at Substation.
- 28.12 Equipment shall have real time digital display in hour, minute, second (24 hour mode) & have a separate time display unit to be mounted on the top of control panels having display size of approx. 100 mm height.

29. Type Tests

- 29.1 The reports for following type tests shall be submitted during detailed engineering for the Protective relays, Fault Recorder, Fault locator and Disturbance recorder:
- Insulation tests as per IEC 60255-5
 - DC Voltage dips and interruptions/Variation as per IEC 6100-4-29.
 - High frequency disturbance test as per IEC 61000-4 16, Class IV (Not applicable for electromechanical relays)
 - Electrostatic discharges as per IEC 61000-4-2, level; 4 (not applicable for Electromechanical relays)
 - Fast transient test as per IEC 61000, Level IV (Not applicable for electromechanical relays)
 - 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.
 - Tests for thermal and mechanical requirements as per IEC 60255-6
 - Tests for rated burden as per IEC 60255-6
 - Contact performance test as per IEC 60255-0-20 (not applicable for Distance to fault locator and Disturbance recorder)
- 29.2 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.
- 29.3 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 analyzer/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.

30. Configuration of Relay and Protection Panels

- 30.1 The following is the general criteria for the selection of the equipment to be provided in each type of panel. However, contractor can optimize the requirement of panels by suitably clubbing the feeder protection and CB relay panels. It may be noted that Main-I and Main-II protections for line cannot be provided in single panel. Similarly, Group-I & Group-II protections for transformer cannot be provided in single panel.

30.2 Control Panel

Various types of control panels shall consist of the following:

a.	Ammeter	3 set for each
b.	Wattmeter with Transducer	1 set for each
c.	VAR meter with Transducer	1 set for each
d.	CB Control Switch	1 no. for each Circuit Breaker

e.	Isolator Control Switch	1 no. for each Isolator
f.	Semaphore	1 no. for each Earth Switch
g.	Red Indicating Lamp	1 no. for each Circuit Breaker and Isolator
h.	Green Indicating Lamp	1 no. for each Circuit Breaker and Isolator
i.	White Indicating Lamp (DC healthy lamp)	2 nos. for each feeder
j.	Annunciation windows with associated annunciation relays	18 nos. for each feeder
k.	Push button for alarm (Accept/Reset/Lamp Test)	3 nos. for each Control Panel
l.	Synchronizing Socket	1 no. for each Circuit Breaker
m.	Synchronizing Selector Switch if required	1 no. for each Circuit Breaker
n.	Mimic to represent SLD	Lot in all Control Panels
o.	Voltmeter with selector	1 no. for each
p.	Cut out, mounting and Wiring for RWTI and Selector Switch	Lot for Transformer
q.	Frequency Meter	1 Nos for each
r.	Protection Transfer Switch	1 no. for each breaker (if required)

Notes:

1. For transformer feeders, all equipment 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 equipment mentioned for control panel is generally applicable unless it is defined elsewhere and in case of bay extension in existing substations, necessary equipment for matching the existing control panel shall be supplied.
4. Common synchronizing switch is also acceptable in Synchronizing trolley for new Substations. In this case. Individual synchronizing selector switch is not required for each Circuit Breaker in control panel.
5. Each line /HV side of transformer/MV/LV side of transformer /Bus reactor /TBC /BC/ Bus Section shall be considered as one feeder for above purpose.

30.3 132/33 kV Transformer Control & Relay Panel

The Transformer Control and Relay Panel shall consist of the following but not limited to:

S. No.	Description	HV Side	LV Side
a.	Numerical Transformer Differential Protection Scheme	1 no.	
b.	Restricted Earth Fault Protection Scheme	1 no.	1 no.

c.	Numerical Directional Backup O/C And E/F Relay with Non-Direction High Set Feature	1 set	Nil
d.	Non-Directional Backup O/C and E/F Relay with High Set Feature	Nil	1 Set
e.	Over Fluxing Protection Scheme	--	1 no.
f.	Overload Protection Scheme	1 no.	Nil
g.	Three Phase Trip Relays	2 nos.	2 nos.
h.	VT Selection Relays/Transformer Alarms & Trip Function as per Scheme Requirement	Lot	Lot
i.	Disturbance Recorder	1 no.	Nil
j.	Trip Supervision Relay	2 nos.	2 nos.
k.	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	
l.	Revenue Energy Meter HV and LV	1 no.	

30.4 33 kV Line Protection Panel

The Line Protection panel for 33 kV lines shall consist of following protection features/schemes but not limited to:

S. No.	Description	HV Side
a.	Numerical / Directional Over current and E/F protection scheme with high set feature	1 set
b.	Backup Over current and E/F protection scheme.	1 set
c.	Bay Control Unit/Bay Control & Protection Unit	1 no.
d.	Electronic Trivector Meter with 0.2 class accuracy with RS 485, RS 232 & Front Optical port	1 no.
e.	Master trip relay with adequate no of contacts & Electrical resettable type	1 no.
f.	CB troubles and Alarm(Part of BCU)	1 set
g.	Metering (Part of BCU)	1 set

31. Erection and Maintenance Tool Equipment

29.1 All special testing equipment required for the installation and maintenance of the apparatus, instruments devices shall be furnished in relevant schedule.

32. Tropicalisation

30.1 Control room will be normally air-cooled/air- conditioned. All equipment 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.

Volume II

Section 6: Employer's Requirements

CHAPTER 10: SUBSTATION AUTOMATION SYSTEM

Table of Contents

1.	General.....	2
2.	System Design	2
3.	Functional Requirement.....	5
4.	System Hardware	13
5.	Software Structure	16
6.	Tests	17
7.	System Operation.....	19
8.	Power Supply.....	20
9.	Documentation	20
10.	SCADA Integration	21
11.	Training, Support Services, Maintenance and Spares	23
12.	Reliability and Availability	26
13.	List of Equipment	27
	Annexure – 1: List of Analogue and Digital Inputs.....	29
	Annexure – 2: Typical Architectural Drawing of Substation Automation System.....	30

CHAPTER 10

SUBSTATION AUTOMATION SYSTEM

1. 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 132 kV system or higher for at least 2 (Two) years as on the date of Tender 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) to be located in Bagthala Substation/Bajhang DC as well as from local control centre.

The SAS shall contain the following main functional parts:

- a. Bay control Intelligence Electronic Devices (IEDs) for control and monitoring.
 - b. Station Human Machine Interface (HMI)
 - c. Redundant managed switched Ethernet Local Area Network communication infrastructure with hot standby.
 - d. Redundant Gateway for remote control via industrial grade hardware (to LDC & ECC) through IEC60870-5-104 protocols.
 - e. Gateway for remote supervisory control (to RLDC, LDC & ECC), the gateway should be able to communicate with to LDC & ECC on IEC 60870-5-104 protocols. Protocol converter should be used wherever required to match to existing communication system. It shall be the Tenderer's responsibility to integrate his offered system with existing MCC system for exchange of desired data. The requirement of IO point shall be worked out by the Tenderer as per criterion enclosed as Annexure-2 for data exchange with LDCs.
 - f. Remote HMI.
 - g. Peripheral equipment like printers, display units, key boards, Mouse etc.
 - h. Control & Monitoring of Substation ACDB/DCDB, Battery Chargers, Firefighting System, Surveillance System etc.
 - i. Adequate Cyber Security as per relevant existing Government norms and guidelines are to be maintained. All required hardware and software to comply the same is under the scope of Tenderer.
- 1.3 It shall enable local station control via a PC by means of human machine interface (HMI) and control software package, which shall contain an extensive range of supervisory control and data acquisition (SCADA) functions.
 - 1.4 It shall include communication gateway, intelligent electronic devices (IED) for bay control and inter IED communication infrastructure. An architecture drawing for SAS is enclosed.
 - 1.5 The communication gateway shall facilitate the information flow with remote control centers. 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

- 2.1.1 The Substation Automation System (SAS) shall be designed considering the substation to be unmanned type.

- 2.1.2 The Substation Automation System (SAS) shall be suitable for operation and monitoring of the complete substation including future extensions as given in Chapter 2 - GTS.
- 2.1.3 The systems shall be of the state-of-the art suitable for operation under electrical environment present in extra high voltage substations, follow the latest engineering practice, and ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.
- 2.1.4 The offered SAS shall support remote control and monitoring from Remote Control Centre viz. Master Control Centre (MCC), Load Dispatch Centre (LDC) 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.
- 2.1.5 The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signaling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records.
- 2.1.6 Maintenance, modification or extension of components may not cause a shutdown of the whole substation automation system.
- 2.1.7 Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.
- 2.1.8 **Tenderer 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 communication panels (described in other sections of technical specifications) and Station HMI in Control Room building for overall optimization in respect of cabling and Control Room Building.**

2.2 System Architecture

- 2.2.1 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.
- 2.2.2 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.

2.2.3 Bay Level

At bay level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The IEDs should be directly connected to the switchgear without any need for additional interposition or transducers.

Each bay control IED shall be independent from each other and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station.

The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fibre-optic cables, thereby guaranteeing disturbance free communication. The fibre optic cables shall be run in GI conduit pipes.

Data exchange is to be realized using IEC 61850 protocol with a redundant managed switched Ethernet communication infrastructure. The communication shall be made in fault tolerant ring in redundant mode, excluding the links between individual bay IEDs to switch wherein the redundant connections are not envisaged, such that failure of one set of fibre shall not affect the normal operation of the SAS. However failure of fibre shall be alarmed in SAS. Each fibre optic cable shall have four (4) spare fibres.

2.2.4 Station Level

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 realized at bay level, e.g. alarm list or event list related to the entire substation, gateway for the communication with remote control centre. The GPS time synchronizing 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 Clause 1.2 above.

2.3 Operational Requirements

2.3.1 The high-voltage apparatus within the station shall be operated from different places:

- a. Remote control Centre
- b. Station HMI
- c. Local Bay controller IED (in the bays)

Operation shall be possible by only one operator at a time.

The operation shall depend on the conditions of other functions, such as interlocking, Synchro check, etc. (see description in "Bay level control functions").

2.3.2 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.

2.3.3 Command Supervision

Bay/Station Interlocking and Blocking Software

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 Tenderer 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.

2.3.4 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.

2.3.5 Self-supervision

Continuous self-supervision function with self-diagnostic feature shall be included.

2.3.6 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).

3. Functional Requirement

3.1 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

3.2 Bay level functions

3.2.1 In a decentralized architecture the functionality shall be as close to the process as possible. Separate IEDs shall be provided for Bay Control Function and Bay Protection Function.

In this respect, the following functions can be allocated at bay level:

- a. Bay control functions including data collection functionality in bay control/protection unit.
- b. Bay protection functions

3.2.2 Bay Control Functions

a. 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
- Controlling of all switching devices of the bay with annunciation
- Monitoring of all monitoring devices of the bay with annunciation

b. **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.

c. **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.
- Synchronizing 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.

d. **Transformer tap changer control**

Raise and lower operation of OLTC taps of transformer shall be facilitated through Bay controller IED.

3.2.3 Bay protection functions

a. 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.

b. 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 9 – Control, Relay & Protection Panels**.

c. 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.

3.3 System level functions

3.3.1 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.

3.3.2 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.

3.3.3 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 millisecond. The tentative list for various feeders and systems are enclosed as **Annexure-I**.

3.3.4 Station HMI

a. 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.

b. Presentation and Dialogues

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

c. HMI design principles

Consistent design principles shall be adopted with the HMI concerning labels, colors, dialogues and fonts. Non-valid selections shall be dimmed out.

The object status shall be indicated using different status colors 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

d. 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.

e. **System Supervision/Display and Common Base Time**

The SAS system shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are recorded as a faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication infrastructure and remote communication links, and printers at the station level, etc.

The internal clock of each SAS/RTUs shall be synchronized either from an internal. Contractor supplied and installed time synchronization source, such as a Global Positioning System (GPS) or an Omega synchronizing signal receiver or through the telecommunication network from a master clock installed at the LDC.

The synchronization shall be done periodically such that the time- lags in each RTU shall be with five milliseconds (5 ms) accuracy between all RTUs.

Manufacturers shall clearly indicate the method used for time synchronization and describe in detail how the required accuracy is achieved.

In the SAS/RTU there shall be a digital output from which time synchronization message can be forwarded to external devices. The frequency of the activation of message shall be adjustable.

f. **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

g. **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.

h. **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.

i. **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

3.3.5 **User-authority levels**

It shall be possible to restrict activation of the process pictures of each object (bays, apparatus etc) within a certain user authorization 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 authorization 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.

3.3.6 **Reports**

The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise:

a. **Trend reports**

- Day (mean, peak)
- Month (mean, peak)
- Semi-annual (mean, peak)
- Year (mean, peak)

b. **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 on demand:

- a. 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.
- b. Weekly trend curves for real and derived analogue values.
- c. 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
- d. 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).
- e. Equipment operation details shift wise and during 24 hours.
- f. 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.
- g. Printout on adjustable time period as well as on demand system frequency and average frequency.
- h. Reports in specified formats which shall be handed over to successful Tenderer. The Tenderer has to develop these reports. The reports are limited to the formats for which data is available in the SAS database.

3.3.7 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.

3.3.8 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.

3.3.9 Disturbance Analysis

The PC-based work station shall have necessary software to evaluate all the required information for proper fault analysis.

3.3.10 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.

3.3.11 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.

3.4 Gateway

3.4.1 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 centers (MCC, RCC & RSCC/LDC). The substation automation system shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to each remote control centre. Also, each control center's data scan and control commands may be different for different data points within the substation automation system's database.

3.4.2 Remote Control Centre Communication Interface

Employer will supply communication channels between the Substation Automation System and the remote control centre. The communication channels provided by Employer will consist either of power line carrier, optical fibre or leased line, the details of which shall be provided during detailed Engineering.

3.4.3 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.

3.4.4 Communication Protocol

The communication protocol for gateway to control centre must be open protocol and shall support IEC 60870-5-101 with 104 and IEC 61850 for all levels of communication for sub-station automation such as Bay to station HMI, gateway to remote station etc.

4. System Hardware

4.1 Redundant Station HMI, Remote HMI and Disturbance Recorder Work station

- 4.1.1 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. Manufacturer 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:

- a. Storage of all analogue data (at 15 Minutes interval) and digital data including alarm , event and trend data for thirty(30) days,
- b. Storage of all necessary software,
- c. 20GB space for EMPLOYER'S use.

Manufacturer shall demonstrate that the capacity of hard disk is sufficient to meet the above requirement.

4.1.2 HMI (Human Machine Interface)

The VDU shall show overview diagrams (Single Line Diagrams) and complete details of the switchgear with a color 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.

4.1.3 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 color graphic displays. The display shall accommodate resolution of 1280 X 1024 pixels.

4.1.4 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.

4.1.5 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, Rock ridge and Joliet File systems. 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.

4.1.6 Ethernet network topology

SAS shall comply with IEC62439-3 clause 4 PRP (Parallel Redundant Protocol) principle, based on the duplication of the Ethernet network infrastructure.

Preferably, main system component (bay controllers, protection devices, HMI and gateway PC's) shall embed redundant interface to be doubly attached on a PRP network. Manufacturer shall submit necessary compliance certificate for PRP from statutory authority/certifying agencies like KEEMA, UCA, CPRI etc.

The Software to be supplied shall also be PRP compliant.

Each network infrastructure can on its own be compliant with any other Ethernet redundancy principle.

4.1.7 Switched Ethernet Communication Infrastructure

The Manufacturer shall provide the redundant switched optical Ethernet communication infrastructure for SAS. One switch shall be provided to connect all IEDs for two bays to the 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

- 4.2.1 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.
- 4.2.2 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.
- 4.2.3 One number Bay level unit shall be provided for supervision and control of each 132 kV and 33 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.
- 4.2.4 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.
- 4.2.5 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.
- 4.2.6 **Input/output (I/O) Modules:** The I/O modules shall form a part of the bay level unit and shall provide coupling to the substation equipment. The I/O modules shall acquire all switchgear information (i.e. data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear. The measured values of voltage and current

shall be from the secondaries of instrument transformers. The digital inputs shall be acquired by exception with 1 ms resolution. Contact bouncing in digital inputs shall not be assumed as change of state.

4.3 Extendibility in future

Offered substation automation system shall be suitable for extension in future for additional bays. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the employer. During such event, normal operation of the existing substation shall be unaffected and system shall not require a shutdown. The contractor shall provide all necessary software tools along with source codes to perform addition of bays in future and complete integration with SAS by the user. These software tools shall be able to configure IED, add additional analogue variable, alarm list, event list, modify interlocking logics etc. for additional bays/equipment which shall be added in future.

5. Software Structure

5.1 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.

5.2 The Software to be supplied shall be PRP compliant.

5.3 The Contractor shall provide in two copies of all software in CD to load into the system in case of any problem related with Hardware/Communication etc.

5.4 Station Level Software

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.

5.5 Bay Level Software

5.3.1 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 synchronizing with the remaining system without any manual interface. This shall be demonstrated by contractor during integrated system test.

5.3.2 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.

5.3.3 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 Er work-station and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any fault in the monitored devices. The NMS shall

- a. Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports
- b. Maintain a graphical display of SAS connectivity and device status.
- c. Issue alarms when error conditions occur
- d. Provide facility to add and delete addresses and links

6. Tests

- 6.1 The substation automation system offered by the Contractor 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:

6.2 Type Tests

Control IEDs and Communication Equipment

- a. **Power Input**
 - i. Auxiliary Voltage
 - ii. Current Circuits
 - iii. Voltage Circuits
 - iv. Indications
- b. **Accuracy Tests**
 - i. Operational Measurand 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

6.3 Factory Acceptance Tests:

- 6.3.1 The Manufacturer 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.
- 6.3.2 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.
- 6.3.3 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).

- 6.3.4 **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.
- 6.3.5 **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.
- 6.3.6 **Site Acceptance Tests:** The site acceptance tests (SAT) shall completely verify all the features of SAS hardware and software. The Contractor shall submit the detailed SAT procedure and SAT procedure shall be read in conjunction with the specification.

7. System Operation

- 7.1 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 color VDU, a standard keyboard and a cursor positioning device (mouse). The coloured screen shall be divided into 3 fields:
- Message field with display of present time and date
 - Display field for single line diagrams
 - Navigation bar with alarm/condition indication
- 7.2 For display of alarm annunciation, lists of events etc. a separate HMI View node shall be provided.
- 7.3 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 colour. 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
- 7.4 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.
- 7.5 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.

- 7.6 The offer shall include a comprehensive description of the system. The above operation shall also be possible via WINDOWS based system by mouse.

8. Power Supply

- 8.1 Power for the substation automation system shall be derived from substation 110 V DC system.
- 8.2 Inverter of suitable 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 110 V DC independent source and should be used to drive 1 no each server/HMI/Gateway so that in case any failure of DC power supply system is not affected.

9. Documentation

- 9.1 The following documents shall be submitted for Employer's approval during detailed engineering:
- System Architecture Drawing
 - Hardware Specification
 - Functional Design Document
 - Clear procedure describing how to add an IED/bay/diameter in future covering all major supplier
- 9.2 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

- r. Listing of software and loadable in CD ROM
 - s. Other documents as may be required during detailed engineering
- 9.3 Two sets of hard copy and four sets of CD ROM containing all the as built documents/drawings shall be provided.
- 9.4 In addition to the above, all the relevant .cd & .scd configuration files are to be handed over to the Employer.

10. SCADA Integration

- 10.1 The Supervisory Control and Data Acquisition (SCADA) system at the LDC shall scan the new SASs utilizing the communication network.
- 10.2 The Contractor shall be responsible for the complete design, installation, wiring, testing, commissioning and documentation of the SASs, including any required new or parallel connections to NEA's field equipment as described in the specification, including synchronization with the existing SCADA equipment.
- 10.3 Compatible interfacing shall be for all aspects, including software and hardware. In addition to other necessary compatibilities and interfacing, the Contractor shall be fully responsible for the integration of the SCADA data associated with the scope in this tender in the SINAUT Spectrum- the processing software of the Load Dispatch Centre. This integration requires modification, addition and parameterization in the Spectrum for the following main activities:
- a. SCADA data entry: this includes data entry of different components of the substations, lines and other relevant components.
 - b. Creating Graphics: this includes creating graphics for substations, lines and other relevant components, network map creation and integration with existing system etc.
 - c. Data entry for Tele-controls Interface (TCI);
 - d. Testing and Commissioning of the newly integrated SCADA system for its full functioning; and
 - e. Network Application data entry required for network analysis/
- 10.4 For these purposes, the Contractor shall carry out necessary studies/ investigation of the existing system carefully, in full coordination with the Load Dispatch Centre, and design / propose, install and integrate a suitable scheme/system to fulfil the specified scope of works for Tele-protection, SCADA, voice communication etc. as required by NEA (Load Dispatch Centre).

10.5 Data Acquisition Principles

New SASs at each substation shall be installed and interfacing of the following supervisory controls shall be executed and data to be acquired shall be provided for:

Remote Control

- Remote control of all 132kV circuit breakers
- Remote control of all 33kV circuit breakers (off-control only for load curtailment)

Status Indications

- Status indication of all 132 and 33 kV circuit breakers
- Status indication of all 132 kV and 33 kV bus bar and line isolators
- Status indication of all 33 kV line feeders

In case of load shedding from the LDC, the substation operator shall be informed that the trip command for the respective 33 kV CBs was initiated from the LDC. For this

purpose, an annunciation lamp and audio alarm shall be installed at all 33 kV feeders taking part in the load shedding scheme. The associated audio alarm shall be integrated in the central annunciation system of local 33 kV cubicles.

Alarms

- All 132 kV and 33 kV main protection trip indications (MPT)
- All 132 kV and 33 kV backup protection trip indications (BPT)
- One grouped alarm summarizing all causes that prevent operation of a circuit breaker (circuit breaker fault alarm, CBF)
- One grouped alarm summarizing all faults not affecting operation of a circuit breaker (Bay fault alarm, BFA)
- Single indication for operation of auto re-closure relay for 33 kV feeder (ARO)
- Transformer alarms:
 - "Temperature alarm" (oil and winding temperature as grouped alarm)
 - "Temperature trip" (oil and winding temperature as grouped alarm)
 - "Buchholz alarm" (tank and OLTC as grouped alarm)
 - "Buchholz trip" (tank and OLTC as grouped alarm)
 - "General alarm" (all other alarms except the above as one grouped alarm)
 - "General trip" (all other alarms except the above as one grouped alarm)
- For all 132 kV and 33 kV bus bars a voltage status alarm (BVS)
- General station alarms and warnings
- Station urgent fault (SUF)
- Station none urgent fault (SNF)
- RTU alarm (RTU)
- Communication Equipment Alarm (COM)
- Station Control Disabled (SCD) etc.

A table summarizing the alarms to be acquired by LDC from each type of bay in the 132 and 33 kV network is shown below.

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

Type of alarm	Line bay	Transformer Bay	Coupler Bay	Busbar	Station
Main protection trip	MPT	MPT	MPT		
Back-up protection trip	BPT	BPT	BPT		
Bay fault	BFA	BFA	BFA		
Circuit breaker fault	CBF	CBF	CBF		
Auto-recloser operated	ARO				
Temperature alarm		TAL			
Temperature trip		TTR			
Buchholz alarm		BAL			
Buchholz trip		BTR			
General transformer/reactor alarm		GTA			

Type of alarm	Line bay	Transformer Bay	Coupler Bay	Busbar	Station
General transformer/reactor trip		GTT			
Busbar voltage status				BVS	
Station urgent fault					SUF
Station none-urgent fault					SNF
Station control disabled					SCD
RTU alarm					RTU
Communication alarm					COM
Total	5	10	4	1	5

Measurements

- Bus bar voltage (separate for each bus bar and section) of all 132 kV and 33 kV bus bars
- Active/reactive power for
 - All 132/33 kV transformers feeding into the distribution networks (at secondary side)
 - All 33 kV feeders
- Single phase current measurements for all 33 lines participating in the load shedding scheme.
- In analog measurements, the information to the SAS is given in the form of an analog current supplied by the output of an analog measuring transducer.
- The analog signals shall be converted to digital mode by an analog to digital converter to which the inputs are connected. All inputs of a module shall be measured within one cycle, regardless of the number of inputs in use. Thus, new points can be added to the SAS without reprogramming.
- Analog measurements shall be transmitted to the master station with 16 bits or 16 bits sign bit.

11. Training, Support Services, Maintenance and Spares

11.1 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. It shall provide all necessary training material for five trainees. 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. All the cost of trainings excluding trainee's expenses shall be paid by contractor.

The Contractor shall also arrange at least for seven (7) days detail training at the manufacturer premises for the SAS for three concerned nominated Technical officers before approving detail design and engineering of the SAS program under this project

to make them competent enough to understand theoretical background with practical knowledge about drawing, design, construction details for approving, operating and maintenance and future expansion of SAS system. All the cost of training including (i) accommodation charges (ii) payment of per diem allowance to NEA trainees @ daily allowance USD 150 per day per trainee for the duration of training abroad towards meals and other incidental expenses and (iii) to and fro economy class air ticket from Nepal to place of training (travelling allowance) shall be paid by the contractor. Therefore, Tenderers are instructed to include all the cost of training including travelling and daily allowance of NEA personnel in overall Tender price.

11.2 Requirement of Training

The Contractor shall provide training comprehensively covering the following courses for both training programs, however the training in Nepal shall focus on operation, general maintenance and trouble-shooting of the SAS:

- a. Computer System Hardware
- b. Computer System Software
- c. Application Software

11.2.1 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 trainee 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 equipment.
- c. **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.
- d. **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.
- e. **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.

11.2.2 Computer System Software Course

The Contractor shall provide a computer system software course that covers the following subjects:

- a. **System Programming:** All applicable programming languages and all standalone 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:** User aspects of the operating system, such as program loading & integrating procedures; scheduling, management, service, utility functions; system expansion technique and procedure.
- 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.

11.2.3 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.

11.3 Maintenance

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 bimonthly 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 15days.

11.4 Spares

11.4.1 Consumables

All consumables such as paper, cartridges shall be supplied by the contractor till the SAS is taken over by the owner.

11.4.2 Availability Spares

In addition to mandatory spares as mentioned below for SAS, the Tenderer 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 Tenderer and shall be considered in the evaluation of the Tenders. 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.

List of Spares

- a. One no. spare BCU with sufficient no. of analog & digital modules which can be used for any bays for analog and digital inputs
- b. One no. Ethernet Switch

12. Reliability and Availability

12.1 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:

- a. Mechanical and electrical design
- b. Security against electrical interference (EMI)
- c. High quality components and boards
- d. Modular, well-tested hardware
- e. Thoroughly developed and tested modular software
- f. Easy-to-understand programming language for application programming
- g. Detailed graphical documentation and application software
- h. Built-in supervision and diagnostic functions
- i. Security
 - Experience of security requirements
 - Process know-how
 - Select before execute at operation
 - Process status representation as double indications
- j. Distributed Solution
- k. Independent units connected to the local area network
- l. Back-up functions
- m. Panel design appropriate to the harsh electrical environment and ambient conditions
- n. Panel grounding immune against transient ground potential rise

12.2 Outage Terms

- a. **Outage:** The state in which substation automation system or a unit of SAS is unavailable for Normal Operation 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.

- b. **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 1/4th of an hour. Time less than 1/4th of an hour shall be counted as having duration of 1/4th of an hour.
- c. **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).
- d. **Actual Outage hours (AOH):** The sum of actual outage duration within the reporting period.

$$AOH = \sum AOD$$
- e. **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.

12.3 Guarantees Required

- a. The availability for the complete SAS shall be guaranteed by the Contractor. Tenderer 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 1000Hours period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.
- b. 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. List of Equipment

13.1 Quantity of equipment shall be decided by bidder in order to achieve guaranteed reliability and availability as declared by bidder.

- a. Main & Standby Server
- b. Station and Remote HMI
- c. Gateways (main & standby)
- d. Bay level units along with bay mimic.
- e. Bay Level Unit for Auxiliary system (as per requirement)
- f. Disturbance Recorder Work Station (Maintenance HMI)
- g. Colour Laser Printer (For Reports & Disturbance records)
- h. Dot matrix printers (for Alarms and log sheets)
- i. All interface equipment for gateway to SLDC
- j. Communication infrastructure between Bay level units, Station HMI, Printers, gateways, redundant LAN etc. as required
- k. Ethernet switch

- l. Modems as per requirement
- m. Any other equipment as necessary.

13.2 Global Positioning System (GPS)

GPS receiver for synchronization for communicating over IEC-60870-5-101/104 shall be supplied with a GPS clock.

13.3 Inter-Operability Profile of IEC 60870-5-101/104 Protocol

Interoperability Profile shall be provided to the successful bidder. However, it is the responsibility of the bidder to make it compatible with existing Net Work Management System (NMS) and/or new NMS of Remote Control Centre (SLDC).

13.4 Data Polling Method

13.4.1 The Gateway shall respond to the Master stations request for the at least the following commands as per the protocol:

- a. Status of Link
- b. Reset of Link
- c. Delay acquisition command
- d. Clock synchronization command
- e. General interrogation command
- f. Interrogation of Scan group 1 command (all status data)
- g. Interrogation of Scan group 2 command (all analog data)
- h. Class 1/2 data polling
- i. File transfer in Monitor direction (SOE file)

13.4.2 For supervisory control commands SBO procedure is to be used.

13.4.3 Gateway shall send all Analog and status data in response to the General interrogation command.

13.4.4 All digital inputs are to be assigned to Scan Group-1.

13.4.5 Analogs are defined as periodic data and are sent to SLDC on Class 2 request. The periodicity varies from 10 seconds to 15 seconds depending upon the quantity of data and available bandwidth.

13.4.6 Digital input state changes are to be reported spontaneously by Gateway as Class 1 data. The Digital input data have higher priority than Analog values. An integrity scan is performed for all the digital inputs using Scan group-1 at every 10 minutes interval.

13.4.7 The SOE (Sequence of Events) information is stored in a file in the Gateway. The format of SOE data is enclosed in a separate file (please see the details in SOE_erldc_nerldc_nrlldc.pdf document). This file is transferred using the file transfer feature of IEC 60870-5-101/104 protocol.

Annexure – 1: List of Analogue and Digital Inputs

Basic Monitoring and/or Control requirements are as follows but not limited to:

A. Digital Input

1. Healthiness of all IED
2. Healthiness of all Trip relay
3. Healthiness of all Trip coil
4. Healthiness of all supervised AC/DC circuits
5. Trip of all MCB
6. Low pressure condition (stage-1,2 etc.) of all gas chamber
7. High pressure condition (stage-1,2 etc.) of all gas chamber
8. Position of all switches (L/R, Normal/Bypass, PT selection, E/T selection, U/F selection, AIR selection, carrier selection, etc.)
9. Status of all switchgear (CB, isolator, Earth switch, etc.)
10. Healthiness of CB (spring charge, SF₆ pr., runtime error, etc.)
11. All protection start (phase wise)
12. All protection operation (phase wise)
13. All parameter required for AR operation
14. Any other parameter required for SOE
15. All parameter of Transformer (electrical parameter, temperature and oil level)
16. Status of all fans (running/trip etc.)
17. All alarms related to ACDB, DCDB, Battery charger, BHMS, Fire alarm, Air-Conditioning etc.

B. Analog (MV) Input

1. Bus voltage (for all bus, phase-wise)
2. Bus Frequency (for all bus)
3. Voltage (3-phase), Current (3-phase), Power Factor (pf), Power (MW, MVAR) for all feeder
4. Fault Location (Impedance, km) for all line feeder
5. Fault Current (for all feeder)

C. Analog (4-20 mA) Input

1. Tap Position of transformer
2. Winding and Oil Temperature of transformer
3. Current, Voltage and Power of all auxiliary System

D. Command

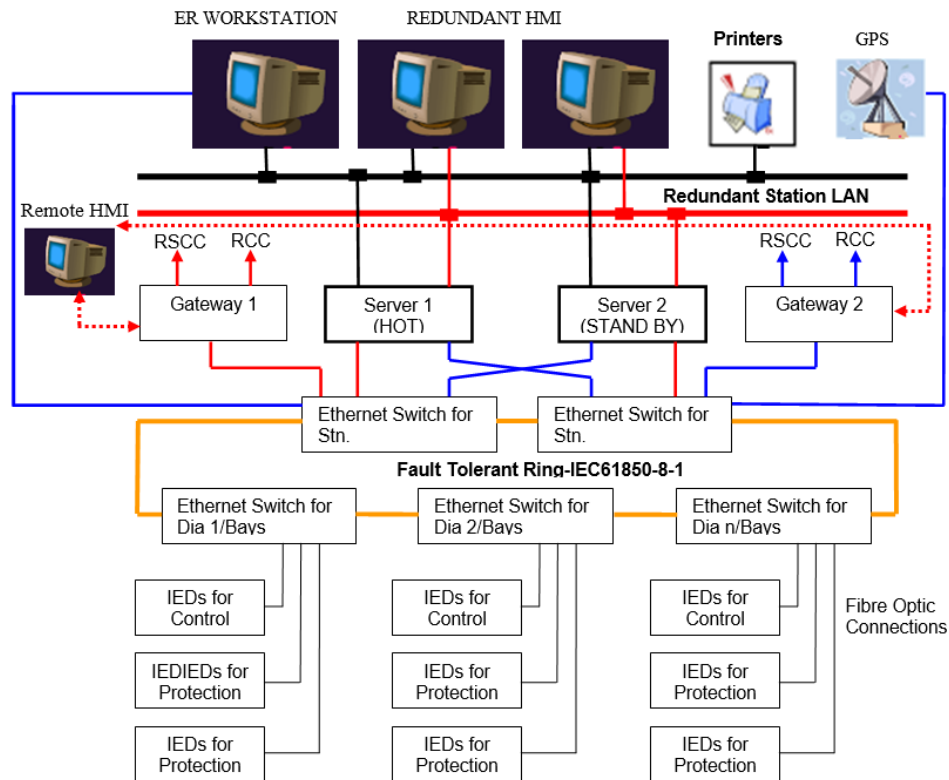
1. Open/close command for all switchgear (CB, isolator, Earth switch, ACB of ACDB/DCDB etc.)
2. Reset of all trip relays
3. Reset of all LED
4. Reset of any latch required in system
5. Reset of any latch required in AUX system

Note

The exact number and description of inputs/outputs shall be as per system requirement. Apart from the above-mentioned inputs and outputs, minimum of 20% spare shall be considered.

Software License (with lifetime validity) shall be taken considering above requirement.

Annexure – 2: 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. The IEDs and switches for one bay in 132 kV level and for two bays in 33 kV or lower Level can be housed in one switchyard panel along with its switch.
3. Inside the sub-station, all connections shall be realized as per IEC 61850 protocol.
4. For gateway, it shall communicate with Remote Supervisory Control Centre (RSCC) or SLDC or MCC on IEC 60870-5-101/104 protocol.
5. 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.
6. 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 LDC

1. MW and MVAR for all lines and transformers
2. Voltage of all buses
3. Frequency of 132 kV Bus
4. All Breakers and Isolators
5. Tap Position for all transformers
6. Master protection signal for all feeders, transformers Units and Bus Bar
7. Loss of Voltage signal for Bus bar
8. All the points identified in point (4) and (7) above as GPS Time stamped.
9. Temperature value per substation
10. Any other point decided during detailed engineering

Volume II

Section 6: Employer's Requirements

CHAPTER 11: VISUAL MONITORING SYSTEM

Table of Contents

1.	Scope of work.....	2
2.	Technical requirements of major equipment of Visual Monitoring System	2
3.	System Requirements	3
4.	Video Surveillance Application Software.....	4
5.	Network Video Recorder	4
6.	VMS Camera.....	4
7.	PTZ-Keyboards.....	5
	Technical Particulars and Compliance Sheet.....	6

CHAPTER 11

VISUAL MONITORING SYSTEM

1. Scope of work

- 1.1 Visual monitoring system (VMS) for effective watch and ward of substation premises covering the areas of entire switchyard, Control Room cum Administrative building, main gate etc. shall be provided. The contractor shall design, supply, erect, test and commission the complete system including cameras, Digital video recorder system, mounting arrangement for cameras, cables, LAN Switches, UPS and any other items/accessories required to complete the system. To provide all the necessary licenses to run the system successfully shall be in the scope of contractor.
- 1.2 System with Color IP Cameras for VMS surveillance would be located at various locations including indoor areas and outdoor switchyard and as per the direction of Engineer-In- Charge. The VMS data partly/completely shall be recorded (minimum for 15 days) and stored on network video recorder.
- 1.3 The number of cameras and their locations shall be decided in such a way that any location covered in the area can be scanned. The cameras shall be located in such a way to monitor at least:
 - a. The operation of each and every isolator pole of the complete yard.
 - b. The Operation of each bays of switchyard as Applicable.
 - c. All Transformers, all the Entrance doors of Control Room Building and Switchyard Panel room as applicable.
 - d. All the gates of switchyard.
 - e. Main entrance Gate
 - f. All the equipment inside control room.
 - g. All other necessary areas as directed by the project.
- 1.4 The cameras can be mounted on structures, buildings or any other suitable mounting arrangement to be provided by the contractor.

2. Technical requirements of major equipment of Visual Monitoring System

- 2.1 The system shall provide inter-operability of hardware, operation protocols; system expansion shall be possible through off-the-shelf available system, software, networking, printing, database connectivity, and reporting & communication hardware.
- 2.2 The Video Monitoring system shall be an open standard based integrated system with IP network centric functional and management architecture aimed at providing high-speed manual/automatic operation for best performance.
- 2.3 The system shall facilitate viewing of live and recorded images and controlling of all cameras by the authorized users.
- 2.4 The system shall use video signals from various types of indoor/outdoor CCD color cameras installed at different locations, process them for viewing on workstations/monitors in the control Room and simultaneously record all the cameras after compression using H 264/MPEG 4 or better standard. Mouse/Joystick-Key-board controllers shall be used for Pan, Tilt, Zoom, and other functions of desired cameras.
- 2.5 The System shall provide sufficient storage of all the camera recordings for a period of 15 days or more @ 25 FPS, at 4 CIF or better quality using necessary compression techniques for all cameras. It shall be ensured that data once recorded shall not be

altered by any means. The recording resolution and frame rate for each camera shall be user programmable.

- 2.6 The surveillance VMS System shall operate on 230 V, 50 Hz single-phase power supply. System shall have back up UPS power supply meeting the power supply need of all the cameras in the stations including those which are installed at gate for a period of 2 hours. The bidder shall submit the sizing calculation for the UPS considering the total load requirement of Video Monitoring System.
- 2.7 The camera and supplied software both shall be ONVIF (Open Network Video Interface Forum) compliant for easy integration with different make of cameras and hardware for future expansion.

3. System Requirements

- 3.1 System must provide built-in facility of watermarking or Digital certificate to ensure tamper proof recording.
- 3.2 All cameras may be connected through a suitable LAN which shall be able to perform in the substation environments without fail.
- 3.3 All camera recordings shall have Camera ID & location/area of recording as well as date/time stamp. Camera ID, Location/Area of recording & date/time shall be programmable by the system administrator with User ID & Password.
- 3.4 Facility of camera recording in real-time mode (25 FPS)/15/12.5/10 or lower FPS as well as in any desired combination must be available in the system.
- 3.5 Facility of Camera recording in HD (1280X720p), D1, 4CIF, CIF, VGA, as well as in any combination i.e. any camera can be recorded in any quality.
- 3.6 System to have facility of 100% additional camera installation beyond the originally planned capacity.
- 3.7 In order to optimize the memory, while recording, video shall be compressed using H 264/MPEG-4 or better standard and streamed over the IP network.
- 3.8 System shall be triplex i.e. it shall provide facility of Viewing, Recording & Replay simultaneously.
- 3.9 The offered system shall have facility to export the desired portion of clipping (from a specific date/time to another specific date/time) on CD or DVD. Viewing of this recording shall be possible on standard PC using standard software like windows media player etc.
- 3.10 System shall have provision of WAN connectivity for remote monitoring.
- 3.11 The equipment shall generally conform to Electromagnetic compatibility requirements for outdoor equipment in EHV switchyards. The major EMC required for Cameras and other equipment shall be as under:
 - a. Electrical Fast Transient (Level 4) – As per IEC 61000-4-4
 - b. Damped Oscillatory (1 MHz and 100 KHz) (level 3) – As per IEC 61000-4-
 - c. AC Voltage Dips & Interruption/Variation (class 3) – As per IEC 61000-4-
 - d. Electrostatic Discharge (Level 4) – As per IEC 61000-4-2
 - e. Power Frequency Magnetic Field (level 4) – As per IEC 61000-4-8
 - f. Ripple on DC input Power Supply Port immunity test(level - As per IEC 61000-4-

Type test reports to establish compliance with the above requirement shall be submitted during detailed engineering.

4. Video Surveillance Application Software

- 4.1 Digital video surveillance control software shall be capable to display and manage the entire surveillance system. It shall be capable of supporting variety of devices such as cameras, video encoder, Servers, NAS boxes/Raid backup device etc.
- 4.2 The software shall have inbuilt facility to store configuration of encoders and cameras.
- 4.3 The software shall Support flexible 1/2/4/8/16/32 Windows Split screen display mode and scroll mode on the PC monitor.
- 4.4 The software shall be able to control all cameras i.e. PTZ control, Iris control, auto / manual focus, and color balance of camera, Selection of presets, Video tour selection etc.
- 4.5 The software shall have user access authority configurable on per device or per device group basis. The system shall provide user activity log with user ID, time stamp, action performed, etc.
- 4.6 The users shall be on a hierarchical basis as assigned by the administrator. The higher priority person can take control of cameras, which are already being controlled by a lower priority user.
- 4.7 It shall have recording modes viz. continuous, manual, or programmed modes on date, time and camera-wise. All modes shall be disabled and enabled using scheduled configuration. It shall also be possible to search and replay the recorded images on date, time and camera-wise. It shall provide onscreen controls for remote operation of PTZ cameras. It shall have the facility for scheduled recording. Different recording speeds (fps) and resolution for each recording mode for each camera shall be possible.
- 4.8 The software for clients shall also be working on a browser based system for remote users. This will allow any authorized user to display the video of any desired camera on the monitor with full PTZ and associated controls.
- 4.9 **Retrieval:** The VMS application shall allow retrieval of data instantaneously or any date/ time interval chosen through search functionality of the application software. In case data is older than 15 days and available, the retrieval shall be possible. The system shall also allow for backup of specific data on any drives like DVD's or any other device in a format which can be replayed through a standard PC based software. Log of any such activity shall be maintained by the system.
- 4.10 VMS shall provide the full functionality reporting tool which can provide reports for user login/logoff, camera accessibility report, server health check reports etc.

5. Network Video Recorder

- 5.1 The Network Video recorder (NVR) shall include at least Server (min 3.0 GHZ, 4GB RAM, 3000GB HDD (min)), RAID 5, with suitable configuration along with Colored TFT 22" High resolution monitor, and Internal DVD writer. Windows XP/Vista/7 Prof. or VMS compatible operating system latest version with hardware like graphic cards, licensed Anti-virus etc.

6. VMS Camera

- 6.1 The color IP camera for substation shall have PAN, TILT and ZOOM facilities so that it can be focused to the required location from the remote station through a controller. Whereas wireless IP cameras with PTZ controls are required for installation at gates of the premises as per the direction of Engineer In-Charge
- 6.2 The IP Camera at the main gate can be fixed or PTZ based and shall be used for monitoring entry and exit.

- 6.3 It shall have sufficient range for viewing all the poles of isolators and other equipment with high degree of clarity.
- 6.4 The VMS camera shall be suitable for wall mounting, ceiling mounting and switchyard structure mounting.
- 6.5 It shall be possible to define at 128 selectable preset locations so that the camera gets automatically focused on selection of the location for viewing a predefined location.
- 6.6 The camera shall be able to detect motion in day & night environments having light intensity of Color: 0.5 Lux; B&W: 0.05 Lux.
- 6.7 Housing of cameras meant for indoor use shall be of IP 42 or better rating whereas outdoor camera housing shall be of IP 66 or better rating. Housing shall be robust and not have the effect of electromagnetic induction in 765/400KV switchyard.
- 6.8 All camera recordings shall have Camera ID & location/area of recording as well as date/time stamp. Camera ID, Location/Area of recording & date/time shall be programmable by the system administrator with User ID & Password.
- 6.9 Facility of camera recording in real-time mode (25 FPS)/15/12.5/10 or lower FPS as well as in any desired combination must be available in the system.

7. PTZ-Keyboards

- 7.1 The features of PTZ shall include:
 - a. Fully functional dynamic keyboard/joystick controllers
 - b. Controls all pan, tilt, zoom, iris, preset functions
 - c. Control up to 255 units from a single keyboard
 - d. Many preset options and advanced tour programming
 - e. Compatible with all connected cameras

1	Key Application	Wired keyboard control operation of PTZ functions for weatherproof dome cameras
2	Pan / Tilt / Zoom Protocol Languages Supported	Selectable
3	PTZ Data Transfer Baud Rates Supported	Selectable 1200 bps / 2400 bps / 4800 bps / 9600 bps
4	Additional Features	Dynamic joystick for smooth camera movements, preset location option for quick access to frequently monitored areas

Technical Particulars and Compliance Sheet

A. Outdoor IP Fixed Megapixel Camera Specifications (For Main Gate)

1	Image Sensor	2-megapixel Progressive, 1 / 3" CMOS/CCD sensor, Minimum illumination 0.1 Lux
2	Min Luminous	0.5 LUX (Color) 0.05 Lux (Black)
3	Camera Enclosure Type	IP66 Grade
4	Iris/Focus	Auto/Manual
5	Video Compression	Dual Stream H.264 and MPEG 4 user selectable
6	Support Dual-stream	Primary/secondary stream, H.264/MPEG 4 optional
7	Video Definition	Primary stream: 1600x1200, 1280x960, 1280x720 Secondary stream: 800x600, 400x288, 192x144
8	Video Parameters	Brightness, hue, contrast, saturation and image quality
9	Video Frame Rate	PAL: 1-25frames/second NTSC: 1-30frames/second
10	Video Compression BR	32Kbit/S - 6Mbit/S
11	Video Output	One channel composite Streaming
12	Supported Protocols	TCP, UDP, IP, HTTP, FTP, SMTP, DHCP, DNS, ARP, ICMP, POP3, NTP, IPsec, UpnP, RTP, RTCP
13	Operating Temperature	As per climatic condition
14	Operating Humidity	As per climatic condition

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

1	Image Sensor	1/3 type Solid State CCD, WDR(High Definition) Progressive Scan
2	Security	Multiple user access with password protection
3	Effective Pixels	(PAL) Main Stream : 1280x720 Sub Stream: 640x360, 320x280 selectable
4	Compression	Dual Stream H.264 and MPEG 4 user selectable
5	Signal System	50 Hz
6	S/N Ratio (signal to noise)	Better than 50 dB
7	Electronic Shutter	1/60 - 1/10,000 sec. automatic or better
8	Scanning System	Progressive/Interlace
9	Low (lux) Light Sensitivity	Color: 0.5 Lux; B & W: 0.02 Lux
10	Lens	Minimum 10 x (minimum) optical in High Definition (The system shall be able to zoom the images on the monitor without any distortion to the maximum level of optical zoom)
11	Lens Size	Minimum 4.1-73.8 mm
12	Lens Aperture	F1.6 (wide)-F2.8 (tele), f=4.1-41.0mm, 10 x Zoom, Video Auto Focus Angle of View Horizontal: 52°(wide) 2.8°(tele)
13	PTZ Data Baud/Bit Supported Transfer Rates	Selectable 2400 bps / 4800 bps / 9600 bps

14	Panning Range	Complete 360 degrees (horizontal)
15	Pan Speed	Adjustable, 0.1 degrees / second degrees / second ~ 250
16	Tilting Range	Minimum 180° Tilt Rotation
17	Tilt Speed	Adjustable, 0.1 degrees / second ~ degrees / second 150
18	In Built Storage	Camera shall have inbuilt storage TF or SD format for recording and storing Pictures
19	IP Class	IP66 Standard
20	Working temperature	As per climatic condition
21	Working Humidity	As per climatic condition

C. PC base Network Video Recorder (NVR)

1	Server Spec	Intel Quad Core (or better) 3.0 Ghz (min.), 8 MB Cache, 4 GB memory, with suitable NVIDIA graphics card, 3 TB HDD, Raid 5
2	Recording and Display Frame Rate	Real-time 25 frames per second per channel , manual select
3	Recording Resolution	(PAL): 1280X720, 704(H) x 586(V). It shall be possible to select lower resolutions
4	Compression Method	H.264/MPEG-4 or better and latest
5	Video Motion Detection Capable	Standard and built-in (selectable in menu)
6	Monitoring Options	Split screen 1, 2, 4, 8, 16, 32 or more cameras
7	Playback Options	Search, still image capture
8	Alarm/Event Recording Capable	To be provided with built-in external alarm input/ output ports minimum (8 in, 2 out)
9	Network Operation Capable	To be provided by using WAN or LAN router
10	Remote Internet Viewing Capable	Using WAN or LAN router
11	HDD Storage Consumption	1GB per hour / channel variable based on frame speed and resolution settings, as well as compression
12	Operation	Triplex operation (simultaneous recording, playback, network operation)
13	Number of Video Channel	32
14	Audio Recording Capable	32
15	Input Voltage	230V AC or equivalent with UPS as a backup for 30 minutes

Volume II

Section 6: Employer's Requirements

CHAPTER 12: BATTERY AND BATTERY CHARGER

Table of Contents

1.	General Technical Requirements	2
2.	Battery.....	2
3.	Battery Charger	6
4.	Battery Health Monitoring System (BHMS).....	10

CHAPTER 12

BATTERY AND BATTERY CHARGER

1. General Technical Requirements

- 1.1 All materials/components used in battery chargers and batteries shall be free from flaws and defects and shall conform to the relevant Indian/IEC standards and good engineering practice.
- 1.2 DC System shall consist of two (2) float-cum-boost chargers and one (1) battery sets for each of 110 V and 48 V systems respectively. The standard scheme drawing is enclosed with this specification. All the necessary connections for main and standby float cum boost chargers shall be make available by the contractor so that any charger can be used at necessitate time.
- 1.3 Bidder shall select number of cells, float and Boost voltage to achieve following system requirement:

System Voltage	Max. voltage during Float Operation	Min. voltage available when no charger working and battery fully discharged up to 1.85V per cell	Min. nos of cell	Ampere Hr
110 V	121 V	99 V	54	400 AH
48 V	52.8 V	43.2 V	23	300 AH

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

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

2. Battery

2.1 Type

The DC Batteries shall be VRLA (Valve Regulated Lead-Acid) type and shall be Normal Discharge type. These shall be suitable for a long life under continuous float operations and occasional discharges. Air-conditioning shall be provided in Battery room the requirement of which has been specified elsewhere in the Technical Specification. The 110 V DC system is unearh and 48 V DC system is positive earth system.

2.2 Constructional Requirements

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

2.3 Container

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

2.4 Cell Covers

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

2.5 Separators

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

2.6 Pressure Regulation Valve

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

2.7 Terminal Posts

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

2.8 Connectors, Nuts & Bolts, Heat Shrinkable Sleeves

Where it is not possible to bolt the cell terminals directly to assemble a battery, separate non-corroding lead or copper connectors of suitable size shall be provided to enable connection of the cells. Copper connections shall be suitably lead coated to withstand corrosion due to sulphuric acid at a very high rate of charge or discharge.

Nuts and bolts for connecting the cells shall be made of copper, brass or stainless steel. Copper or brass nuts and bolts shall be effectively lead coated to prevent corrosion. Stainless steel bolts and nuts can be used without lead coating.

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

2.9 Flame Arrestors

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

2.10 Battery Bank Stand

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

2.11 Capacity Requirements

When the battery is discharged at 10 hour rate, it shall deliver 80% of C (rated capacity, corrected at 27°C) before any of the cells in the battery bank reaches 1.85V/cell.

The battery shall be capable of being recharged from the fully exhausted condition (1.75V/cell) within 10 hrs up to 90% state of charge. All the cells in a battery shall be designed for continuous float operation at the specified float voltage throughout the life.

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

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

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

2.12 Expected Battery Life

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

2.13 Routine Maintenance of Battery system

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

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

2.14 Type Test of Battery

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

S. No	Description of test
1.	Gas emission
2.	High current tolerance

3.	Short circuit current and DC internal resistance
4.	Protection against internal ignition from external spark sources
5.	Protection against ground short propensity
6.	Content & durability of required markings
7.	Material identification
8.	Valve operation
9.	Flammability rating of materials
10.	Inter cell connector performance
11.	Discharge Capacity
12.	Charge retention during storage
13.	Float service with daily discharges for reliable mains power
14.	Recharge behavior
15.	Service life at an operating temperature of 40°C for brief duration exposure time
16.	Impact of a stress temperature of 60°C for brief duration exposure time with 3h rate discharge test.
17.	Abusive over-discharge
18.	Thermal runaway sensitivity
19.	Low temperature sensitivity
20.	Dimensional sensitivity at elevated internal pressure and temperature
21.	Stability against mechanical abuse of units during installation

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

2.15 List of Factory & Site Tests for Battery

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

2.16 Installation and commissioning

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

Contractor shall be submitted following documents for approval:

- Data sheet as per Annexure-I
- GA of cell and layout drawing

- c. Discharge Data for 10 Hour, 8 Hour, 3 Hour, 2 Hour, 1 Hour, 15 Minutes and One Minute indicating capacity factors for end cell voltage of 1.75 V & 1.85 V
- d. Temperature correction factors
- e. Installation and commissioning Instructions
- f. O & M Manual

3. Battery Charger

- 3.1 The DC system for 110 V DC is unearthed and for 48 V DC is +ve earthed. The Battery Chargers as well as their automatic regulators shall be of static type and shall be compatible with offered VRLA batteries. All battery chargers shall be capable of continuous operation at the respective rated load in float charging mode, i.e. float charging the associated Lead-Acid Batteries at 2.13 to 2.27 Volts per cell while supplying the DC load. The chargers shall also be capable of Boost charging the associated DC Battery at 2.28 to 2.32 volts per cell at the desired rate.
- 3.2 Charger shall regulate the float/ boost voltage in case of prescribed temperature rise of battery as per manufacturer's recommendation to avoid thermal runaway. Necessary temperature sensors shall be provided in mid location of battery banks and shall be wired up to the respective charger for feedback control. The manufacturer shall demonstrate this feature during testing of each charger.
- 3.3 All Battery Chargers shall be provided with facility for both automatic and manual control of output voltage and current. A selector switch shall be provided for selecting the mode of output voltage/current control, whether automatic or manual. When on automatic control mode during Float charging, the Charger output voltage shall remain within +1% of the set value, for AC input voltage variation of +10%, frequency variation of +2.5%, a combined voltage and frequency variation of +10%, and a DC load variation from zero to full load.
- 3.4 All battery chargers shall have constant voltage characteristics throughout the range (from zero to full load) at the floating value of the voltage so as to keep the battery fully charged but without harmful overcharge.
- 3.5 All chargers shall have load limiters having drooping characteristic, which shall cause, when the voltage control is in automatic mode, a gradual lowering of the output voltage when the DC load current exceeds the Load limiter setting of the Charger. The Load-limiter characteristics shall be such that any sustained overload or short circuit in DC System shall not damage the Charger, nor shall it cause blowing of any of the Charger fuses. The Charger shall not trip on overload or external short circuit.
- 3.6 Uniform and step less adjustments of voltage setting (in both manual and automatic modes) shall be provided on the front of the Charger panel covering the entire float charging output range specified. Step less adjustments of the Load-limiter setting shall also be possible from 80% to 100% of the rated output current for charging mode.
- 3.7 During Boost Charging, the Battery Charger shall operate on constant current mode (when automatic regulator is in service). It shall be possible to adjust the Boost charging current continuously over a range of 50 to 100% of the rated output current for Boost charging mode.
- 3.8 The Charger output voltage shall automatically go on rising, when it is operating on Boost mode, as the Battery charges up. For limiting the output voltage of the Charger, a potentiometer shall be provided on the front of the panel, whereby it shall be possible to set the upper limit of this voltage anywhere in the output range specified for Boost Charging mode.

- 3.9 The Charger manufacturer may offer an arrangement in which the voltage setting device for Float charging mode is also used as output voltage limit setting device for Boost charging mode and the Load-limiter of Float charging mode is used as current setting device in boost charging mode.
- 3.10 Suitable filter circuits shall be provided in all the chargers to limit the ripple content (Peak to Peak) in the output voltage to 1%, irrespective of the DC load level, when they are not connected to a Battery.
- 3.11 **MCCB**
All Battery Chargers shall have 2 Nos. MCCBs on the input side to receive cables from two sources. Mechanical interlock should be provided such that only one shall be closed at a time. It shall be of P2 duty and suitable for continuous duty. MCCB's should have auxiliary contacts for annunciation.
- 3.12 **Rectifier Transformer**
The rectifier transformer shall be continuously rated, dry air cooled (A.N) and of class F insulation type. The rating of the rectifier transformer shall have 10% overload capacity.
- 3.13 **Rectifier Assembly**
The rectifier assembly shall be fully/half controlled bridge type and shall be designed to meet the duty as required by the respective Charger. The rectifier shall be provided with heat sink having their own heat dissipation arrangements with natural air cooling. Necessary surge protection devices and rectifier type fast acting HRC fuses shall be provided in each arm of the rectifier connections.
- 3.14 **Instruments**
One AC voltmeter and one AC ammeter along with selector switches shall be provided for all chargers. One DC voltmeter and DC ammeter (with shunt) shall be provided for all Chargers. The instruments shall be flush type, dust proof and moisture resistant. The instruments shall have easily accessible means for zero adjustment. The instruments shall be of 1.5 accuracy classes. In addition to the above a centre zero voltmeter with selector switch shall also be provided for 110 V chargers for testing purpose.
- 3.15 **Air Break Switches**
One DC output switch shall be provided in all chargers. They shall be air break type suitable for 500 volts AC/ 250 DC. The contacts of the switches shall open and close with a snap action. The operating handle of the switch shall be fully insulated from circuit. 'ON' and 'OFF' position on the switch shall be clearly indicated. Rating of switches shall be suitable for their continuous load. Alternatively, MCCB's of suitable ratings shall also acceptable in place of Air Break Switch.
- 3.16 **Fuses**
All fuses shall be HRC Link type. Fuses shall be mounted on fuse carriers which are in turn mounted on fuse bases. Wherever it is not possible to mount fuses on carriers, fuses shall be directly mounted on plug-in type base. In such case one insulated fuse pulling handle shall be supplied for each charger. Fuse rating shall be chosen by the Bidder depending on the circuit requirement. All fuses in the chargers shall be monitored. Fuse failure annunciation shall be provided on the failure of any fuse.
- 3.17 **Blocking Diode**
Blocking diode shall be provided in the positive pole of the output circuit of each charger to prevent current flow from the DC Battery into the Charger.

3.18 Annunciation System

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

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

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

3.20 Name Plates and Marking

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

3.21 Charger Construction

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

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

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

3.22 Painting

All sheet steel work shall be pre-treated, in tanks, in accordance with IEC/International Standards. Degreasing shall be done by alkaline cleaning. Rust and scale shall be removed by pickling with acid. After pickling, the parts shall be washed in running water. Then these shall be rinsed in slightly alkaline hot water and dried. The phosphate

coating shall be in accordance with IEC/International Standards. Welding shall not be done after phosphating. The phosphating surfaces shall be rinsed and passivated prior to application of stoved lead oxide primer coating. After primer application, two coats of finishing synthetic enamel paint of shade-692 (smoke grey) shall be applied, unless required otherwise by the Employer. The inside of the chargers shall be glossy white. Each coat of finishing synthetic enamel paint shall be properly staved. The paint thickness shall not be less than fifty (50) microns.

3.23 Tests

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

- a. Voltage regulation test
- b. Load limiter characteristics test
- c. Efficiency tests
- d. High voltage tests
- e. Temperature rise test
- f. Short circuit test at no load and full load at rated voltage for sustained short-circuit
- g. Degree of protection test
- h. Measurement of ripple by oscilloscope
- i. Temperature compensation feature demonstration

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

- a. Insulation resistance test
- b. Checking of proper annunciation system operation

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

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

- a. Switches
- b. Relays/MCCBs
- c. Instruments
- d. DC fuses
- e. SCR
- f. Diodes
- g. Condensers
- h. Potentiometers
- i. Semiconductor
- j. Annunciator
- k. Control wiring
- l. Push buttons and contactors

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

4. Battery Health Monitoring System (BHMS)

4.1 General

Battery Health Monitoring System (BHMS) shall be a microcontroller based intelligent system which continuously monitors and checks the trend of individual cells in a battery bank. BHMS calculates the net charge of Battery bank, deterioration of batteries in battery bank during the charge/discharge cycles and actual efficiency of the batteries.

Continuously monitors each cell in the battery bank to identify deterioration in the cell prior to failure.

4.2 Key Components

- a. BMS Main Panel
- b. Latest licensed Windows OS based PC with licensed BHMS software for Remote Monitoring and Data logging.
- c. Required Converter and communication cables.
- d. Battery Junction Box, Current Transducer, lugs, temperature sensor etc.
- e. All cables for connection to individual cell.

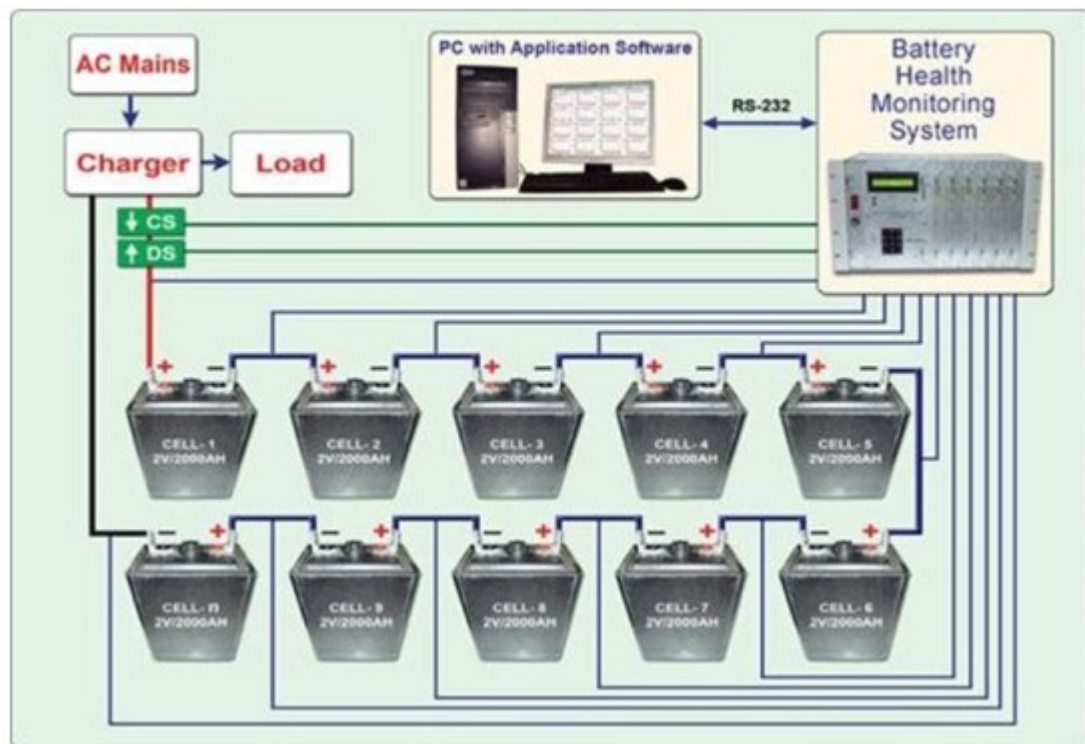
4.3 Technical Parameters

a. Monitoring cells	2V DC (nominal voltage).
b. Current measurement range	0-200A.
c. Batteries / any equipment temperature measurement range	0° to 75° Centigrade
d. Number of battery bank	Capable to monitor four battery banks.
e. Number of parameters that can be monitored	Minimum 50.
f. Inbuilt memory storage	Minimum last one-month data.
g. Data transfer	Windows based PC via application software.
h. Operating voltage	24V / 12V DC
i. Operating temperature range	-5° to 50° Centigrade
j. Humidity	95% at 50°C non-condensing
k. Altitude	1000 meter above MSL
l. Insulation level	Withstand 1kV rms for 1sec, except electronic cards
m. Parameter Setting	Over Voltage range, Under Voltage Range, Battery Type, Threshold for cell voltage imbalance in a bank etc.

4.4 Required Features

- Individual cell voltage (up to 2nd decimal) and average cell voltage
- Battery bank voltage and charge/discharge current
- Battery bank temperature and Ambient temperature (Accuracy $\pm 2^{\circ}\text{C}$)
- Information regarding weak cells
- Facility for remote monitoring
- Generates audio-visual alarm as soon as a cell is found weak or the battery goes below predefined under voltage value or a cell is open
- Facility for logged data extraction through the software as user friendly reports.
- Potential free contact for remote alarm / control.
- Option of both manual and auto scanning.

4.5 Tentative Scheme of Battery Cell Monitoring System



Volume II

Section 6: Employer's Requirements

CHAPTER 13: AIR CONDITIONING SYSTEM

Table of Contents

1.	General.....	2
2.	Scope.....	2
3.	Technical Specifications	3

CHAPTER 13

AIR CONDITIONING SYSTEM

1. General

- 1.1 This specification covers supply, installation, testing and commissioning and handing over to NEA of Air conditioning system for the control room and Staff Quarter buildings.
- 1.2 Air conditioning units for control room building shall be set to maintain the inside DBT at $24^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and the air conditioning system for switch-yard panel rooms shall be set to maintain DBT inside switch-yard panel rooms below 24°C .
- 1.3 Controllers shall be provided in Control room and Battery room for controlling and monitoring the AC units in these rooms as detailed in clause no 2.3.4.
- 1.4 Each switch-yard panel room shall be provided with temperature transducer to monitor the temperature of the panel room. The Temperature transducer shall have the following specification:
 - a. Sensor Air temperature sensor (indoor use)
 - b. Output 4 to 20mA
 - c. Temperature range -5°C to 60°C
 - d. Resolution 0.1°C
 - e. Accuracy 0.5°C or better.

2. Scope

- 2.1 Air Conditioning requirement of control room building shall be met using a combination of following types Air Conditioning units as required in Bill of Quantity.
- 2.2 The scope of the equipment to be furnished and services to be provided under the contract are outlined hereinafter and the same is to be read in conjunction with the provision contained in other sections/ clauses. The scope of the work under the contract shall be deemed to include all such items, which although are not specifically mentioned in the bid documents and/or in Tenderer's proposal, but are required to make the equipment/system complete for its safe, efficient, reliable and trouble free operation.
 - a. Required number of Ductable split type AC units of 3TR capacity with air cooled outdoor condensing unit with semi hermetic/hermetic compressors including refrigerant pipes, controls, thermostats, filters, outlet dampers, etc.
 - b. Required number of Cassette type split AC units of 2TR capacity each complete with air cooled outdoor condensing unit having hermetically sealed compressor unit with cordless remote controller.
 - c. Required number of High wall type split AC units of 1.5 TR capacities each complete with air cooled outdoor condensing unit having hermetically sealed compressor and high wall type indoor evaporator unit with cordless remote controller
 - d. Copper refrigerant piping complete with insulation between the indoor and outdoor units as required.
 - e. First charge of refrigerant and oil shall be supplied with the unit.
 - f. GSS/Aluminium sheet air distribution ducting for distributing conditioned dehumidified air along with supply air diffusers and return air grilles with volume control dampers and necessary splitters etc., suitable fixtures for grilles/diffusers and supports for ducting complete with insulation.

- g. Local start/stop facility for local starting/ stopping of all electrical equipment/ drives.
- h. All instruments and local control panels along with controls and interlock arrangements and accessories as required for safe and trouble free operation of the units.
- i. PVC drain piping from the indoor units up to the nearest drain point.
- j. Supply and erection of Power and control cable and earthing
- k. MS Brackets for outdoor condensing units, condensers as required.

3. Technical Specifications

3.1 Ductable Split Type AC Units

- 3.1.1 Each Split Air conditioner shall have an indoor unit and an outdoor unit, designed to provide free delivery of conditioned air to the conditioned space. The indoor unit shall be suitable for mounting on the ceiling concealed above the false ceiling. Outdoor unit can be placed on the roof. Each unit shall include a primary source of refrigeration for cooling and dehumidification, means for circulation and cleaning air.
- 3.1.2 **Cabinet**
The cabinets housing the components of indoor units & outdoor units shall be of heavy gauge sheet steel and suitable for floor mounting/mounting from ceiling. The access panels shall be of easily removable type. The entire casing shall be lined with 25mm thick insulation of totally flame proof type. Suitable drain connection shall be provided for removal of condensate collected inside a tray under cooling coil.
- 3.1.3 **Compressor**
The compressor shall be Semi hermetically/hermetically sealed type and complete with drive motor. The compressor shall be mounted on spring inside the lower most section of the unit so that it is easily accessible for servicing.
- 3.1.4 **Condenser**
Air cooled condenser of adequate surface area shall be offered. The air cooled condenser shall be made of copper tubes with external fins.
- 3.1.5 **Air Handling Fan**
The air handling fan shall be centrifugal type complete with belt drive and electric motor.
- 3.1.6 **Filter**
Pre-filter at the suctions to remove dust particles down to 10 micron size with 90% efficiency and fine filters to remove dust particles down to 5 micron size with 99% efficiency at the outlet. All filters shall be of panel type
- 3.1.7 **Cooling Coil**
Cooling coils shall be of direct expansion type and made of heavy gauge copper with aluminium fins. Rows shall be staggered in the direction of air flow. Separate tubings from the distributor shall feed refrigerant uniformly to different sections of the coil.
- 3.1.8 **Refrigerant Piping**
Refrigerant piping shall be of heavy gauge copper, heavy class seamless M.S. pipe complete with thermostatic expansion valve, liquid strainer, dehydrator, liquid line shut off valve, high and low pressure gauges.

3.1.9 Condensate Trays

An adequate method of condensate removal shall be provided. Condensate tray of adequate size, made of corrosion-resistant material or suitably treated with corrosion-resistant coating shall be provided. The tray shall be adequately insulated to avoid condensation over its external surface.

3.1.10 Refrigerant Strainer

A refrigerant strainer shall be provided in the liquid line immediately before the expansion device.

3.1.11 Vibration Isolator

A minimum of six 25 thick neoprene rubber pads shall be supplied for each unit.

3.1.12 Cooling capacity of each 3TR unit shall be not be less than 36000 BTU/hr.

3.2 Cassette Type Split AC unit

3.2.1 The Cassette type AC units shall be complete with indoor evaporator unit, outdoor condensing units and cordless remote control units.

3.2.2 Outdoor unit shall comprise of hermetically/ semi hermetically sealed compressors mounted on vibration isolators, fans and copper tube aluminium finned coils all assembled in a sheet metal casing. The casing and the total unit shall be properly treated and shall be weatherproof type. They shall be compact in size and shall have horizontal discharge of air.

3.2.3 Indoor units shall be of 4-way, ceiling mounted cassette type. The indoor unit shall be compact and shall have elegant appearance. They shall have low noise centrifugal blowers driven by suitable motors and copper tube aluminium finned cooling coils. Removable and washable polypropylene filters shall be provided. They shall be complete with multi-function cordless remote control unit with special features like programmable timer, sleep mode etc.

3.2.4 Cooling capacity of 3TR AC units shall not be less than 36000 BTU/hr and their EER shall not be less than 2.7.

3.3 High wall type split AC units

3.3.1 The split AC units shall be complete with indoor evaporator unit, outdoor condensing units and cordless remote control units.

3.3.2 Outdoor unit shall comprise of hermetically/semi hermetically sealed compressors mounted on vibration isolators, propeller type axial flow fans and copper tube aluminium finned coils all assembled in a sheet metal casing. The casing and the total unit shall be properly treated and shall be weatherproof type. They shall be compact in size and shall have horizontal discharge of air.

3.3.3 The indoor units shall be high wall type. The indoor unit shall be compact and shall have elegant appearance. They shall have low noise centrifugal blowers driven by suitable motors and copper tube aluminium finned cooling coils. Removable and washable polypropylene filters shall be provided. They shall be complete with multi-function cordless remote control unit with special features like programmable timer, sleep mode and soft dry mode etc.

3.3.4 Cooling capacity of 2TR AC units shall not be less than 22000btu/hr. and shall have energy efficiency rating of 3star or above.

3.3.5 Controllers shall be provided in Control room and Battery room, one controller for each room, to control and monitoring of AC units and shall have the following facilities;

- a. Standby units shall come in to operation automatically when the running main unit fails
- b. Main and standby units shall be changed over periodically which shall be finalized during detailed engineering.
- c. Following alarms shall be provided:
 - Compressor On/OFF condition of each unit
 - Compressor failure of each unit
 - Power OFF to AC unit
 - High temperature in room.

3.4 **Warranty**

All compressors shall have minimum 5 years Warranty from the date of commissioning.

3.5 For employer's remote monitoring purposes, necessary digital inputs shall be provided for 'ON' and 'OFF' condition of each compressor.

3.6 Measurement and payments of the item Air conditionings system shall be made as per BOQ.

Volume II

Section 6: Employer's Requirements

CHAPTER 14: POWER AND CONTROL CABLE

Table of Contents

1.	General.....	2
2.	Equipment to be furnished	2
3.	33 kV Power Cables, Straight Joints and Sealing Ends	2
4.	Low voltage Power, Control and Instrumentation Cable.....	7
5.	Tests for Power, Control, Instrumentation and Communication Cables	10
6.	Performance Guarantee.....	12

CHAPTER 14

POWER AND CONTROL CABLE

1. General

- 1.1 This specification covers the design, manufacture, factory test, supply, delivery, installation, field-testing and commissioning of all XLPE Power, Control, and Instrumentation cables required for the entire project.
- 1.2 Manufacturer of power, control, and instrumentation cables shall hold valid ISO 9001 quality certificate.
- 1.3 The equipment and installation works specified in this Section shall conform to the latest edition of the appropriate IEC specifications and/or other recognized international standards
- 1.4 The equipment to be furnished shall strictly be in accordance with the specifications and the Price Schedule.

2. Equipment to be furnished

- 2.1 The following cables shall be furnished in accordance with specification
 - a. 33 kV XLPE Power Cable, termination equipment and Sealing ends
 - b. 1.1 kV Power cable
 - c. Control and instrumentation cable
 - d. Other Miscellaneous materials
- 2.2 The Contractor shall be responsible for estimating and supplying the quantity of various types and sizes of the cables. In course of actual execution, if it is found that additional cross-sections, types or quantities of cables for the transformer are required other than those indicated in his proposal; the same shall be supplied without any additional charge to the employer.
- 2.3 All other materials necessary for proper operation of the Plant and not mentioned in these specifications shall be supplied under the Contract. The prices of such materials shall be deemed to be included in the prices of the miscellaneous materials without any additional cost to the Employer unless stated otherwise in the Price Schedule.

3. 33 kV Power Cables, Straight Joints and Sealing Ends

3.1 General

The following 33 kV power cables, straight through joints and sealing ends shall be supplied and installed according to approved Drawings and the requirements as hereafter specified. Non erasable Sequential Marking of length shall be provided by embossing on outer sheath of the cable for each meter length. The quality of insulation should be good and insulation should not be deteriorated when exposed to the climatic conditions.

3.2 Technical Requirement

3.2.1 33 kV Power cable

The 33 kV power cables and spare shall be supplied and installed from transformer LV side up to 33 kV Busbar.

The 33 kV power cable shall be of single-core, cross linked polyethylene (XLPE) insulated, screened and steel tape red, PVC sheathed, copper

conductor type and shall have a conductor size as per BOQ. Cable shall conform to BS 6622 & IEC 60502-2.

Operating temperature 90°C

Short circuit temperature 250°C

Conductor: Annealed Plain Copper Stranded compacted circular conductor conform to BS 6360 and IEC 60228, class 2

Conductor Screening: Semi-Conducting layer over conductor; IS: 7098 Part 2, IEC: 60502 Part – 2, BS: 6622, BS: 7835.

Insulation: Cross linked Polyethylene to (XLPE); IS: 7098 Part 2, IEC: 60502 Part – 2, BS: 6622, BS: 7835.

Insulation Screening: Semi-Conducting layer over insulation, in combination with Copper tape.

Bedding: Extruded PVC

Armour: Single Core - Galvanized steel round wire. Non magnetic

Outer Sheath: Extruded PVC / Special PVC compound such as Flame Retardant (FR), Flame Retardant Low Smoke (FRLS), and Low Smoke Zero Halogen (LSOH) or equivalent compatible with the system can be used for outer sheath to suit a variety of environment and fire risk conditions. Flammability test confirms to IEC 332. For installation where fire and associated problems such as emission of smoke and toxic fumes offer a serious potential threat, special LSF (Low smoke & fumes) compound can be provided. LSF compound is Halogen free (Fluorine, Chlorine, Bromine) when tested as per BS 6425 (Pt 1) & IEC 60754 (Pt 1). The acid gas evolved during combustion is less than 0.5% by weight of material.

The 33 kV power cables shall be rated as follows:

a. Rated voltage, phase to phase (U ₀)	33 kV
b. Highest voltage of three-phase system (U _m)	36 kV
c. Rated lightning impulse withstand voltage	170 kV
d. Rated power-frequency short duration withstand voltage for one minute	70 kV
e. Maximum short-circuit current	25/31.5 kA
f. Maximum time for short-circuit current	3 second

The 33 kV XLPE cables shall be installed in the flexible pipe conduits as per approved Drawing. Flexible pipes shall be provided by Contractor and shall be included in cost of cable. The necessary civil trench works / other works shall be carried accordingly.

At the opening of the civil structures where the power cables are passing through, suitable sealing means shall be provided by the Contractor to keep out rain from the outside.

The method of cable laying shall be designed by the Contractor to ensure higher security and reliability during and after the installation. The cable installation shall be carried out by the Contractor in accordance with the approved procedures.

3.2.2 Cable termination/Sealing ends

Outdoor type sealing ends with post insulator support shall be supplied and installed for termination of the 33 kV XLPE power cables. Straight through shall be provided as per requirement.

Each sealing end shall be complete with porcelain/Polymer insulator, leading conductor, condenser cone, stress relief cone, insulating compound, shielding cover, protective case, grounding terminal, lower metal with rigid flange and other necessary materials to properly seal the cable terminal.

Thermal expansion and contraction of the cable due to temperature change shall be considered for designing the joint insulation of the sealing end.

Cross bond earthing (or any other) shall be employed so that shielding of both sides of each joint shall be connected to the shielding of the other phase, so as to suppress the induced voltage. Necessary design and materials for such cross-bond earthing shall be provided by the Contractor.

The minimum creepage distance of outdoor sealing-ends shall be as required for heavily polluted atmospheres in line with the IEC 137 standard.

3.2.3 Accessories

The following accessories shall be provided with the 33 kV power cable for each end.

a. Name plates

b. Phase Identification

Phase identification for conductor cables shall be in accordance with the following:

Phase A (R)	Red
Phase B (Y)	Yellow
Phase C (B)	Blue

c. Voltage Identification

The plastic covering shall be embossed with the name of the manufacturer, number of conductors, the cross sections and type of insulation.

3.2.4 Cable Drum

Cable drum shall be non-returnable and shall be made of steel, suitably protected against corrosion for spare length. Drum Schedule shall be finalized after detail layout in substation.

3.3 Installation Works

3.3.1 Scope of Works

The installation of the transmission materials and substation equipment specified under this subsection shall cover from LV side of the transformer up to 33 kV Busbar and any other facility if any as per field requirement.

The scope of works is as below but not limited to:

a. **Installation of 33 kV underground cables for single circuit line (three conductors separately) with flexible pipes and civil structure as required including its termination**

The contractor shall lay cables in accordance with approved Drawing by using flexible pipes and necessary civil works.

Termination works for the cables shall be made with utmost care by the skilled workers. Extra loop of approximately 5 m length at cable termination and joint shall be made as far as the space is available. The contractor shall install the steel and/or concrete cable mark as approved by the Employer at 50 m intervals along the cable route.

The cables shall be terminated with sealing ends and post insulators. Each terminal shall be provided with phase identification marks of A-B-C (R-Y-B).

Arrangement of flexible pipes for cable installation is shown in Tender Drawing. Terminations of those pipes shall be properly made so that penetration of water inside the flexible pipes after completion of the works is not allowed.

Prior to pull-through of the cable into the flexible pipes, the Contractor shall calculate the pull-through length of the cable and confirm that the pull-through tension is not more than permissible tension. The shields of the 33 kV power cables shall be grounded in the approved manner at each joint.

b. Installation of outdoor type sealing ends for 33 kV cables with post insulators or as directed by employer

The 33 kV cable end shall be made as per IEC standard. Necessary additional steel structure with concrete foundation shall be constructed if required for the installation of bushings as well as Lightning arrestors (LA).

c. Inspection and test

Through the work execution, various inspections and tests on the progressing works will be ordered to the Contractor by the Employer.

Following inspections and tests will be carried out after completion of the works section by section. The Contractor shall perform all the inspections and tests in accordance with IEC Standard.

Underground Power Cables

- Visual inspection of the underground cable lines
 - Back filling and grade
 - Cable and joint marks
 - Cable termination and connection
- Measurement insulation resistance of the lines

3.4 Tests for Power Cables, Sealing ends and Accessories

3.4.1 Test at works

The following tests shall be carried out at the manufacturer's premises before shipment as far as applicable for type of conductors and cables:

a. 33 kV XLPE power cable

- Appearance check
- Conductor resistance measurement
- Capacitance measurement
- Insulation resistance measurement
- A.C. withstand voltage

- A.C. long duration withstand voltage
- Impulse withstand voltage
- A.C. long duration breakdown voltage
- Impulse break-down voltage
- Dielectric loss tangent
- Temperature-voltage characteristic
- Dimension
 - Conductor outermost diameter
 - Insulation thickness
 - Sheath thickness
 - Over-sheath thickness
 - Thickness of each tape
 - Interval of tape lapping
 - Total diameter
- Bending withstand characteristic
- Over-sheath
 - tensile strength
 - thermal aging
 - oil-proof
 - non-in flammability
 - thermal deformation
 - hardness
- b. **Sealing ends**
 - Construction
 - A.C. long duration withstand voltage
 - Impulse withstand voltage
 - A.C. long duration breakdown voltage
 - Impulse breakdown voltage
 - Porcelain or epoxy insulator
 - construction
 - power frequency flash-over voltage (dry)
 - power frequency flash-over voltage (wet)
 - 50% impulse flash-over voltage
 - cantilever strength
 - thermal mechanical performance
- c. **Other conductors**
 - Construction test
 - Resistance tests
 - Withstand voltage test
 - Insulation resistance test
 - High temperature insulation resistance test

- Tensile strength test
- Coiling test
- Thermal deformation test
- Oil proof test
- Non-inflammability test
- Shield conductivity test
- Thermal shrinkage test
- A.C. breakdown voltage test
- Impulse breakdown voltage test
- Tin plating test
- Acid and alkaline proof test
- Oxygen index measurement
- Chlorine gas measurement

3.4.2 Test on Completion:

After completely installing the 33 kV XLPE power cables, sealing ends and other conductors at site, the following tests shall be carried out by the Contractor.

- DC High voltage test

3.5 Payment

Payment for Construction and Installation of Contract item for "33 kV XLPE HT copper power cable" shall be made at the unit price per running meter of the cable as per bid. Therefore, in the Price schedules, such unit prices shall include full compensation for all costs incurred in furnishing, construction (Cutting of asphalt road, Construction of Cable trench, Man hole, laying of flexible pipe, placing of fine sand, laying of power cable, making the road same as it was before digging, placing of route marker) and installing all power cable. In case of the material that are quoted in LS basis in BOQ they are also converted into the run meter and payment is made.

4. Low voltage Power, Control and Instrumentation Cable

4.1 Low Voltage Power Cable

4.1.1 General

The low voltage cables shall be 1.1 kV grade polyethylene insulated and PVC sheathed. Low voltage AC power systems will be solidly grounded neutral with phase-to-phase voltage level of 400 V and phase to neutral voltage of 230 V AC system and the DC system with 110/48 V. The size of the single core conductor shall not be less than 2.5 sq. mm for lighting and 4 sq. mm for power. The main (incomer) cable to AC distribution panel shall be three & half (3.5) core.

Sizing of power cables shall be done by the contractor, keeping in view continuous current, voltage drop & short-circuit consideration of the system. Relevant calculations shall be submitted by Tenderer during detailed engineering for employer's approval.

While preparing cable schedules for control/protection purpose following shall be ensured:

- Separate cables shall be used for AC & DC.
- Separate cables shall be used for DC1 & DC2.

- For different cores of CT & CVT separate cable shall be used
- At least one (1) core shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.
- For control cabling, including CT/VT circuits, 2.5 sq. mm size copper cables shall be used per connection. However, if required from voltage drop/VA burden consideration additional cores shall be used. Further for potential circuits of energy meters separate connections by 2 cores of 2.5 sq. mm size shall be provided

4.1.2 Conductor

Conductor shall consist of stranded annealed copper wires made from high conductivity copper rods. They shall comply with IEC publication. The cable is intended for use at normal conductor operating temperatures not exceeding 75°C.

4.1.3 Insulation

The electrically and thermally stable polyethylene insulation shall be extruded onto the conductor so as to prevent contamination and voids in the insulation.

4.1.4 Current Rating

The Contractor shall state the maximum continuous current rating and conditions of installation for low voltage power cables.

4.1.5 Jacket

The cable core assembly shall be covered with a flame-retardative and moisture resistant PVC jacket, which is free stripping from the insulation. The overall jacket shall be clean, dry, and free of grease and shall be suitable for ink or paint application.

4.1.6 Anti-- Termite Covering

Anti-termite protection shall be applied to the cable and shall consist of either a non-magnetic metallic barrier or layer of nylon sheathing

4.1.7 Identification

Each cable shall have a printed legend on the overall jacket with the manufacturer's name, voltage class, the number and size of conductors, type of insulation

The colors for core identification and colour sequence shall be in accordance with follows

- Single-core	Black
- Double-core	Red and black
- Three-core	Red, yellow and blue
- Four-core	Red, yellow, blue and black

4.2 Control and Instrumentation Cable

4.2.1 General

All control and instrumentation cable shall be 1.1 kV grade as per IEC standard, multi conductor, color-coded, PVC insulated armored cable. Each multicore cable shall have not less than 20 percent or 2 spare cores, whichever is the greater.

4.2.2 Conductor

Conductor shall consist of stranded circular non-compacted annealed copper wires of a minimum 2.5 sq.mm. The Contractor shall calculate the load of CT core considering all connected loads and submit to the employer for approval. In case of CT burden constrain, CT circuit cable cross sectional area shall be increased. In this case the Contractor shall supply and install the cable required cross-section area without any additional cost to the Employer.

4.2.3 Insulation

The electrically and thermally stable PVC insulation shall be extruded onto the conductor so as to prevent contamination and voids in the insulation.

4.2.4 Assembly

Multi-core conductor cables shall be assembled in accordance with applicable IEC standards.

A flame-retardative binder tape may be used underneath the overall jacket of multi-conductor cables, if required, to achieve the desired flame retardative characteristics. Tapes, if used, shall be non-hygroscopic.

4.2.5 Jacket

The cable core assembly shall be covered with a flame-retardative and moisture resistant PVC jacket, which is free stripping from the insulation.

The overall jacket shall be clean, dry, and free of grease and shall be suitable for ink or paint application.

Cable jacketing and the interstices within the jacket shall be free of water. Evidence of water shall be the ground for rejection of the cable.

4.2.6 Anti-- Termite Covering

Anti-termite protection shall be applied to the cable and shall consist of either a non-magnetic metallic barrier or layer of nylon sheathing.

4.2.7 Identification

Each cable shall have a printed legend on the overall jacket with the manufacturer's name, voltage class, the number and size of conductors, and a unique number or code indicating the production run or batch. The identification shall remain legible for the life of the cable.

4.3 Communication Cable

4.3.1 All cables and wiring shall have copper conductors and PVC insulation and shall comply with IEC standards

4.3.2 Each communication cable shall have not less than 20 percent or 4 spare twisted pairs whichever is the greater. Cabling and wiring installations shall be arranged to minimize the risk of fire and damages, which might be caused in the event of fire.

4.3.3 For telephone type cables, 2 conductor wires of not less than 0.6 mm dia shall be used. Where twin or quad make up is required in any cable, the cores shall be uniformly twisted and the lays arranged such that cross talk is reduced to a minimum.

4.3.4 No conductor smaller than 32/0.2mm (1mm²), or having less than three strands, shall be used for interconnecting the cables except in the case of telephone extensions. All cables shall have insulation, which will withstand the highest temperature to be experienced in service.

- 4.3.5 Each conductor of a multicore cable shall be readily identified by a numbered marker tape or, in the case of telephone type cables, colour coded insulation.

4.4 Special Requirements

- 4.4.1 The Contractor shall be responsible for estimating and supplying the quantity of various types and sizes of the cables. In course of actual execution, if it is found that additional cross-sections, types or quantities of cables are required for the completion of the specified works the same shall be supplied without any additional charge to the employer.
- 4.4.2 Small cut piece lengths of cables will not be accepted. Cables up to 500 meters in length or as approved by Employer shall be of one length shipped in a drum of adequate size. For higher quantities, multiple lengths/drums may be shipped subject to the approval of Employer.

5. Tests for Power, Control, Instrumentation and Communication Cables

5.1 Routine and Design Tests

Power cable shall be subjected to following routine tests. As far as practical, the procedure of IEC shall be followed:

- a. Measurement of the electrical resistance of conductor
- b. Partial discharge test
- c. Voltage test

The power cable design tests shall include following:

- a. Partial discharge test
- b. Bending test, followed by a partial discharge test
- c. Tan delta measurement
- d. Heating cycle test, followed by a partial discharge test
- e. Impulse test, followed by voltage test
- f. Voltage test for 4 hours.

The Tenderer shall submit copy of design test report from recognized testing laboratory for the offered power cable along with the bid.

5.2 Field Tests

After installation at Site, cables shall be subjected but not limited to the following tests:

- a. Measurement of insulation resistance
- b. DC dielectric test

5.3 Type Tests

- 5.3.1 All cables shall conform to all type, routine and acceptance tests listed in the relevant IEC.

5.3.2 XLPE Insulated Power Cables (For working voltages up to and including 1.1 kV)

- a. Following type tests (on one size in a contract) as per IEC: 60502 (Part 1) including its amendments shall be carried out as a part of acceptance tests on XLPE insulated power cables for working voltages up to and including 1100 V:
 - Physical tests for insulation
 - Hot set test
 - Shrinkage test

- Physical tests for outer sheath
 - Shrinkage test
 - Hot deformation
 - Heat shock test
 - Thermal stability
- b. Contractor shall submit type test reports as per **clause no. 9.2** of Technical Specification, Chapter 2: GTR for the following tests-
 - Water absorption (gravimetric) test.
 - Ageing in air oven
 - Loss of mass in air oven
 - Short time current test on power cables of sizes 240 sq.mm and above on
 - Conductors.
 - Armours.
 - Test for armouring wires/strips.
 - Oxygen and Temperature Index test.
 - Flammability test.

5.3.3 PVC Insulated Power & Control Cables (For working voltages up to and including 1.1 kV)

- a. Following type tests (on one size in a contract) as per IEC: 60502 (Part 1) including its amendments shall be carried out as a part of acceptance tests on PVC insulated power & control cables for working voltages up to and including 1100 V:
 - Physical tests for insulation and outer sheath
 - Shrinkage test
 - Hot deformation
 - Heat shock test
 - Thermal stability
 - High voltage test.
- b. Contractor shall submit type test reports as **per clause no. 9.2** of Technical Specification, Chapter 2: GTR for the following-
 - High voltage test
 - Ageing in air oven
 - Loss of mass in air oven
 - Short time current test on power cables of sizes 240 sq. mm and above on
 - Conductors
 - Armors
 - Test for armoring wires/strips
 - Oxygen and Temperature Index test
 - Flammability test.

5.3.4 **XLPE INSULATED HV POWER CABLES (For working voltages from 3.3 kV and including 33 kV)-**

- a. Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Chapter 2: GTR for XLPE insulated HV power cables (as per IEC: 60502 Part-2).
- b. Terminating/jointing accessories as per IEC 60840:1999/ IEC62067

6. **Performance Guarantee**

- 6.1 The performance figures quoted on schedule of Technical Data shall be guaranteed within the tolerance permitted by relevant standards and shall become part of the Contract. In case of failure of the cables to meet the guarantees, the Employer reserves the right to reject the item. The Contractor shall have to rectify/ replace the defect/ defective part at no extra cost to the Employer and without delaying the commissioning schedule.

Volume II

Section 6: Employer's Requirements

CHAPTER 15: SWITCHYARD ERECTION

Table of Contents

1.	General.....	2
2.	String Insulator and Hardware	2
3.	ACSR Conductor	5
4.	Galvanized Steel Earth wire.....	8
5.	Aluminium Tubular Bus	10
6.	Earthing Conductors.....	12
7.	Bus Post Insulators	12
8.	Grounding System	15
9.	Bay Equipment	17
10.	Equipment Erection Details	17
11.	Junction Box	17
12.	Storage	18
13.	Cabling Material	18
14.	Directly Buried Cables	19
15.	Installation of Cables	20
16.	Junction Box	23
17.	Testing and Commissioning.....	24

CHAPTER 15

SWITCHYARD ERECTION

1. General

1.1 The detailed Scope of work includes design, engineering, manufacture, testing at works, supply at site basis, insurance, handling, storage erection, testing and commissioning of various items and works as details herein.

1.2 This Chapter covers the description of the following items:

1.2.1 Supply of

- a. String insulators and hardware
- b. AAC/ ACSR conductor
- c. Galvanized Steel Earth wire
- d. Aluminium Tubular Bus Bars
- e. Bus post insulators
- f. Earthing & earthing materials
- g. Lightning protection materials
- h. Cabling material
- i. Other items

1.2.2 Erection of all items

2. String Insulator and Hardware

2.1 General

The insulators for suspension and tension strings shall conform to IEC-60383 and Insulator hardware shall conform to equivalent international standard.

2.2 Construction Features

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.

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

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

2.3 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:

2.3.1 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 20% and 22% for 132 KV suspension and tension insulator strings respectively.
- d. **Mechanical strength test:** The complete insulator string along with its hardware fitting excluding arcing horn, corona control ring, grading ring, tension/suspension clamps shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to dismantle them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No failure should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

2.3.2 Type Tests on Insulators

Type test report for Thermal Mechanical Performance tests as per IEC 60575, Clause 3 shall be submitted for approval as per **clause 9.2 of Chapter 2 GTR.**

2.3.3 Acceptance Tests for Insulators:

- a. Verification of Dimensions as per IEC- 60383.
- b. Temperature cycle test as per IEC- 60383.
- c. Puncture Test as per IEC-60383
- d. Galvanizing Test as per IEC- 60383.
- e. Mechanical performance test as per IEC-60575 Cl. 4
- f. Test on locking device for ball and socket coupling as per IEC-60372(2).
- g. Porosity test as per IEC- 60383

2.3.4 Acceptance Test on Hardware Fitting

- a. Visual Examination as per relevant international standard.
- b. Verification of Dimensions as per relevant international standard.
- c. Galvanizing/Electroplating tests as per relevant international standard.
- d. Slip strength test as per relevant international standard.
- e. Shore hardness test for the Elastomer (if applicable as per the value guaranteed by the Contactor).
- f. Mechanical strength test for each component (including corona control rings and arcing horns).
- g. The load shall be so applied that the component is stressed in the same way as it would be in dual service and the procedure as given above should be followed.
- h. Test on locking devices for ball and socket coupling as per IEC -60372(2).

2.3.5 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

2.3.6 Routine Test on hardware Fittings

- a. Visual examination as per relevant IEC-61109

2.3.7 Test during manufacture on all Components as applicable on insulator

- a. Chemical analysis of zinc used for galvanizing:
- b. Samples taken from the zinc ingot shall be chemically analyzed. The purity of zinc shall not be less than 99.95%.
- c. Chemical Analysis, mechanical hardness tests and magnetic particle inspection for malleable casting:
- d. 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.

2.3.8 Test during manufacture on all components as applicable on hardware fittings:

- a. Chemical analysis of zinc used for galvanizing:
- b. Samples taken from the zinc ingot shall be chemically analyzed. The purity of zinc shall not be less than 99.95%
- c. Chemical analysis, hardness tests and magnetic particle for forgings:
- d. The chemical analysis, hardness tests and magnetic particle inspection for forgings will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding tests will be as discussed and mutually agreed to by the Contractor and Owner in Quality Assurance Programme.
- e. Chemical analysis and mechanical hardness tests and magnetic particle inspection for fabricated hardware:
- f. 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.

2.4 Parameters**2.4.1 Disc Insulators**

S. No.	Description	Data
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 (as required to meet total creepage distance)	Min. 430 mm
e.	Markings	Markings on porcelain applied before firing
f.	Power frequency puncture withstand voltage	1.3 times the wet flashover voltage

2.4.2 Insulator String

S. No.	Description	132 kV	33 kV
1.	Power frequency withstand voltage of the complete string with corona control ring (wet)– KV rms	275	75
2.	Lightning impulse withstand Voltage of string with corona control rings (dry) kVp	± 650	± 170
3.	Minimum total creepage distance of the insulator string (mm)	4650	900
4.	Total no. of discs per strings	11	3

3. ACSR Conductor

3.1 Details of ACSR Conductor

3.1.1 ACSR CARDINAL Conductor

The details of the **ACSR CARDINAL** conductors shall be as per the standard guaranteed technical particulars as tabulated below:

S. No.	Description	Unit	Data
1.	Conductor size	mm ²	547.33
2.	Conductor type	ACSR	Cardinal
3.	Number and size of wires		
	a. Aluminum		
	Strands	No	54
	Diameter	mm	3.38
	b. Steel		
	Strands	No	7
	Diameter	mm	3.38
4.	Cross section		
	a. Aluminum	mm ²	484.53
	b. Steel	mm ²	62.81
	c. Total	mm ²	547.33
5.	Conductor Diameter	mm	30.42
6.	Ultimate Strength	kN	149
7.	Modulus of Elasticity Final	KN/mm ²	73.2
8.	Coefficient of Linear Expansion	Per °C	19.85x10 ⁻⁶
9.	Standard mass of Conductor	Kg/km	1803
10.	Electrical DC resistance at 20°C	Ω/km	0.0595
11.	Standards		IEC 1089/BS 215 Part 2

3.1.2 ACSR Dog Conductor

The details of the **ACSR DOG** conductors for 33 kV line shall be as per the standard guaranteed technical particulars as tabulated below:

S. No.	Description	Unit	Data
1.	Conductor size	mm ²	100
2.	Conductor type	ACSR	Dog
3.	Number and size of wires		
	a. Aluminum		
	Strands	No	6
	Diameter	mm	4.72
	b. Steel		
	Strands	No	7
	Diameter	mm	1.57
4.	Cross section		
	a. Aluminum	mm ²	105.00
	b. Steel	mm ²	13.5
	c. Total	mm ²	118.5
5.	Conductor Diameter	mm	14.15
6.	Ultimate Strength	kN	32.41
7.	Modulus of Elasticity Final	kN/mm ²	75
8.	Coefficient of Linear Expansion	Per °C	19.8x10 ⁻⁶
9.	Standard mass of Conductor	Kg/km	394
10.	Electrical DC resistance at 20°C	Ω/km	0.279
11.	Standards		IEC 1089/BS 215 Part 2

3.2 Workmanship

The finished conductor shall be smooth, comp, uniform and free from all imperfections including kinks (protrusion of wires), wire cross over, over riding, looseness (wire being dislocated by finger/hand pressure and/or unusual bangle noise on tapping), material inclusions, white rust, powder formation or black spot (on account of region with trapped rain water etc.), dirt, grit etc.

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

The steel strands shall be hot dip galvanized 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.

The steel strands shall be pre-formed 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 galvanization during pre-forming and post-forming operation.

3.3 Joints in Wires

3.3.1 Aluminium Wires

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

3.3.2 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.

3.4 Tolerances

The manufacturing tolerances shall be as per relevant International standard.

3.5 Materials

3.5.1 Aluminum

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%.

3.5.2 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

3.5.3 Zinc

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

3.6 Standard Length

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

3.7 Tests

The following type (if required), acceptance & routine tests and tests during manufacturing shall be carried out on the conductor in presence of the Employer.

3.7.1 Type Tests

In accordance with the stipulation of specification, the following type tests reports of the conductor shall be submitted for approval.

- UTS test on stranded conductor
- Corona extinction voltage test (dry)
- Radio Interference voltage test (dry)
- DC resistance test on stranded conductor

3.7.2 Acceptance Tests

- a. Visual check for joints, scratches etc. and lengths of conductor
- b. Dimensional check on steel and aluminum strands
- c. Check for lay ratios of various layers
- d. Galvanizing test on steel strands
- e. Torsion and Elongation test on steel strands
- f. Breaking load test on steel and aluminum strands
- g. Wrap test on steel and aluminum strands
- h. DC resistance test on aluminum strands
- i. UTS test on welded joint of aluminum strands

3.7.3 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 (b) above to be carried out on each coil

3.7.4 Tests during Manufacturer

- a. Chemical analysis of zinc used for galvanizing
- b. Chemical analysis of aluminum used for making aluminum strands
- c. Chemical analysis of steel used for making steel strands

3.7.5 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

4. Galvanized Steel Earth wire**4.1 Details of Earth wire**

The contractor shall supply the earthwire as per the standard guaranteed technical particulars enclosed and separate approval is not required during detailed engineering.

Owner has also standardized the guaranteed technical particulars for the earthwire which are enclosed. The contractor shall supply the earthwire as per the standard guaranteed technical particulars.

The basic details of the earth wire are tabulated below:

S. No.	Description	Unit	Data
1.	Stranding and Wire Diameter	Mm	7/3.35 (steel)
2.	Strands		
	a. Steel core	No.	1
	b. Outer Layer	No.	6
3.	Total sectional area	Mm ²	61.7

4.2 Workmanship

All steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions and kinks after drawing and also after stranding.

The finished material shall have minimum brittleness as it will be subjected to appreciable vibration while in use.

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.

The steel strands shall be pre-formed and post-formed in order to prevent spreading of strands while cutting of composite earth wire. Care shall be taken to avoid damage to galvanization during preforming and post forming operation.

To avoid susceptibility towards wet storage stains (white rust), the finished material shall be provided with a protective coating of boiled linseed oil.

4.3 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.

4.4 Tolerances

The manufacturing tolerances shall be as per relevant International standard.

4.5 Materials

4.5.1 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	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

4.5.2 Zinc

The zinc used for galvanizing shall be electrolytic High Grade Zinc of 99.95% purity. It shall conform to and satisfy all the requirements of relevant international standard.

4.6 Standard Length

The earth wire shall be supplied in standard drum length of manufacturer.

4.7 Tests

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

4.7.1 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

4.7.2 Acceptance Tests

- a. Visual check for joints, scratches etc. and length of Earthwire
- b. Dimensional check
- c. Galvanizing 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

4.7.3 Routine Tests

- a. Check that there are no cuts, fins etc. on the strands.
- b. Check for correctness of stranding.

4.7.4 Tests During Manufacture

- a. Chemical analysis of zinc used for galvanizing
- b. Chemical analysis of steel

4.7.5 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.

5. Aluminium Tubular Bus**5.1 General**

The contractor shall supply the aluminum tubes as per the standard guaranteed technical particulars enclosed and separate approval is not required during detailed engineering.

Owner has also standardized the guaranteed technical particulars for the aluminium tube which are enclosed. The contractor shall supply the aluminium tube as per the standard guaranteed technical particulars.

5.2 Constructional Features

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

The aluminum tube shall be supplied in suitable cut length to minimize wastage.

The welding of aluminum tube shall be done by the qualified welders duly approved by the owner.

5.3 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.

5.4 Technical Parameters

S. No.	Description	3" AL. TUBE
1.	Size	3" IPS (EH Type)
2.	Outer diameter	100 mm for 132kV & 100 mm/75 mm for 33kV
3.	Thickness	7.62 mm min
4.	Cross-sectional area	1945.80 sq.mm min
5.	Weight	5.27 kg/m min

5.5 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 drawings enclosed with the Tender documents. After each two bay a bus bar expansion joint shall be provided.

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

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

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 600 mm length.

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.

To minimize 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.

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 Tender. Welding at site shall be done by adopting a qualified procedure and employing qualified welders as per ASME-Section IX.

6. Earthing Conductors

6.1 General

All conductors buried in earth and concrete shall be of mild steel. All conductors above ground level and earthing leads shall be of galvanized steel, except for cable trench earthing.

6.2 Constructional Features (Galvanized Steel)

The minimum weight of the zinc coating shall be 618 gm/sq. m. and minimum thickness shall be 85 microns.

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

6.3 Tests

In accordance with stipulations of the specifications galvanized steel shall be subjected to four one-minute dips in copper Sulphate solution as per relevant international standard.

7. Bus Post Insulators

7.1 General

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

7.2 Constructional Features

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.

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.

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

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.

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

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.

All ferrous parts shall be hot dip galvanized. The zinc used for galvanizing 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.

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. 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.

All bolts and nuts shall be of steel with well-formed hexagonal heads forged from the solid and shall be hot dip galvanized. 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.

Contactors 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.

7.3 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.

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

- Ultrasonic test as an acceptance test
- Soundness test, metallurgical tests and magnetic test on MCI caps and pedestal tests as acceptance test.
- All hot dip galvanized components shall be subject to check for uniformity of thickness and weight of zinc coating on sample basis.
- 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.
- Acceptance norms for visual defects allowed at site and also at works shall be agreed in the Quality plan.

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.**

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

7.4 Technical Parameters of Bus Post Insulators

- Bus Post Insulators for 132 kV System

S. No.	Description	132 kV
a.	Type	Solid Core
b.	Voltage Class (kV)	145
c.	Dry and wet one minute power frequency withstand voltage(kV rms)	275

d.	Dry lightning impulse withstand Voltage (kVp)	± 650
e.	Wet switching surge withstand voltage (kVp)	—
f.	Max. Radio interference voltage (in microvolts) at voltage of 508 kV (rms), 305 kV (rms) and 156 (rms) for 765 kV, 400 kV & 220 kV respectively between phase to ground.	500
g.	Corona extinction voltage (kV rms) (min.)	105
h.	Cantilever Strength	
	Total minimum cantilever strength (Kg)	600
	Total minimum breaking strength (Kg)	720
i.	Minimum torsional moment	As per IEC-273
j.	Total height of insulator (mm)	
k.	P.C.D	
	Top (mm)	127
	Bottom (mm)	254
l.	No. of bolts	
	Top	4
	Bottom	8
m.	Diameter of bolt/holes (mm)	
	Top	M16
	Bottom dia	18
n.	Pollution level as per IEC-815	Heavy (III)
o.	Minimum total creepage distance for Heavy Pollution (mm)	3165

b. Bus Post Insulators for 33 kV System

S. No.	Description	33 kV
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)	
h.	Pollution level as per IEC-815	Heavy (III)
i.	Minimum total creepage distance for Heavy Pollution (mm)	900

7.5 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. 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 Chapter.

8.2 Grounding Installation Features

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.

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

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

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.

The maximum size of each grid of grounding mat shall not exceed 4x4 meters. The terminals for connecting ground mat and equipment shall be terminated whenever necessary.

8.3 Grounding Conductor

8.3.1 Main Ground Grid

The main ground system shall consist of a grounding grid buried minimum 0.6 meter below grade level. The grounding grid shall consist of copper flat conductor cable or stranded copper wire of minimum size (cross sectional area) 120 sq. mm.

8.3.2 Ground Electrodes

The ground electrodes shall be 25 mm diameter and 3.250 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 50x10 mm MS flat size connected at one end to the main ground mat and at the other end to the equipment.

8.4 Design Requirements

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.

The Contractor shall calculate the cross-section considering the maximum fault level of 31.5 kA.

The Contractor shall submit the details of calculations of the grounding system for the Employer's approval. The earthing system shall be of single earthing system for the whole substation i.e. all earthings shall be connected to main earthing grid

8.5 Tests

On completion of the installation, either wholly or in sections, it shall be tested in compliance with relevant Code by the Contractor in presence of the Employer. The cost of any test including labor, material and equipment charges shall be borne by the Contractor. If the ground grid resistance cannot be obtained as per his design, then additional grounding conductors shall be buried in the earth, or if necessary, buried in treated soil to obtain the required low ground resistance without any additional cost.

8.6 Lightning Protection

The outdoor equipment of the substation and the substation building shall be protected against lightning. The lightning protection shall be achieved by an overhead lightning shield system of galvanized steel wire of 7/3.35 mm, which shall be connected to the main grounding grid by steel conductor of 7/3.35 mm. Lightning mast with electrode length of 2.5mtr (maximum) may be used in switchyard 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

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	Required
1. Main ground grid conductor material		Copper
2. Main ground grid conductor size	Sq.mm	≥ 120
3. Cross section of riser conductors	Sq mm	≥ 120
4. Ground electrodes		
-Material		Copper clad steel
-Diameter	mm	≥16
-Length	meter	3
5. Material of risers		Copper
6. Earthing system designed for	ohm	≤ 1

9. Bay Equipment

- 9.1 The disposition of various bay equipment shall be as per single line diagrams and layout drawings.
- 9.2 **Bay Marshalling Kiosk:** One no. of bay marshalling kiosk shall be provided for each 132 kV bay under present scope. In addition to the requirements specified elsewhere in the specification, the bay marshalling kiosk shall have two distinct compartments for the following purpose: -
 - a. 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.
 - b. To distribute minimum ten outgoing 230V, 10 Amps single phase supplies to be controlled by MCB to be drawn from above 3 phase incomers.
 - c. 200 nos. terminal blocks in vertical formation for interlocking facilities for substations without automation system.
 - d. Necessary Terminal Blocks for terminating cables from ACDB and switchyard panel rooms.

10. Equipment Erection Details

- 10.1 For equipment interconnection, the surfaces of equipment terminal pads, Aluminium tube, conductor & terminal clamps and connectors shall be properly cleaned. After cleaning, 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.
- 10.2 Muslin or leather cloth shall be used for cleaning the inside and outside of hollow insulators.
- 10.3 All support insulators, circuit breaker interrupters and other fragile equipment shall preferably be handled with cranes having suitable booms and handling capacity.
- 10.4 Bending of Aluminum tube and compressed air piping if any should be done by a bending machine and through cold bending only. Bending shall be such that inner diameter of pipe is not reduced.
- 10.5 Cutting of the pipes wherever required shall be such as to avoid flaring of the ends. Hence only a proper pipe cutting tool shall be used. Hack saw shall not be used.
- 10.6 Handling of equipment shall be done strictly as per manufacturer's/supplier's instructions/instruction manual.
- 10.7 Handling equipment, sling ropes etc. should be tested periodically before erection for strength.
- 10.8 The slings shall be of sufficient length to avoid any damage to insulator due to excessive swing, scratching by sling ropes etc.

11. Junction Box

- 11.1 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.
- 11.2 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.

- 11.3 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.

12. Storage

- 12.1 The Contractor shall provide and construct adequate storage shed for proper storage of equipment, where sensitive equipment shall be stored indoors. All equipment 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. Cabling Material

13.1 Cable Tags And Markers

Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.

The tag shall be of aluminium with the number punched on it and securely attached to the cable conduit by not less than two turns of 20 SWG GI wire. Cable tags shall be of rectangular shape for power cables and of circular shape for control cables.

Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanized iron plate.

Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable joints".

The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road and drain crossings.

Cable tags shall be provided on all cables at each end (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 centers, control and relay panels etc., wherever required for cable identification, where a number of cables enter together through a gland plate.

13.2 Cable Supports and Cable Tray Mounting Arrangements

The Contractor shall provide embedded steel inserts on concrete floors/walls to secure supports by welding to these inserts or available building steel structures.

The supports shall be fabricated from standard structural steel members.

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.

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

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.

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.

Supply of all consumable material shall be in the scope of Contractor.

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.

Control cable cores entering control panel/switchgear/MCCB/MCC/ miscellaneous panels shall be neatly bunched, clamped and tied with nylon strap or PVC perforated strap to keep them in position.

The Contractor shall tag/ferrule control cable cores at all terminations, as instructed by the 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.

Spare cores shall be similarly tagged with cable numbers and coiled up.

All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively closed.

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.

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.

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.

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.

Crimping tool used shall be of approved design and make.

Cable lugs shall be tinned copper solderless crimping type conforming to relevant international standard. Bimetallic lugs shall be used depending upon type of cables used.

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

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. 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 Contractor shall ascertain the soil conditions prevailing at site, before submitting the Tender.

- 14.2 The cable (power and control) between LT station, control room and fire lighting pump house shall be laid in the buried cable trenches. In addition to the above, for lighting purpose also, buried cable trench can be used in outdoor area.
- 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. Installation of Cables

- 15.1 Cabling in the control room shall be done on ladder type cable trays for vertical runs while cabling in switchyard area shall be done on angles in the trench.
- 15.2 All cables from bay cable trench to equipment's including and all interpole cables (both power and control) for all equipment, shall be laid in PVC pipes of minimum 50 mm nominal outside diameter which shall be buried in the ground at a depth of 250mm below finish formation level. Separate PVC pipes shall be laid for control and power cables. Cable pull boxes of adequate size shall be provided if required.
- 15.3 Cables shall be generally located adjoining the electrical equipment through the pipe insert embedded in the floor. In the case of equipment 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.
- Power cables on top tiers.
 - 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 de-interlocking 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:

<u>Cable</u>	<u>Minimum Bending Radius</u>
Power cable	12 D
Control cable	10 D
D is overall diameter of cable	

- 15.11 Where cables cross roads, drains and rail tracks, these shall be laid in reinforced spun concrete or steel pipes buried at not less than one metre depth.
- 15.12 In each cable run some extra length shall be kept at a suitable point to enable one (for LT cables)/two (for H.T. cables) straight through joints to be made in case the cable develop fault at a later date.
- 15.13 Selection of cable drums for each run shall be so planned as to avoid using straight through joints. Cable splices will not be permitted except where called for by the drawings, unavoidable or where permitted by the Owner. If straight through joints are unavoidable, the Contractor shall use the straight through joints kit of reputed make.
- 15.14 Control cable terminations inside equipment enclosures shall have sufficient lengths so that changing of termination in terminal blocks can be done without requiring any splicing.
- 15.15 Metal screen and armour of the cable shall be bonded to the earthing system of the station, wherever required by the Owner.
- 15.16 Rollers shall be used at intervals of about two meters 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**
 - a. The cable trays shall be of G.S. sheet and minimum thickness of sheet shall be 2mm.
 - b. 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

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.

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.

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.

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.

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.

Each conduit run shall be painted with its designation as indicated on the drawings such that it can be identified at each end.

Embedded conduits shall have a minimum concrete cover of 50 mm. Conduit run sleeves shall be provided with the bushings at each end.

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.

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.

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

For underground runs, Contractor shall excavate and back fill as necessary.

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 galvanized 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.

All unarmored cables shall run within the conduits from lighting panels to lighting fixtures, receptacles etc.

Size of conduit for lighting shall be selected by the Contractor during detailed engineering.

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. Conduit supports shall be provided at an interval of 750mm for horizontal runs and 1000mm for vertical runs.

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.

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.

Spacing of embedded conduits shall be such as to permit flow of concrete between them. Where conduits are placed along with cable trays, they shall be clamped to supporting steel at an interval of 600mm.

For directly embedding in soil, the conduits shall be coated with an asphalt-base compound. Concrete pier or anchor shall be provided wherever necessary to support the conduit rigidly and to hold it in place.

Conduit shall be installed in such a way as to ensure against trouble from trapped condensation.

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.

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.

For long conduit run, pull boxes shall be provided at suitable intervals to facilitate wiring. Conduit shall be securely fastened to junction boxes or cabinets, each with a lock nut inside and outside the box.

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.

Field bends shall have a minimum radius of four (4) times the conduit diameter. All bends shall be free of kinks, indentations or flattened surfaces. Heat shall not be applied in making any conduit bend. Separate bends may be used for this purpose.

The entire metallic conduit system, whether embedded or exposed, shall be electrically continuous and thoroughly grounded. Where slip joints are used, suitable bonding shall be provided around the joint to ensure a continuous ground circuit.

After installation, the conduits shall be thoroughly cleaned by compressed air before pulling in the wire.

Lighting fixtures shall not be suspended directly from the junction box in the main conduit run.

16. Junction Box

- 16.1 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.
- 16.2 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.

- 16.3 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. 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 specialties of the items as per the field Q.P./instructions of the equipment Contractor or Owner without any extra cost to the Owner. The Contractor shall arrange all equipment instruments and auxiliaries required for testing and commissioning of equipment along with 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 galvanized 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 galvanized surfaces.
- e. Dip test on earth conductor prior to use.

17.4 AAC/ ACSR Stringing Work, Tubular Bus Work And Power Connectors

- a. Physical check for finish
- b. Electrical clearance check
- c. Testing of torque by torque wrenches on all bus bar power connectors and other accessories.
- d. Millivolt drop test on all power connectors.
- e. Sag and tension check on conductors.

17.5 Aluminium Tube Welding

- a. Physical check
- b. Millivolt drop test on all joints.
- c. Dye penetration test & Radiography test on 10% sample basis on weld joints.
- d. 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 equipment" by the contractor. This document shall be provided to the successful contractor during detailed engineering stage.

Volume II

Section 6: Employer's Requirements

CHAPTER 16: MISCELLANEOUS MATERIAL

Table of Contents

1.	General.....	2
2.	Technical Requirements.....	2
3.	Tests	6
4.	Packaging and Marking	8
5.	Guarantee	8

CHAPTER 16

MISCELLANEOUS MATERIAL

1. General

- 1.1 This specification covers the design, fabrication, properly packing for transportation, delivery, installation, testing and putting into efficient and trouble-free operation of the bus materials, insulators and miscellaneous items complete with all accessories.

2. Technical Requirements

2.1 Insulators

2.1.1 General

All types of insulators shall satisfactorily withstand the specified climatic and service conditions. The strength of insulators as given by the electro-mechanical tests shall be such that the factor of safety when supporting their maximum working loads shall be not less than two and a half.

Design shall be such that stresses due to expansion and contraction in any part of the insulators and fittings do not lead to development of defects.

All insulators, whether cylindrical post or string shall have plain shed profiles.

Damaged insulators shall be replaced at no costs to the Employer.

2.1.2 Materials

Porcelain insulators shall be in accordance with IEC standards, where applicable. Porcelain shall be sound, free from defects and thoroughly vitrified and the glazed.

Porcelain glaze shall be smooth, hard, of uniform shade of brown and shall completely cover all exposed parts of the insulators. Outdoor insulator fittings shall remain unaffected by atmospheric conditions producing weathering, acids, alkalis, dust and rapid changes in temperature that may be experienced under working conditions.

Suspension and tension insulators shall comprise porcelain units with ball and socket fittings.

Retaining pins or locking devices for insulating units shall be of phosphor bronze or other approved material, and shall effectively prevent accidental separation of the units.

Unless otherwise approved, the individual units of both the suspension and tension insulator sets shall be identical and interchangeable.

2.1.3 Number of discs

-	132 kV	11 Nos (minimum)	per set
-	33 kV	3 Nos (minimum)	per set

2.1.4 Marking

Each insulator shall have marked on it the manufacturer's name or trademark, the year of manufacture and the manufacturer's reference mark. Tension and suspension insulators shall also be marked with the guaranteed electromechanical strength. Marks shall be legible and indelible.

2.1.5 Post insulator

Post insulator shall be cylindrical type, solid core porcelain, single stacked, provided in accordance with following requirements.

Particulars	Type A	Type B
Rated voltage	145 kV	36 kV
Nominal voltage	132 kV	33 kV
Impulse withstand voltage	650 kV	170 kV
Color	Brown	Brown

Test shall be divided into three groups in accordance with IEC 148.

2.1.6 Standard particulars of insulator units

Insulator units shall comply with the following requirements. (IEC 305)

a. Porcelain disc diameter	254 mm
b. Unit spacing	146 mm
c. Creepage distance	292 mm
d. Electro mechanical failing load	12,000 kg
e. Dry power frequency withstand voltage	70 kV
f. Wet power frequency withstand voltage	40 kV
g. Dry impulse withstand voltage	120 kV
h. Puncture voltage	120 kV

Dimension and tolerances of ball and socket coupling shall comply with IEC Publications 120, and the internal height of the socket shall also comply with the requirements of IEC Publication 372-1 (1977).

2.2 Bus Conductor and Fittings**2.2.1 General**

The bus-bar system to be adopted shall be single bus-bar type for both for 132 kV and 33 kV System.

The post insulator in the price schedules is intended to support the conductor from bus bar to Disconnecting Switches. The contractor has to install the required number of Bus Post Insulator as per the approved drawings.

Bus-bars and electrical connections in outdoor substations shall be in accordance with IEC, BS, ASTM or equivalent national standards in respect of current rating and material analysis.

Bus conductor to be supplied shall be aluminum tube. For connection purpose aluminum conductor steel reinforced may be used, if required. Minimum size and material of each bus shall be as following:

Bus	Material	Min. Size	Thickness
132 kV Main & 33 kV Main	Al-Tube	100 mm	10 mm (Min)
132 kV Branch	Al-Tube	75 mm	7 mm (Min)
33kV Branch	Al-Tube	25 mm	5mm (Min)

The 132 kV bus-bars shall be designed for the following conditions:

<u>Current Carrying Capacity (refer provided)</u>	<u>Fault Level</u>
Main bus-bar	2500 A, 31.5 kA
Branch bus-bar	800A, 31.5kA

The 33 kV bus-bars shall be designed for the following conditions

<u>Current Carrying Capacity (refer provided)</u>	<u>Fault Level</u>
Main bus-bar	2500 A, 25 kA
Branch bus-bar	800A, 25 kA

The Contractor shall submit detailed calculation for approval.

Materials used for bus-bars and connections shall be stressed not to more than two-fifths of their elastic limit. Provision shall be made for expansion and contraction with variation in conductor temperature and bus-bars shall be arranged so that they may be readily extended in length with a minimum of disturbance to existing equipment.

Bus-bars shall be in continuous lengths between supports. Connectors shall be of approved type, and if necessary type tested. Connections dependent upon site welding techniques will not be permitted.

Bus-bars and connections shall be so arranged and supported that under no circumstances, including short circuit conditions, the clearances between live metal and earth, or between other conductors, cross the safe limit.

2.2.2 Strain Bus and Fittings

The conductor shall be aluminum conductor; steel reinforced (ACSR)"CARDINAL" (Overall cross sectional area of 547.3 sq. mm.)

The conductor shall be constructed of hard-drawn aluminum and zinc-coated steel wires which have the mechanical and electrical properties in accordance with the latest revisions of ASTM or equivalent.

The direction of lay of the outer layer shall be right-hand. The direction of lay shall be reversed in successive layers; continuous layer shall in all cases have opposite lay.

The external form and surface of the finished conductor shall be uniformly cylindrical upon completion of manufacture and shall remain so when erected in place on the line.

The surface of the conductor shall be free from points, sharp edges, abrasions or other departures from smoothness or uniformity that would tend to increase radio interference and corona loss. When the conductor is subjected to tensions up to 50 percent of its rated ultimate strength, the conductor surface shall not depart from its general cylindrical form, nor shall any of the strands move relative to each other in such a way as to get squeezed out of place and disturb the longitudinal smoothness of the conductor. Strands of a section of "popped" cable shall not protrude more than 1/2 of their diameter of a strand. The conductor shall be capable of withstanding the normal handling necessary for manufacture and erection, such as, reeling, unreeling, and pulling through stringing sheaves under sufficient tension to keep the conductor off the ground, etc., without being deformed from the cylindrical form that causes to increase radio interference and corona loss.

The make-up and lay of wires shall be such as to produce a conductor essentially free from a tendency to untwist or spring when cut. The steel wires shall be pre-formed or post-formed so that when the conductor is cut and the aluminum wires are stripped away from the core as required for splicing, the steel wires can be readily regrouped and easily held in place with one hand to allow a splicing sleeve to be slipped over the steel core wire at the cut end of the conductor.

This forming of the core is required and shall be done in a manner which will not in any way scratch, scrape, remove or otherwise damage the zinc coating of the steel core wires, individually or collectively.

The conductor shall be free from excessive amounts of die grease, metal particles and dirt. The Bidder shall describe in complete detail the method, which he proposes to use to clean the conductor in normal production. The effectiveness of the cleaning process shall be subject to verification.

Where dissimilar metals are in contact, approved means shall be provided to prevent electro-chemical action and corrosion. Unless otherwise approved, joints and surfaces of copper or copper alloy fittings shall be tinned.

Suspension and tension conductor clamps shall be of approved types and shall be as light as possible. Those for aluminum conductor shall preferably be compression type. Suspension and tension clamps shall be designed to avoid any possibility of deforming the stranded conductor and separating the individual strands.

Tension conductor clamps shall not permit slipping of or damage to, or failure of the complete conductor or any part thereof, at a load less than 95 per cent of the ultimate strength of the conductor.

Clamps and fittings made of steel or malleable iron shall be galvanized. All bolts and nuts shall be as specified and shall be locked in an approved manner.

2.2.3 Tubular Bus and Fittings

Tubular bus shall be made of first melting aluminum alloy, cold rolled or hard-drawn and assembled using corona free fittings. The bus-bar shall be designed and manufactured in such a way to dampen any vibration.

The tubular bus conductor shall be designed to withstand mechanical forces due to short circuit currents; and its temperature when carrying full load current shall not exceed 75°C. A safety factor of 2 for normal working loads and 1.5 with short circuit currents shall be used. Vibration of bus shall be checked for the design wind conditions.

The tubular bus shall include a small drain hole in any low section. Where joints are required they shall be of the thin leaf type. They are required at all potheads and as required on bus bars. Bus supports for main tubular buses shall include rigid fixed conductor clamp with slide fit on adjacent supports.

All bus support clamps shall be cast of first melting aluminum alloy. Each clamp shall be adjustable for alignment with insulator and furnished with four galvanized steel mounting bolts.

- Bolted type clamps shall be furnished with first melting alloy and, bolts, nuts and washers shall be finished with an anodic coating and lubricated. The clamps for tubing shall have dimensions and sections suitable for splicing two pieces of tubing in the clamp.
- Flexible elements of expansion bus support clamps shall be laminated aluminum strap, which has current capacity equivalent to the tube.

Terminal connectors for aluminum shall be of first melting cast aluminum alloy. All terminal pads shall be furnished with stainless steel bolts, nuts and Bellville washers.

The bolted type terminal connectors shall be a multigrip type terminal and furnished with first melting aluminum alloy with bolts, nuts and washers finished with anionic coating and lubricated.

Bolted type connectors shall be furnished with first melting aluminum alloy with bolts, nuts and washers finished with anionic coating and lubricated.

Angle connectors: All angle connectors shall be of streamlined, bolted type and made of first melting cast aluminum alloy. Tap element sockets shall be deep enough to allow for error in cut-off.

- Couplers: All couplers shall be of bolted type and made of first melting cast aluminum alloy.
- Corona Bells: All corona bells shall be streamline internal type and cast of first melting aluminum alloy.

The Contractor shall submit calculations regarding selection of the size of the bus material for approval.

2.2.4 Overhead ground wire

Overhead shield wire shall be galvanized steel wire, stranded with a minimum cross sectional area of 61.7 sq mm and shall comply with BS 183.

Earth wires shall be greased as for conductors and the outer strands shall have a right hand lay.

Each completed shield wire shall be bare and shall be composed of the specified number of strands.

The nominal diameter of individual wires shall have a variation of not more than plus or minus one and one-half (1.5) percent.

Joints or splices may be made in the individual wires prior to drawings to final size or in the finished wire composing the strand. Such joints shall have protection to corrosion equivalent to that of the finished wire itself and shall not decrease the strength of the finished strand below the specified minimum breaking strength. Joints in the individual wires in the finished strand shall be separated by at least 15.2 meters.

All strands in the wire shall lay naturally in their true position in the completed cable, shall tend to remain in position when the cable is cut at any point, and shall permit restraining by hand after being forcibly raveled at the end of the cable. The strand shall be free from imperfections and consistent with good commercial practice with a carefully controlled finish completely free from any dirt, loose metal particles, nicks, scratches, abrasions or deformities of any nature.

Each item of material to be furnished by the Contractor shall be accompanied by the manufacturer's routine factory test certificates/reports.

3. Tests

3.1 Insulators

The insulators shall be tested in accordance with IEC standards. Certified copies of the tests shall be submitted for approval to the Employer.

- a. Design tests
 - Power frequency wet withstand voltage test

- Critical - impulse flashover test
 - Impulse withstand test
 - Radio-interference voltage test
 - Compression strength test
 - Thermal shock test
- b. Quality conformance tests
- Visual and dimensional test
 - Porosity test
 - Galvanizing test
 - Cantilever strength test
 - Torsional strength test
 - Tensile strength test
- c. Routine tests
- Flashover test
 - Tension test

3.2 Bus Materials

Following shop tests shall be performed by the manufacturer on the bus material. The Contractor shall submit such test reports to the Employer for approval before dispatch.

- a. Aluminum Tube
- General inspection
 - Chemical composition of aluminum alloy
 - Conductivity measurement of aluminum tube
 - Dimension and weight measurement
 - Certified report of aluminum alloy from the original manufacturer
- b. Bus Support Clamp and Connector
- General inspection
 - Dimension measurement
 - Chemical composition of aluminum alloy
 - Certified report of aluminum alloy from the original manufacturer
- c. Connectors for Stranded Conductor
- General inspection
 - Measurement of dimensions
 - Compression tests
 - Certified report of aluminum alloy from the original manufacturer
- d. Miscellaneous Hardware
- General inspection
 - Measurement of dimensions
 - Tension test
 - Galvanizing test

4. Packaging and Marking

4.1 Insulator

4.1.1 Packaging

The insulators shall be packed in strong wooden boxes with a waterproof lining. These boxes shall provide adequate protection against salt spray, chemical attack and damage that might be encountered in transportation and rough handling during loading, transportation to job site, unloading to temporary storage, ocean transportation, etc.

4.1.2 Marking

In addition to marks required for shipping purposes, each crate and pallet shall be marked with shipper's identity, Employer's name and address and quantity and type of contents etc. Also, the gross, tare and net weights in kilograms shall be stenciled on each pallet.

4.2 Bus Materials

4.2.1 Packing

The conductor shall be furnished on non-returnable wooden reels, and shall be properly protected to prevent displacement, chafing, distortion, damage from corrosive atmosphere or other damage to the conductor, which might be encountered in shipping, storage for handling, etc. Each layer of conductor shall be separated from the adjacent layer in such a manner as to prevent abrasion or other damage during handling and shipping.

The non-returnable reels shall be made of strong materials suitably strengthened for ocean transport and treated to withstand rotting or any type of damages due to ocean atmosphere. The reels shall be capable of withstanding all stresses due to braking and string operations. The Employer will accept the use of returnable reels, but any additional costs in disposing such reels shall be the responsibility of the Contractor.

4.2.2 Marking

In addition to marks required for shipping purposes, each reel-head shall be stenciled to show serial number, type of conductor, length of conductor in meters, the gross, tare, and net weights in kilograms. Each reel shall also be plainly marked to indicate the direction in which it should be rolled to prevent loosening of the conductor on the reel. Those reels from which test samples were taken shall be marked "TESTED" with length of sample conductor removed and removal included in the markings.

5. Guarantee

5.1 Any defects in materials or workmanship or other failure to meet requirements of these specifications, which are disclosed prior to the Operational Acceptance Certificate by the Employer, be corrected entirely (including removal and replacement) at the expense of the Contractor.

5.2 Any latent defects not disclosed before date of the Operational Acceptance Certificate but disclosed within Defects Liability Period shall be corrected promptly by and at the expense of the Contractor.

Volume II

Section 6: Employer's Requirements

CHAPTER 17: LIGHTING SYSTEM

Table of Contents

1.	General.....	2
2.	System Description.....	2
3.	Description of Items	4
4.	Lighting System Installation Works.....	12
	ANNEXURE-1	14

CHAPTER 17

LIGHTING SYSTEM

1. General

- 1.1 The scope of work comprises of design, engineering, testing, supply, installation, testing and commissioning of various lighting fixtures complete with lamps, supports and accessories, ceiling fans complete with electronic regulators, exhaust fans for toilets and pantry & accessories, lighting panels, lighting poles complete with distribution boxes, galvanized rigid steel /rigid PVC conduits, lighting wires, G.I. Earth wire, receptacles, tag block & telephone sockets, switchboards, switches, junction boxes, pull out boxes complete with accessories, for control, staff quarter, guard cum store buildings, Switchyard and street lighting. The lighting fixtures, Fans supplied and installed under this contract shall be power efficient (low power consumption). For DC lights at control room building shall also be provided.
- 1.2 The entire control, Staff quarter and Guard cum store buildings, switchyard and street lighting shall be done by LED based low power consumption luminaries to achieve desired lux level specified. **The bidder shall quote their prices for lighting system on respective buildings; therefore, bidders are instructed to include all the costs to complete the lighting job either in respective building or in BOQ items, no separate payments shall be made.**

2. System Description

- 2.1 The Lighting System shall comprise of the following:
- 2.1.1 **AC Normal Lighting**
AC lights will be connected to AC lighting panels. All the lights connected to the AC lighting system in different areas will be connected to the main lighting distribution boards.
- 2.1.2 **D.C. Emergency lighting**
A few DC emergency lighting fixtures operated on the DC system will be provided in the strategic locations including main control room, Battery charger room, LT switchgear room in control room building so that the operating personnel can safely find their way even during emergency of a total AC failure including necessary DC lights shall be provided in switchyard area too. These lights will be normally 'OFF' and will be switched 'ON' automatically when under voltage occurs in the AC main lighting distribution board. LED lamps/ LED tube lights down lighters in false ceiling area and Bulkhead fixtures in non-false ceiling area to be used. In addition to these two numbers of portable type dc emergency lighting fixtures shall also be supplied with case without any additional cost to employer.
- 2.2 The lighting layout for and around Control, Staff Quarter, Guard Buildings indicating the type & BOQ for items shall be prepared and submitted by the contractor for employer's approval during detailed engineering. No separate measurement and payment of lighting system shall be made except mentioned in bill of quantity. Therefore, Bidders are instructed to include the cost of lighting system required to complete the specified works under this contract in respective Buildings.
- 2.3 The average lux levels to be maintained at floor level/Equipment Connections level/Ground level in the control building and switchyard shall be as per following:
- a. Control Building
- | | |
|--|---------|
| - Control Room and Conference Room | 350 Lux |
| - Battery Room, Passage, Pantry, Toilets, Corridors etc. | 100 Lux |
| - All other Rooms | 250 Lux |

b. Switchyard

- Main Equipment e.g. Transformer, ISO, CB, CT, CVT etc.	50 Lux
- Balance area of switchyard and street/road	20 Lux
- Other area	10 Lux

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

For achieving the specified lux levels in the switchyard, the contractor can provide luminaries of low power consumption LED bulbs/ tube lights with appropriate wattage as per requirement.

In addition to the normal lighting provided in the switchyard area to maintain the desired lux levels, high beam fixtures on swivel support shall be provided in strategic locations near equipment which shall be kept normally OFF and these shall be switched ON in case of maintenance work. **No separate payments shall be made for this works; therefore, bidders are requested to include the cost of these additional fixtures in switchyard lighting in BOQ item.**

- 2.4 Ceiling fans (1400 mm sweep, AC 230 volts) shall be provided in all non-AC rooms in the control room building and as per the requirements. Exhaust fans shall be provided in toilets, battery room and Kitchen pantry. No separate payments shall be made for this works; therefore, bidders are requested to include the cost of these ceiling fans in Control building in BOQ LS item.

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

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

- Switchyard Area.
- Switchyard Control, Staff quarter and guard cum store Building area
- Street lighting (peripheral) inside switchyard fencing (Street lighting shall be done using street lighting poles)
- Peripheral area across substation boundary wall.

2.7 **For Outdoor Illumination**

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

2.8 **For Indoor Illumination**

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

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

- 2.10 The tag shall be made up of aluminum with the number punched on it and securely attached to the cable by not less than two turns of G.I. wire. Cable tags shall be rectangular in shape for power cables and circular shape for control cables.
- 2.11 Location of cables laid directly under ground shall be indicated clearly by cable marker made of galvanized iron plate embedded in concrete block.
- 2.12 The location of underground cable joints if any, shall be clearly indicated with cable marker with an additional inscription "cable joint".
- 2.13 The marker, which is a concrete block, shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change of direction. It shall also be located on both sides of the road or drain crossing.

3. Description of Items

3.1 Description of Items for Substation Lighting

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

3.1.1 Lighting Panels

- a. Each panel shall be provided with one incoming triple pole MCB with neutral link and outgoing miniature circuit breakers as per clause 2.0. The panels shall conform to IEC: 60439.
- b. **Constructional Features**
 - Panels shall be sheet steel enclosed and shall be dust, weather and vermin proof. Sheet steel used shall be of thickness not less than 2.00 mm (cold rolled) smoothly finished, leveled and free from flaws. Stiffeners shall be provided wherever necessary. The indoor lighting panels will be ready made DB of minimum 1.6 mm sheet thickness.
 - The panels shall be of single front construction, front hinged and front connected, suitable for either floor mounting on channels, sills or on walls/columns by suitable M.S. brackets. Indoor panels in control room shall be flush mounted.
 - Panels shall have a dead front assembly provided with hinged door(s) and out door panels will be with padlocking arrangement with single key supplied in duplicate.
 - All outdoor panels, removable covers, doors and plates shall be gasket all around with neoprene gaskets.
 - The outdoor panels shall be suitable for cable/conduit entry from the top and bottom. Suitable removable cable gland-plate shall be provided on the top and bottom of panels. Necessary number of double compression cable gland shall be supplied, fitted on to this gland plate. The glands shall be screwed on top and made of tinned brass.
 - The panels shall be so constructed as to permit free access to connection of terminals and easy replacement of parts.
 - Each panel shall have a caution notice fixed on it.
 - Each panel will be provided with directory holder in which printed and laminated as built circuit directory would be kept inside a document holder/pasted at site.

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

c. **Main Bus Bars**

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

d. **Junction Boxes**

- The junction boxes shall be concealed type for indoor lighting and suitable for mounting on columns, lighting poles, structures etc., for outdoor lighting.
- Junction boxes shall be of square/rectangular type of 1.6 mm sheet steel with minimum 6 mm thick pressure diecast aluminium material LM-6 and shall have bolted cover with good quality gasket lining.
- The junction box and cover of sheet steel construction shall be hot dip galvanized.
- The junction boxes shall be complete with conduit knockouts/threaded nuts and provided with terminal strips. The junction boxes shall be suitable for termination of Cable glands of dia 20 mm, 25 mm, 32 mm, and 40mm on all sides. The junction boxes shall be provided with 4-way terminals suitable for two numbers 10 sq. mm. wire & for street lighting/switchyard lighting suitable for 2 numbers 4C x 16 Sq.mm Al. cable.
 - The junction boxes shall have the following indelible markings
 - Circuit Nos. on the top.
 - Circuit Nos. with ferrules (inside) as per drawings.
 - DANGER sign in case of 400-volt junction box.
- The junction boxes shall be weather proof type with gaskets conforming to IP 55 as per IEC: 60529.

e. **Outdoor Lighting Panel**

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

Type of Panel	Description	Detail of Outgoing Feeders
ACP 2	Outdoor	8 nos- 20 A single pole MCB and 4 No. 32 A Triple pole MCB with Neutral and suitable timer and contactor for automatic switching.
ACP 3	Outdoor Street lighting Panel	4 nos.-32A Triple pole MCB with Neutral with suitable timer and contactor for automatic switching

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

f. **Indoor Lighting Panel**

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

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

110V DC indoor type change over board and 110V DC 32A two wire bus and one 32A contractor backed up by 32A double pole MCB as incomer. The panel shall have local push button controls. Following are the various types of panels required with control timer.

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

3.1.2 **Lighting Fixtures**

For Lighting fixtures please refer Annexure-1.

3.1.3 **Receptacles**

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

- All receptacles shall be of cast steel/ aluminum, heavy duty type, suitable for fixing on wall/column and complete with individual switch.
- In general, the receptacles to be installed are of the following types:
- Type RO:** 15A, 230V, 2 pole, 3 pin type with third pin grounded, metal clad with gasket having cable gland entry suitable for 2Cx6 sq.mm. PVC/aluminum armoured cable and a metallic cover tied to it with a metallic chain and suitable for installation in moist location and or outdoor. The switch shall be of rotary type. Receptacles shall be housed in an enclosure made out of 2 mm thick GI sheet with hinged doors with padlocking arrangements. Door shall be lined with good quality gasketing. This shall conform to IP-55.
- Type RI:** The 5/15-amp 6 pin receptacles with switches will be of Modular type with flush type switches and electroplated metal enclosures of approved make.
- Type RP:** 63A, 400V, 3 phase, 4 pin interlocked plug and switch with earthing contacts. Other requirements shall be same as type RO. The receptacle shall be suitable for 3.5C x 35/3.5Cx70 sq. mm. aluminum conductor cable entry and shall also be suitable for loop-in and loop out connection of cables of identical size. Receptacle shall be suitable for outdoor application. Receptacles shall be housed in a box made out of

2mm thick G.I. sheet, with hinged door with padlocking arrangement. Door shall be lined with good quality gasketing. This shall conform to IP-55.

- 3.1.4 **Switch Boards:** Modular type switches, 5/15 Amp. Receptacles
- 3.1.5 **Conduits And Accessories:** Galvanized Rigid steel or Rigid PVC conduits of 20/25/32 mm for Lighting and Telephone wiring
- 3.1.6 **Junction Boxes:** with 5 Nos of terminal blocks
- 3.1.7 **Lighting Poles:** Type A1 poles & Type E1 poles
- 3.1.8 **Fans:** 1400 mm Sweep with Electronic regulator and 450 mm Wall Mounted fans
- 3.1.9 **Maintenance Equipment**
 - a. A type Aluminum ladder of 3 meters vertical height.
 - b. Cartwheel mounted aluminum ladder Vertical Extendable from 5.1 m to 11m.

No separate payment shall be made for all type of ladders; therefore, bidders are instructed to include all the cost of ladders to be supplied under this package shall be included in other BOQ items.

3.2 Description of Common Items for Lighting

3.2.1 Lighting Fixtures And Accessories

a. General

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

b. Temperature Rise

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

c. Supply Voltage

Lighting fixtures and accessories meant for 230 V A.C operation shall be suitable for operation on 230 V A.C. 50Hz, supply voltage variation of $\pm 10\%$, frequency variation of $\pm 2.5\%$ and combined voltage and frequency variation of $\pm 10\%$.

Lighting fixture and accessories meant for 110V DC operation shall be suitable for operation on 110V DC with variation between 190 to 230 Volts.

d. Lighting Fixtures

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

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

All lighting fixtures shall be complete with LED fluorescent tubes / LED lamps/ as specified and shall be suitably wired up.

All fluorescent lamp fixture shall be complete with all accessories like lamps, holders etc.

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

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

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

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

e. **Lamp holders**

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

f. **Lamps**

LED low power consumption lamps shall be provided unless otherwise specified.

Flexible conduits if required, for any fixture shall be deemed to be included in Contractor's scope.

g. **Switch and Switchboard**

All Switch board/boxes, 5/15 Amp Receptacles and electronic fan regulators located in office/building areas shall be modular flush mounted type or brick wall with only the switch knob projecting outside.

Switch boards/boxes shall have conduit knock outs on all the sides.

The exact number of switches including regulator for fans and layout of the same in the switchboard shall be to suit the requirement during installation.

The maximum number of luminaires, controlled by one no 6 amp switch would 4 nos. For DC fixtures there will be no switch and the same shall be directly controlled from DC LP

The luminaires shall be wired in such a fashion that luminaires on each phase are evenly distributed all over the room

h. **Conduits & conduit Accessories**

The conduits shall conform to IEC: 61386 or IEC: 61035 or IEC: 60614 as applicable. All steel conduits shall be seamed by welding, shall be of heavy gauge and shall be hot dip galvanized.

Flexible conduits wherever required shall be made with bright, cold rolled annealed and electro-galvanized mild steel strips or PVC/Plastic.

All conduits accessories shall conform to relevant IEC and shall be hot dip galvanized or High quality virgin PVC.

i. **Terminal Blocks**

Each terminal shall be suitable for terminating up to 2 Nos. 10 sq. mm stranded Aluminum Conductors without any damage to the conductors or any looseness of connections. Terminal strips provided in street - lighting poles shall be suitable for terminating up to 2 nos. 4C x 16 sq. mm aluminum cables.

j. **Pull Out Boxes**

The pull out boxes shall be concealed type for indoor lighting and suitable for mounting on column, structures etc., for outdoor lighting. The supply of bolts, nuts and screws required for the erection shall be included in the installation rates.

The pull out boxes shall be circular of cast iron or 16 SWG sheet steel and shall have cover with good quality gasket lining.

The pull out boxes and cover shall be hot dip galvanized.

The pull out boxes shall be completed with conduit knock outs/threaded hubs and provided at approximately 3 meters intervals in a conduit run.

k. **Residual Current Circuit Breakers (RCCB)**

For indoor panels 63A 4pole 300 ma RCCB conforming IEC 13947 will be provided along with incomer.

l. **Miniature Circuit Breaker (MCB)**

The miniature circuit breakers shall be suitable for manual closing, opening, automatic tripping under overload and short circuit. The MCBs shall also be trip free. MCB of Type C tripping characteristics as per IEC: 60898 will be used for Switchyard lighting.

Single pole as well as three pole versions shall be furnished as required in the Schedule of Lighting Panels.

The MCBs and panel MCCB together shall be rated for full fault level. In case the MCB rating is less than the specified fault level the bidder shall co-ordinate these breaker characteristics with the back up MCCB in such a way that if fault current is higher than breaker rating, the MCCB should blow earlier than the breaker. If the fault current is less than MCB breaking capacity, MCB shall operate first and not the incomer MCCB.

The MCBs shall be suitable for housing in the lighting panels and shall be suitable for connection with stranded copper wire connection at both the incoming and outgoing side by copper lugs or for bus bar connection on the incoming side.

The terminals of the MCBs and the 'open' 'close' and 'trip' conditions shall be clearly and indelibly marked.

The bidders shall check and co-ordinate the ratings of MCBs with respect to starting characteristics of discharge lamps. The vendor has to furnish overload and short circuit curve of MCB as well as starting characteristics curves of lamps for Employer's approval.

The MCB shall generally conform to IEC: 60898.

m. **Contactors**

Contactors shall be of the full voltage, direct-on line air break, single throw, electro-magnetic type. They shall be provided with at least 2-'NC' and 2'NO' auxiliary contacts. Contactor shall be provided with the three element, positive acting, ambient temperature compensated time lagged, hand reset type thermal overload relay with adjustable settings to suit the rated current. Hand reset button shall be flush with the front of the cabinet and suitable for resetting with starter compartment door closed. The Contactor shall be suitable for switching on Tungsten filament lamp also. The bidder shall check the adequacy of the Contactors rating wire with respect to lighting load.

n. **Push Buttons**

All push buttons shall be of push to actuate type having 2 'NO' and 2 'NC' self-reset contacts. They shall be provided with integral escutcheon plates engraved with their functions. Push buttons shall be of reputed make.

o. **Labels**

The lighting panels shall be provided on the front with panel designation labels on a 3 mm thick plastic plate of approved type. The letter shall be black engraved on white back ground.

All incoming and outgoing circuits shall be provided with labels. Labels shall be made of non-rusting metal or 3 ply lamicold. Labels shall have white letters on black or dark blue background.

p. **Earthing Terminals**

Panels shall be provided with two separate and distinct earthing terminals suitable to receive the earthing conductors of size 50x6 G.S. Flat.

q. **Type Test for Lighting Panels**

Type test reports for following tests on all lighting panels shall be submitted for approval as per clause 9.2 of Section 2: GTR.

- Wiring continuity test
- High voltage (2.5 KV for 1 minute) and insulation test
- Operational test
- Degree of protection (not less than IP-55 test on outdoor Lighting Panels and IP-52 test on indoor Lighting Panels as per IEC: 60947 (part 1)
- Heat run test

r. **Lighting Poles**

The Contractor shall supply, store and install the following types of steel tubular lighting poles required for street lighting.

- Type A1 Street Lighting Pole - for one fixture
- Type E1 Post top lantern pole - for one fixture

Street/flood light poles shall conform to the enclosed drawings. In front of control room building, and Fire Fighting Buildings, decorative post top lantern (Type E1) poles and Bollards shall be installed.

Lighting poles shall be complete with fixing brackets and junction boxes. Junction boxes should be mounted one meter above ground level.

The lighting poles shall be coated with bituminous preserving paint on the inside as well as on the embedded outside surface. Exposed outside surface shall be coated with two coats of metal primer (comprising of red oxide and zinc chromate in a synthetic medium).

The galvanized sheet steel junction box for the street lighting poles shall be completely weather proof conforming to IP-55 and provided with a lockable door and HRC fuse mounted on a fuse carrier and fuse base assembly. The fuses & junction box shall be as specified in the specification. However, terminals shall be stud type and suitable for 2 nos. 16 sq. mm cable.

Wiring from junction box at the bottom of the pole to the fixture at the top of the pole shall be done through 2.5 sq. mm wire.

Distance of centre of pole from street edge should be approximately 1000 to 1200 mm.

Earthing of the poles should be connected to the switchyard main earth mat wherever it is available and the same should be earthed through 3M long, 20 mm dia earth electrode.

s. CEILING FANS AND REGULATORS

The contractor shall supply and install 1400 mm sweep ceiling fans complete with electronic regulator and switch, suspension rod, canopy and accessories. The wall mounted fans shall be of 400 mm sweep

The contractor shall supply and install the switch, electronic regulator and board for mounting switch and electronic regulator for ceiling fans. The regulator will be housed in common switchboard for lighting and shall be of similar make and model as that of modular switches.

Winding of the fans and regulators shall be insulated with Class-E insulating material. Winding shall be of copper wire.

Electronic regulator with stepped control shall be provided.

t. Lighting Wires

The wiring used for lighting shall be standard products of reputed manufacturers.

The wires shall be of 1100 V grade, PVC insulated product of reputed manufacturers.

The conductor sizes for wires used for point wiring beyond lighting panels shall be 2.5 sq. mm, 4 sq. mm, 6 sq. mm and 1.5 sq. mm stranded copper wire.

The wires used for connection of a lighting fixture from a nearest junction box or for loop-in loop-out connection between two fluorescent fixtures shall be single core copper stranded conductor, 1100V grade flexible PVC insulated cords, unsheathed, conforming to IEC:60502 with nominal conductor cross sectional areas of 2.5 sq. mm.

The wires shall be colour coded as follows:

- Red for R - Phase
- Yellow for Y - Phase
- Blue for B - Phase
- Black for Neutral

- White for DC (Positive)
- Grey for DC (Negative)

4. Lighting System Installation Works

4.1 General

In accordance with the specified installation instructions as shown on manufacturer's drawings or as directed by Employer, Contractor shall unload, erect, install, test and put into commercial use all the electrical equipment included in the contract. Equipment shall be installed in a neat, workmanship manner so that it is level, Plumb Square and properly aligned and oriented. Tolerances shall be as established in manufacturers drawing or as stipulated by Employer.

All apparatus, connections and cabling shall be designed so as to minimize risk of fire or any damage which will be caused in the event of fire.

4.2 Conduit System

Contractor shall supply, store and install conduits required for the lighting installation as specified. All accessories/fittings required for making the installation complete, including but not limited to pull out boxes (as specified in specification ordinary and inspection tees and elbow, check nuts, male and female bushings (brass or galvanized steel), caps, square headed make plugs, nipples, gland sealing fittings, pull boxes, conduits terminal boxes, glands, gaskets and box covers, saddle terminal boxes, and all steel supporting work shall be supplied by the Contractor. The conduit fittings shall be of the same material as conduits. The contractor shall also supply 20 mm PVC conduit and accessories for telephone wiring.

All unarmored cables/wires shall run within the conduits from lighting panels to lighting fixtures, receptacles etc.

Size of conduit shall be suitably selected by the Contractor.

Conduit support shall be provided at an interval of 750 mm for horizontal runs and 1000 mm for vertical runs.

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.

Where conduits are along with cable trays, they shall be clamped to supporting steel at an interval of 600 mm.

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.

For long conduit run, pull boxes shall be provided at suitable intervals to facilitate wiring.

Conduit shall be securely fastened to junction boxes or cabinets, each with a lock nut inside and outside the box.

Conduits joints and connections shall be made through water-tight and rust proof by application of a thread compound which insulates the joints. White lead is suitable for application on embedded conduit and red lead for exposed conduit.

The entire metallic/PVC conduit system, shall be embedded, electrically continuous and thoroughly grounded. Where slip joints are used, suitable bounding shall be provided around the joint to ensure a continuous ground circuit.

Conduits and fittings shall be properly protected during construction period against mechanical injury. Conduit ends shall be plugged or capped to prevent entry of foreign material.

4.3 **Wiring**

Wiring shall be generally carried out by PVC insulated wires in conduits. All wires in a conduit shall be drawn simultaneously. No subsequent drawings of wires is permissible.

Wires shall not be pulled through more than two equivalent 90 deg. bends in a single conduit run. Where required, suitable junction boxes shall be used.

Wiring shall be spliced only at junction boxes with approved type terminal strip.

For lighting fixtures, connection shall be teed off through suitable round conduit or junction box, so that the connection can be attended without taking down the fixture.

For vertical run of wires in conduit, wires shall be suitably supported by means of wooden/hard rubber plugs at each pull/junction box.

Maximum two wires can be terminated to each way of terminal connections.

Separate neutral wires are to be provided for each circuit.

AC and DC wiring should not run through the same conduit.

4.4 **Lighting Panels**

The lighting panels shall be erected at the locations to be finalized during detailed engineering.

Suitable foundations/supporting structures for all outdoor type lighting panels shall be provided by the Contractor.

4.5 **Foundation & civil works**

Foundation for street lighting poles, panel foundation and transformer foundation shall be done by the Contractor. The payment towards execution, PCC & RCC shall be made under relevant items of civil work mentioned in Bid Price schedule.

All final adjustment of foundation levels, chipping and dressing of foundation surfaces, setting and grouting of anchor bolts, sills, inserts and fastening devices shall be carried out by the Contractor including minor modification of civil works as may be required for erection.

Any cutting of masonry/concrete work, which is necessary shall be done by the Contractor at his own cost and shall be made good to match the original work.

ANNEXURE-1

S. No.	Type of Lighting Fixture	Description	Philips Catalogue No
1	F1	2x28W T5 type fluorescent lamps in industrial reflector type fixture, complete with accessories and suitable for pendent /surface mounting.	TMS 122/228 HF
2	FF	2x28 T5 energy efficient fluorescent lamps with low glare, mirror optics suitable for recess mounting type lighting fixture.	TBS 088/228 C5 HF
3	FL	2x28W T5 energy efficient fluorescent lamps with low glare mirror optics suitable for pendent/surface mounting with all accessories	TCS 398/228 D6 HF
4	TL	Sleek and Functional electronic decobatten suitable for use with 1x'TLD'36W fluorescent lamp with dual tone end caps. Pre-phosphated & powder coated CRCA steel channel complete with all electrical accessories like electronic ballast, lamp holders all prewired up to a terminal block	TMS500/136 HF
5	IB	60/100w GLS lamp in Bulkhead fixtures with Cast Aluminium alloy body, suitable for column, wall, and ceiling mounting finished stove enameled silver grey outside	NXC101
6	BL	Aesthetic wall/ceiling mounted luminaire suitable for 1x PL-C 13W OR 11W CFL. Low loss O.C. Copper ballast. Built in high gloss anodized reflector. Twin finish UV stabilised SAN diffuser for protection & elimination of lamp glare.	FMC21/113
7	SL	Aesthetic ceiling mounted luminaire for Ecotone crystal/Décor CFL of 2x9W or 1x18W. ABS housing pre-wired with porcelain lamp holder. Pre-phosphated plated CRCA gear tray.	FL343/118
8	BH	Bulkhead luminaire suitable for use with PL-S 9W CFL. Single piece pressure die-cast aluminium & cover retaining Frame. Opal acrylic cover along with a gasket made of E.P.R.	FXC 101/109
9	BLD	2X9 Or 1x18 watt CFL bollard light for landscape lighting having FRP/LLDPE housing	FGC202 /118
10	DLR	2x18 watt CFL Down lighter with HF ballast suitable for recess mounting	FBH145/218L HF
11	DSM	1X13 WATT surface mounted CFL	FCS100/113
12	IF	Incandescent GLS lamp down light	DN622
13	SF1	1 X 400W HPSV lamps in high flood lighting fixture with integral control gear	SWF 330/1X400
14	SF2	2 X 400W HP sodium Vapor lamps in high flood lighting, non-integral control gear:	RVP302/2x400W
15	SF3	1 X 250W HPSV lamps in high flood lighting fixture with integral control gear:	SWF 330/1X250
16	SF4	150W HP Metal halide MHN-TD lamp in flood lighting fixture with integral control gear.	SWF230/150 MHN-TD
17	SF5	125 HP MV Lamp in weather proof post top lantern for mounting on pole top	HPC-101/125 HPF
18	SC	150W SON-T Tubular Sodium Vapor lamp in street lighting Luminaire with toughened glass cover.	SRX-51/150

Volume II

Section 6: Employer's Requirements

CHAPTER 18: FIBRE OPTIC BASED COMMUNICATION EQUIPMENT

Table of Contents

1.	Introduction	2
2.	Scope of Works	2
3.	General Requirements	2
4.	Applicable Standards	5
5.	Network Configuration and Equipment Characteristics	5
6.	Inspection	21
7.	Test Plans and Procedures	21
8.	Training for Operational Staffs	32

CHAPTER 18

FIBRE OPTIC BASED COMMUNICATION EQUIPMENT

1. Introduction

- 1.1 This document describes the technical specifications for Communication Equipment which includes Fibre Optic Terminal Equipment for Establishment of Fibre Optic Communication System under the contract. This specification describes the functional and performance requirements of the system.

2. Scope of Works

- 2.1 The broad scope of the procurement of this part includes the survey, planning, design, engineering, supply, transportation, and insurance, delivery at site, unloading, handling, storage, installation, termination, testing, training, and demonstration for acceptance, commissioning and documentation for:
- a. SDH Equipment (STM-4 MADM up to 4 MSP Protected directions) along with suitable optical line interfaces & tributary cards.
 - b. Local Craft Terminal (Laptop) with full operational programming software and data cables.
 - c. All cabling, wiring, Digital Distribution Frame patch facilities, equipment MDF's and interconnections to the supplied equipment at the defined interfaces.
 - d. MDF & DDF cross connects required to route and activate circuits.
 - e. System integration of the supplied subsystems and also integration with existing communication equipment such as SDH, MUX etc.
 - f. System integration of the supplied equipment (termination equipment system) with existing equipment for seamless transmission of communication channel
 - g. Integration of supplied system with the User equipment such as RTU/SASs, SCADA system, PLCC equipment etc.
 - h. Maintenance of the supplied system
- 2.2 All other associated works/items described in the technical specifications for a viable and fully functional communication network.

3. General Requirements

- 3.1 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.
- 3.2 It should be noted that preliminary design information and bill of quantity (BOQ) specified in these 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.
- 3.3 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.
- 3.4 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.

- 3.5 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.
- 3.6 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.
- 3.7 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.
- 3.8 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.

3.9 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.

3.10 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:

- a. Site visits, and surveys, necessary to identify and provide all equipment needed to implement the network.
- b. Equipment Engineering and design specific to each location including review of, and conformance with local environmental and earthing considerations.

- c. Overall integration of communication equipment/subsystem procured in present and existing network.
- d. 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.
- e. Installation and integration of network management software, hardware and firmware (as applicable).
- f. Project management, project scheduling, including periodic project reports documenting progress, review meeting during the contract period.
- g. Engineering and technical assistance during the contract and warranty period.
- h. 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.
- i. Factory and site testing of all hardware, software, and firmware provided.
- j. Provide documented evidence of satisfactory Type Test performance to the Employer and if required by The Employer, conduct type test.
- k. Provide a Quality Assurance Plan, ensuring the Employer access to the manufacturing process.
- l. Training of the Employer personnel.
- m. Hardware, software, and firmware maintenance, debugging, and support of the equipment through final acceptance, and maintenance on all new equipment throughout the warranty period and for a period of six (6) years after warranty period.
- n. 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.

3.11 The Employer Responsibilities and Obligations

The Employer will provide the following items and services as part of this Project:

- a. Overall project management of the project
- b. Review and approval of the Contractor's designs, drawings, and recommendations.
- c. Communication network configuration data, including:
 - Channel assignments for voice and data
 - Interconnection drawings for existing equipment
- d. Review and approval of test procedures.
- e. Participation in and approval of "Type", factory and site acceptance tests where testing is required.
- f. Review and approval of training plans.
- g. Providing support and access to facilities at the sites.

- h. 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.
- i. Coordination of the Contractor's activities with the Employer's and constituents' concerned departments.
- j. Provide to the extent possible drawings for existing sites and facilities for which equipment installations are planned.
- k. Approval of the key personnel for the project

4. Applicable Standards

- 4.1 The following standards and codes shall be generally applicable to the equipment and works supplied under this Contract:
- a. IEEE 802.3
 - b. 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
 - c. ITU-T/CCITT Recommendations, G.801, G.821, G.822, G.823, G.826.
 - d. ITU-T/CCITT Recommendations of the V Series
 - e. ITU-T/CCITT Recommendations R35, R37, and R38A (or R38B)
 - f. ITU-T/CCITT Recommendations M3010, G771
 - g. Internet Activities Board, RFC-1157 (SNMP)
 - h. International Electrotechnical Commission standards, IEC801-2/3/4/5, IEC-255-4, IEC-255-5, IEC-870-2-1, IEC-721-3-3, IEC-529.
 - i. International Electrotechnical Commission standards, IEC 1000-4-xx series.
 - j. IEC publication 68, 68-2-2, 68-2-3, 68-2-14, 68-2-27, 68-2-32.
 - k. ITU-T/CCITT Recommendations K.11, K.17, K.20.
 - l. International CISPR standards
- 4.2 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.
- 4.3 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.
- 4.4 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.

5. Network Configuration and Equipment Characteristics

5.1 Introduction

- 5.1.1 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:
- a. Fibre Optic Transmission System (FOTS)
 - b. Termination Equipment Subsystems
 - c. MDF, DDF and Cabling
- 5.1.2 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.

- 5.1.3 The security related requirements of the equipment shall be as per relevant agency and shall be followed/complied by the vendor.
- 5.1.4 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.
- 5.1.5 The contractor shall ensure that the supplied equipment 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.
- 5.1.6 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, equipment, software etc. supplied and implemented in the project shall be given for use by the Employer.
- 5.1.7 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.

5.2 General Network Characteristics

5.2.1 Description

The fibre optic network shall be based on the Synchronous Digital Hierarchy (SDH) having bit rate of STM-4 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.

5.2.2 Functional Requirement

The primary function of the communication network is to provide a highly reliable voice and data communication system for grid operation in support of the SCADA/EMS/RTU/SASs/PMUs. The communications support requirement for SCADA/EMS/RTU/SASs/PMUs system is for low & high-speed data, express voice circuits and administrative voice circuits as defined in appendices. A brief summary of the communication system requirements is as follows:

- a. High speed E1 channel support
- b. Data transport supporting Network Management channels
- c. The connectivity envisaged between RTU/SASs and Control Centre over TCP-IP using Ethernet interface.

5.2.3 General Systems Requirements

Required characteristics are defined and specified herein at the system level, subsystem level, and equipment level.

a. System Synchronization

The Contractor shall synchronize the existing equipment and all the new equipment under the contract using existing Master clock, if available. The Contractor shall provide the additional clocks as required under the

set of clocks 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 synchronization plan as per standard ITU-T G.811. All sync equipment 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 equipment 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.

b. 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.

c. 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.

d. 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.

e. 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.

f. **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.

g. **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.

h. **General Site Considerations**

All fiber optic links up to 100 km 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 equipment 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 equipment shall be monitored/managed by Craft Terminal.

i. **Proposed Optical Fibre Characteristics**

The link budget calculations and equipment design shall be based on the specified fibre parameters. The optical cables shall have Dual Window Single Mode (DWSM) fibres conforming to ITU-T Recommendations G.652D and the major parameters of these optical fibre(s) are defined in Table below.

Optical Fibre Characteristics	
Fibre Description:	Dual-Window Single-Mode (DWSM)
Mode Field Diameter:	8.6 to 9.5 μm ($\pm 0.6 \mu\text{m}$)
Cladding Diameter:	125.0 $\mu\text{m} \pm 1\mu\text{m}$
Mode field Concentricity Error:	$\leq 0.6\mu\text{m}$
Core-Clad concentricity error:	$\leq 1.0\mu\text{m}$
Cladding non-circularity	$\leq 1\%$
Cable Cut off Wavelength:	$\leq 1260 \text{ nm}$
1550 loss performance	As per G.652D
Proof Test Level	$\geq 0.69 \text{ Gpa}$
Attenuation coefficient	@1310nm $\leq 0.35 \text{ dB/Km}$ @1550nm $\leq 0.21 \text{ dB/Km}$

Optical Fibre Characteristics	
Attenuation variation with wavelength 1285 nm - 1330 nm 1525 nm - 1575 nm	Attenuation coefficient @1310 ± 0.05 dB @1550 ± 0.05 dB
Point discontinuities	≤ 0.1dB
Chromatic Dispersion; Max.: Zero Dispersion Wavelength Zero Dispersion Slope:	$18.0 \frac{ps}{nm \times km} @ 1550 nm$ $3.5 \frac{ps}{nm \times km} @ 1288 - 1339 nm$ $5.3 \frac{ps}{nm \times km} @ 1271 - 1360 nm$ 1300 to 1324nm $0.092 \frac{ps}{nm^2 \times km} maximum$
Polarization mode dispersion coefficient	$\leq 0.2 \frac{ps}{km^{1/2}}$
Temperature Dependence:	Induced attenuation ≤ 0.05 dB (-60°C - +60°C)
Bend performance:	@1310 nm (75±2 mm dia Mandrel), 100 turns; Attenuation rise ≤ 0.05 dB @1550 nm (30±1 mm dia Mandrel), 100 turns; Attenuation rise ≤ 0.10 dB @1550 nm (32 ± 0.5 mm dia Mandrel), 1 turn; Attenuation rise ≤ 0.50 dB

j. **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.

5.3 **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 equipped with 2 nos. of minimum 8 port E1 interface card, two nos. 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.

The contractor shall provide SDH Equipment as per BOQ and/or requirements.

It is the responsibility of contractor to design, supply and install the above mentioned optical equipment in the respective places and integrate with existing communication equipment in adjacent substations. During integration, the existing data and voice shall be as it is as previous and it should not malfunction the existing NMS (Network Management system) functionality of those equipment up to LDC. It is advised the contractor to study existing communication network at that regions where Coriant hiT 7030 STM -1 equipment has been installed. The contractor is advised to study the existing communication network in the region for successful integration.

5.3.1 SDH Equipment

a. Functional Requirement

There is a requirement for different types of equipment under this project which are described in this section. The Drawing is provided in the appendices. For the purpose of BOQ, the SDH Equipment is considered to be divided in three parts i.e. Optical interface/SFP, Tributary Cards (Electrical tributaries such as E1 & Ethernet 10/100/1000 Mbps) and Base Equipment (Consisting of Common Cards, Control Cards, Optical base card, Power supply cards, sub-rack, cabinet, other hardware and accessories required for installation of equipment i.e. everything besides optical interface/SFP and tributary cards).

If bidder is offering equipment with multifunction cards such as cross-connect or control card with optical interface/SFP or tributary interface, such type of multifunction card shall be considered as Common control card and shall be the part of base equipment. In case optical interface/SFP is embedded with control card, the adequate number of optical interface/SFPs shall be offered to meet the redundancy requirements of the specifications. Further, control card shall not be equipped with more than one optical interface/SFP and optical base card shall not be equipped with more than two optical interface/SFPs.

The equipment shall be configurable either as Terminal Multiplexer (TM) as well as ADM with software settings only.

b. 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.

c. Service Channel

Service channels shall be provided as a function of the SDH equipment and shall be equipped with Service Channel Muldems that shall provide at a minimum: One voice channel (order wire) with analog interface (0.3 to 3.4 kHz) and one data channel. Both omnibus and selective calling facilities shall be provided. There shall be a facility to extend the line system order-wire to any other system or exchange lines on 2W/4W basis.

d. **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.

e. **Synchronization** Error! Bookmark not defined.

The equipment shall provide synchronization as per Table given above. One 2MHz synchronization output from each equipment shall be provided.

f. **Electrical and Optical I/O Characteristics and General Parameters**

Table below provides the electrical and optical characteristics as well as other general parameters for SDH equipment.

Electrical and Optical I/O Characteristics and General Parameters	
Optical Wavelength ^{NOTE (1)}	1310/1550nm
Optical Source ^{NOTE (2)}	Laser
Optical Source Lifespan	Better than 5 X10 ⁵ hours
Optical Fibre Type	G.652 D
Optical Connectors	Type FC-PC
Transmission Quality	Per ITU-T G.821, G.823, G.826
Source Primary Power	-48 Vdc
Equipment Specifications	Per ITU-T G.783
Tributary, Electrical Interface	Per ITU-T G.703, 75 Ω
Ethernet Interface	10/100 Mbps
SDH Bit Rates	Per ITU-T G.703
Optical Interfaces	Per ITU-T G.957, G.958
Frame and Multiplexing Structure for SDH	Per ITU-T G.707
Synchronization	Per ITU-T G.813
Management Functions	Per ITU-T G.774, G.784
Protection Architectures	Per ITU-T G.841
Built In Testing and Alarms	Per ITU-T G.774, G.783, G.784

NOTE (1) Optical wavelength shall be selected considering the characteristics of the optical fibre and the link budget.

NOTE (2) **Eye Safety for Laser Equipment:** To avoid eye damage, when a receiver detects a line interruption, it is required that the optical power of the laser shall be reduced to safe limits on the transmitter in the opposite direction as per ITU-T G.958.

NOTE (3) In case other than FC-PC connector is provided in the equipment, suitable patch cord with matching connector are to be provided to connect with FODP.

5.3.2 Optical Link Performance Requirements

The optical fibre link performance requirements are specified as follows:

a. Link Budget Calculations

The fibre optic link budget calculations shall be calculated based upon the following criteria:

- **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.
- **Splice Loss:** Minimum 0.05 dB per splice. One splice shall be considered for every 3 kms.
- **Connector Losses:** Losses due to connectors shall be considered to be minimum 1.0 dB per link.
- **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.
- **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.
- **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.
- **Other Losses:** Other losses, if any required specifically for system to be supplied shall also be suitably considered.
- **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.
- **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

b. 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.

c. **FODP to SDH Equipment** Error! Bookmark not defined.

The Contractor shall be responsible for connectivity between the FODP and the SDH equipment. The Contractor shall provide patch cords as per FODP types. The patch-cord length between the FODP & equipment rack shall be suitably protected from rodents, abrasion, crush or mechanical damage.

5.4 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 equipment are as follows:

5.4.1 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 synchronization signal according to ITU-T Recommendation G.703.

5.4.2 First Order (Primary) Multiplexing

The Contractor shall be required to provide E-1 Drop & Insert Multiplexer and E-1 Channel Bank primary multiplexing in compliance with the electrical input-output characteristics provided in Table below.

a. **Drop & Insert Primary Multiplexing**

Drop & Insert primary multiplexing in conformance with CEPT E-1 characteristics shall be required at locations where the subscriber requirement is minimal. The drop and insertion of up to thirty 64 Kbps channels supporting subscriber line units (SLU) shall be required at intermediate locations. The Drop & Insert Muxes supplied shall be performance and card compatible with the Channel Bank Equipment provided so that all Subscriber Line Interface cards are interchangeable.

CEPT E-1 Standard First Order Multiplexing
Electrical Input/Output Characteristics

Applicable Standards	CEPT per CCITT Recommendation G.702, G.703, G.711 and G.712
Number of Tributaries	30 X 64 Kbps
Alternative Sub-rate Tributaries	n X 64 Kbps V.36 64Kb/s V.11/V.36

Output Aggregate Rate	2.048 Mb/s $\pm$ 50 ppm
Interface Code	HDB3
Impedance	75 ohm unbalanced
Peak Level @ 120 ohm	3.0 volts $\pm$ 10%
Peak Level @ 75 ohm	2.37 volts $\pm$ 10%
Maximum Insertion Loss	6 dB
Signal Waveform	Per CCITT G.703
Frame Structure	Per CCITT G.742
Jitter Performance	Per CCITT G.823
Power Supply Voltage	-48 Vdc

b. **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).

5.5 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.

5.5.1 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:

- "Normally thru" circuit routing
- Circuit rerouting via patch cord assemblies
- Circuit disconnects 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.

5.5.2 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".

5.6 Patch Cords

The Contractor has to supply Patch cords as described in BOQ. The Patch cord return loss shall be equal to or better than 40dB and insertion loss equal to or less than 0.5dB.

5.7 Telecommunication Management Network 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 network 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 cannot 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.

5.7.1 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.

5.7.2 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:
 - TMN system at LDC (including local operator console, if applicable) shall support management of all equipment 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.
 - Monitoring and control of NEs using Craft Terminals as defined in this Chapter.

- d. Supervisory monitoring and control of the following station associated devices:
 - Intrusion Detection Alarms
 - Power Failure
 - Fire and Smoke Detection
 - 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 centralized 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

5.7.3 Management Functions

The TMN shall support following Management functions:

a. 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:

- Provide tools to establish and maintain the backbone topology and configuration information and provide graphical maps depicting the configurations.
- Gather descriptive information about the current configuration of the equipment, provide operator displays, and prepare reports.
- 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.
- Provide verification testing to support new equipment installation

b. 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:

- 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.
- Obtain status and detect faults through periodic polling, processing of unsolicited alarms and error events, and periodic testing for connectivity.
- 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.
- 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.
- 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.
- Track network equipment failure history.

c. Performance Management

Performance management is concerned with evaluation of the use of network equipment and their capability to meet performance objectives. Minimum specific requirements that shall be satisfied include the following:

- 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 (at least for SDH).
- Monitor point to point & end to end signal quality and history. Provide operator controls to monitor performance of specified events, measures, and resources (at least for SDH). Specifically provide displays to permit the operator to:
 - Select/deselect network equipment, events, and threshold parameters to monitor
 - Set monitoring start time and duration or end time
 - Set monitoring sampling frequency
 - Set/change threshold values on selected performance parameters
 - Set multiple thresholds on certain performance parameters. Alarm categories include as a minimum a warning and a failure.

- Generate alarm events when thresholds are exceeded.
- 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.
- 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.
- Generate reports on a daily, weekly, monthly, and yearly basis containing system statistics.

d. **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.

5.8 **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.

5.9 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

5.10 Hardware Requirements

5.10.1 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, 8 GB RAM, DVD-ROM drive, redundant 500 GB internal Hard Disk Drive, 101-Enhanced style keyboards, mouse, parallel, serial, USB(3.0) 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, 4 GB RAM, DVD-RW drive, 160 GB Hard Disk Drive, 101-Enhanced style keyboards, mouse, parallel, serial and USB (3.0) 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, 4 GB RAM, 2 GB Graphics, 256 MB VRAM, DVD RW drive, 500 GB Hard Disk Drive, keyboard, mouse/trackball etc., parallel, serial/USB (3.0) ports to accommodate printers, and Internal/external Data/Fax modem and a battery back-up of at least 180 minutes. VDUs shall be 15" TFT active matrix color LCD with a minimum resolution of 1024 X 768.

5.10.2 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.

5.10.3 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.

5.10.4 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.

5.11 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.

5.11.1 Operating System Software

Operating system software shall be provided to control the execution of system programs, application programs, and 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.

5.11.2 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.

5.11.3 Software Utilities

A utility shall be provided to convert all reports into standard PC application formats such as excel.

5.11.4 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.

5.11.5 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.

6. Inspection

6.1 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:

- 6.1.1 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.
- 6.1.2 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.
- 6.1.3 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.
- 6.1.4 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 factory by the Employer's representatives prior to shipping this equipment to the Contractor's facility or directly to the Employer.
- 6.1.5 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.

7. Test Plans and Procedures

- 7.1 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.
- 7.2 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.

- 7.3 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.

7.3.1 Factory and Site Test Plans

A test plan for factory and site acceptance tests shall be submitted for approval, at least four (4) weeks before the start of testing. The test plan shall be a single overview document that defines the overall schedule and individual responsibilities associated with conducting the tests, documenting the test results, and successfully completing the test criteria. Test Plans shall include, at a minimum, the information contained in Table below.

Item	Description
1	Test schedule
2	Record-keeping assignments, procedures and forms
3	Procedures for monitoring, correcting and retesting variances
4	Procedures for controlling and documenting all changes made to the communications equipment after the start of testing

7.3.2 Test Procedures

Test procedures for factory and site testing shall be submitted for the Employer approval at least four (4) weeks before each individual test. Fully approved test procedures shall be submitted to the Employer at least four weeks prior to the commencement of testing. Testing shall not commence without approved test procedures. At a minimum, test procedures shall include the items listed in Table below.

All test equipment and/or instruments shall bear calibration stickers indicating valid calibration on and beyond the testing date. The time elapsed since last calibration shall not exceed the test equipment/ jig manufacturer recommended calibration interval or the interval recommended in the test lab's internal quality procedures.

The Contractor shall ensure that all testing will be performed by qualified testing personnel well experienced in performing such tests.

Item	Description
1	Test Title and Revision Level, if applicable
2	List of Standard(s) complied with
3	Function(s) / parameter(s) to be tested
4	Purpose of each test segment
5	List of required test equipment
6	Description of any special test conditions or special actions required. This includes complete descriptions, listings and user interface procedures for all special hardware and software tools and/or display formats to be used during the test.

7	Test setup including test configuration block diagrams and/or illustrations.
8	Test procedures to be followed.
9	Required inputs and expected outputs for each test segment
10	Acceptance criteria for each test segment.
11	List of test data to be supplied by the Contractor(s) and copies of any certified data to be used
12	Format of test reports.

7.3.3 Test Records

Complete and indexed records of all factory and site acceptance tests results shall be maintained and provided to the Employer by the Contractor in hardcopy. The records shall be keyed to the steps enumerated in the test procedures. The minimal items required in test records are described in Table below.

Item	Description
1.	Test Title and Revision Level, if applicable; contract references
2.	Date and time for test start and test completed
3.	Test title and reference to the appropriate section of the test procedures
4.	Description of any special test conditions or special actions taken (Includes test-case data).
5.	Test results for each test segment including an indication of Passed, Conditional Pass, Incomplete or Failed.
6.	Test procedure modifications made during testing.
7.	Variance Report(s) tracking information and copies (if variance(s) was detected).
8.	Contractor's test engineer(s) identification, signature and remarks
9.	Employer's test witness identification, signature and remarks
10.	List of all attachments
11.	Attachments (including system logs, printouts, variances, hard copies of visual test result displays, etc.)

All principle test records, test certificates and performance curves shall be supplied for all tests carried out as proof of compliance with the specifications and/or each and every specified test. These test certificates, records and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Employer within the specified duration after the completion of test. Information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificates refer, and shall also bear the Contractor's reference and heading

7.3.4 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.

7.3.5 4.1.5 Test Periods Defined

The terminology used in Volume I, General Conditions of Contract and their correlation with the tests requirements described within this section is as follows:

Pre-Commissioning & Commissioning Period - The Site Acceptance Test (SAT)

Operational Acceptance - Successful completion of SAT

7.4 Type Testing

7.4.1 "Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the conditions specified in Chapter 2- GTR

7.4.2 List of Type Tests

The type testing shall be conducted on the following equipment

- SDH Equipment with all types of cards (optical card, Tributary card or any other equipment as part of repeater less links)
- Primary Multiplexer & Drop – Insert Multiplexer with subscriber interface card

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:

a. 4.2.1.1.1 Temperature and Humidity Tests

The tests listed below are defined in IEC Publication 60068.

i. 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:

- **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.
- **Degree of Severity:** Test shall be done at 0°C
- **Acceptance Criteria:** No degradation of performance during and after the test.

ii. 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:

- **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).

- **Degree of Severity:** Test shall be done at -10°C
- **Acceptance Criteria:** Degradation of performance is allowable during the test, however there shall be no degradation of performance in the post-test.

iii. **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:

- **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.
- **Degree of Severity:** As per operation to specification range.
- **Acceptance Criteria:** No degradation of performance during and after the test.

iv. **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:

- **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).
- **Degree of Severity:** Test shall be done at 55°C.
- **Acceptance Criteria:** Degradation of performance is allowable during the test, however there shall be no degradation of performance in the post-test.

v. **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:

- **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.
- **Acceptance Criteria:** The equipment shall meet the specified requirement and there shall not be any degradation in BER.

vi. **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.

- Number of cycles required is five (5)
- **The degree of severity:** temperature TL:0°C, TH: As per operation to specification range
- Cycle duration for each temperature is three (3) hours.

- **Ramp:** 1 oC/minute.
- **Acceptance Criteria:** The equipment shall meet the specified requirement and there shall not be any degradation in BER.

b. Power Supply and EMI/EMC tests

The test procedure and acceptance criteria shall be as defined in IEC 60870-2-1.

i. Immunity Tests

The list of Immunity tests are specified below in Table below.

S. No.	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parameters
1.	Voltage Fluctuations	Yes	Yes	N/A	N/A	Table 11 of IEC 60870-2-1: 1995 - Level : 1
2.	Voltage dips and Interruptions	Yes	Yes	N/A	N/A	
3.	1.2/50 - 8/20 μs surges	Yes	Yes	Yes	N/A	Table 12 of IEC 60870-2-1: 1995 - Level : 4
4.	Fast transient bursts	Yes	Yes	Yes	Yes	
5.	Damped oscillatory waves	Yes	Yes	Yes	Yes	
6.	10/700 μs surges	N/A	N/A	N/A	Yes	
7.	Electrostatic discharge	Yes				Table 13 of IEC 60870-2-1: 1995 - Level : 4
8.	Power frequency magnetic field	Yes				Table 14 of IEC 60870-2-1: 1995 - Level : 4
9.	Damped oscillatory magnetic field	Yes				
10.	Radiated electromagnetic field	Yes				Table 15 of IEC 60870-2-1: 1995 - Level : 4
11.	Power Frequency voltage on control and signal lines	N/A	N/A	Yes	Yes	IEC 61000-4-16 : 2002-07 Level : 4
12.	DC voltage on control and signal lines	N/A	N/A	Yes	N/A	IEC 61000-4-16 : 2002-07 Level : 4

ii. **Emission Tests**

The list of Emission tests are specified below in Table.

S. No.	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parameters
1	LF disturbance voltages CCITT recommendation P.53	N/A	Yes	N/A	N/A	Table 17 of IEC 60870-2-1: 1995 - Class : B
2	RF disturbance voltages CISPR 22	Yes	Yes	N/A	N/A	
3	RF disturbance currents CISPR 22	N/A	N/A	N/A	Yes	
4	RF radiated fields CISPR 22	Yes				

iii. **Insulation Withstand Voltages**

As per section 6 of IEC 870-2-1. Recommended class: VW1 of Table 18.

c. **Mechanical Tests**i. **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.

ii. **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.

7.5 Factory Acceptance Tests

- 7.5.1 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 Equipment, associated line & tributary cards, Termination Equipment (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.
- 7.5.2 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 authorized representatives unless waiver for witnessing by Employer's representatives is intimated to the contractor.
- 7.5.3 Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.
- 7.5.4 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.
- 7.5.5 For Test equipment & clock, FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer's final inspection certificate/report.

Factory Acceptance Testing Requirements for Termination Equipment (MUX)

Item	Description
1.	Physical Inspection for conformance to DRS, BOQ, drawings and appearance of equipment
2.	Performance of supervision, alarm, control and switching systems, diagnostics, loopbacks, Craftsperson interface etc.
3.	Electrical interface tests which include: output and input jitter, bit error rate, pulse shape, cable compensation, and line rate tolerance for the channel banks/low-level multiplexers
4.	Framing, signaling, and operational and maintenance tests consistent with applicable ITU-T requirements
5.	Simulation of failure conditions and failover of each redundant unit
6.	Test of spare card slots and test of spare parts/modules/cards as per applicable tests
7.	Checks of power supply/converter voltage margins and short circuit and overvoltage protection
8.	Random inspections to verify the accuracy of documentation

Factory Acceptance Testing on Craft Terminal

Item	Description
1.	Physical inspection of Craft Terminal hardware for conformance to approved BoQ, DRS & drawing
2.	Testing of Craft Terminal to demonstrate proper operation of all functions

7.6 Site Acceptance Tests

- 7.6.1 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.
- 7.6.2 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.
- 7.6.3 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.
- 7.6.4 Phases for Site Acceptance Testing

The SAT shall be completed in following phases:

a. 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 Chapter.

b. 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 requirement shall be demonstrated as per RFC 2544:

- Ping test
- Throughput test
- Latency test
- 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 equipment 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.

c. 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:

- Equipment configuration shall be checked to establish that it supports the channel routing.
- End to end testing of all individual voice circuits
- End-to-end testing of all individual Data Circuits.
- Demonstration of Protection switching and synchronization of equipment as per synchronization plan.

Fibre Optic Transmission System Installation Testing

Item	Description
1.	Physical Inspection for conformance to drawings, rack elevations and appearance of equipment and cabling
2.	Station power supply input and equipment power supply (DC-DC converter) output voltage measurements
3.	Terminal transceiver performance testing (Tx power, Tx spectrum, receive signal strength, connector losses etc.)
4.	Service channel performance
5.	Craftsperson interface, alarm and control functional performance
6.	Rack and local alarms: No alarms shall be present and all alarms shall be demonstrated to be functional
7.	Network management interface and supervision performance
8.	Correct configuration, level setting & adjustments and termination of Input/ output interfaces
9.	Proper establishment of Safety and signalling earthing system and resistance to ground to be checked.
10.	Simulation of failure conditions and failover of protected components.

Termination Equipment Sub-System Installation Testing

Item	Description
1.	Physical Inspection for conformance to drawings, rack elevations and appearance of equipment and cabling
2.	Power supply/converter voltage measurements
3.	Muldem performance testing
4.	Craftsperson interface, alarm and control functional performance
5.	Rack and Local alarms
6.	Network management interface and supervision performance
7.	Channel performance
8.	Safety and signalling earthing system
9.	Simulation of failure conditions and failover of protected components.

NMS Installation Testing (if Applicable)

Item	Description
1.	Physical inspection for conformance to drawings, rack elevations and appearance of equipment and cabling
2.	Workstation hardware inventory, configuration and characteristics
3.	Demonstration of proper operation of all hardware, including workstations peripherals

8. Training for Operational Staffs

The Contractor shall design and arrange a training programme at his own cost at the manufacturer's premises at least for seven (7) days for the Fibre Optic Based Communication system for two concerned NEA personnel so as to make them competent enough to operate and maintain the proposed equipment/system. The overview of such programme shall be proposed by the prospective contractor along with its technical proposal. The Employer and the Project Manager or their designated representatives shall be entitled to attend such training at their own cost.

Volume II

Section 6: Employer's Requirements

CHAPTER 19: INSPECTION TESTING AND COMMISSIONING

Table of Contents

1.	Scope of Work	2
2.	Objective	2
3.	Quality Assurance Inspection and Testing.....	2
4.	Tests at Manufacturers Works	3
5.	Responsibilities.....	5
6.	Safety Procedures	5
7.	Training of the Employer's Staff	5
8.	Commissioning Staff.....	6
9.	Test Equipment	6
10.	Commissioning Program	6

CHAPTER 19

INSPECTION TESTING AND COMMISSIONING

1. Scope of Work

- 1.1 The whole of the Works supplied under the Contract shall be subject to inspections and tests by the Employer or their Representatives during manufacture, erection and after completion. The inspections and tests shall include, but not be limited to, the requirements of this section of the Specifications.
- 1.2 The Contractor shall provide all costs, appliances, apparatus, supervision, labor and services necessary to carry out all tests, unless specifically stated otherwise.
- 1.3 The Contractor shall furnish the detailed schedule of his commissioning plan at least one month prior to the scheduled date. The schedule shall include the commissioning procedures, testing sequences and details of special testing equipment, tests and commissioning record formats, information about relevant standards etc.
- 1.4 The scope of the commissioning program includes the site testing and putting into successful operation of all the equipment supplied under the Contract, for 132kV, 33kV, 11kV, AC & DC plants and all secondary voltages systems. Testing of energy meters and certification of their accuracy shall also be included.

2. Objective

- 2.1 The objectives of commissioning work, prior to the successful energization of Plant at full voltage and connection to the system, are the following:
 - a. Confirm the integrity (correctness) of installation.
 - b. Confirm the integrity of insulation, connections and phasing.
 - c. Ensure proof of equipment characteristics.
 - d. Review workmanship.
 - e. Confirm the correct implementation of the design.
 - f. Check equipment ratings.
 - g. Check settings and operation of protective relays.
 - h. Check and measure resistivity of earthing grid and earthing system.
 - i. Confirm the proper functioning of SCADA system.

3. Quality Assurance Inspection and Testing

- 3.1 To assure that the supply and services under the scope of this Contract whether manufactured or performed within the Contractor's works or at his subcontractor's premises or at the Site or at any other place of work, are in accordance with the Specifications, the Contractor shall adopt suitable quality assurance program to control such activities at all points necessary. Such program shall be outlined by the Contractor and shall be finally accepted by the Employer after discussions before the award of the Contract. A quality assurance program of the Contractor shall generally cover, but not be limited to the following:
 - a. His organization structure for the management and implementation of the proposed quality assurance program.
 - b. Documentation control system.
 - c. Qualification data for bidder's key personnel.

- d. The procedure for purchases of materials, parts, components, and selection of sub-contractor's services including vendor analysis, source inspection, incoming raw materials inspection, and verification of materials purchases.
 - e. System for shop manufacturing including process controls and fabrication and assembly controls.
 - f. Control of non-conforming items and system for corrective actions.
 - g. Control of calibration and testing of measuring and testing equipment.
 - h. Inspection and test procedure for manufacture.
 - i. System for indication and appraisal of inspection status.
 - j. System for quality audits.
 - k. System for authorizing release of manufactured products to the Employer.
 - l. System for maintenance of records.
 - m. System for handling storage and delivery.
 - n. A quality plan detailing out the specific quality control procedure adopting for controlling the quality characteristics relevant to each item of supply.
- 3.2 The quality plan shall be mutually discussed and approved by the Employer after incorporating necessary corrections by the Contractor as may be required.

3.3 **Quality Assurance Documents**

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

The Employer, through his duly authorized representatives, reserves the right to carry out Quality Audit and Quality Surveillance of the systems and the procedures of the Contractor's and the subcontractor's Quality Management and Control Activities.

3.4 **Inspection, Testing and Inspection Certificates**

The provisions of the clauses on Test and Inspection of the General Conditions of Contract and Special Conditions of Contract shall be applicable to the supply and erection portions of the Works. The Employer shall have the right to re-inspect at his expenses, any material though it would have been previously inspected and approved by him at the Contractor's works before, and if, after the same are inspected at Site following the latter, material is found defective, then the Contractor shall bear the cost of this inspection and reinstatement according to specification.

4. **Tests at Manufacturers Works**

4.1 **General**

Where no specific test is specified, then the various items of materials and equipment shall be tested in accordance with the relevant British, IEC, or American Standards. Where no appropriate standard is available, tests shall be carried out in accordance with the maker's standard practice, which shall be subject to the Employer's approval.

Inspection of equipment will not be carried out unless the Employer has approved copies of the relevant sub-orders, drawings and test procedures.

No equipment shall be packed, prepared for shipment, or dismantled for the purpose of packing for shipment, unless it has been satisfactorily inspected, or inspection has been waived by the Employer.

Functional electrical and mechanical tests shall be carried out on the completed plant after assembly in the Works. The extent and method of recording the results shall be

agreed by the Employer in sufficient time to enable the tests to be satisfactorily witnessed or to make any changes to the proposed program of tests.

All instruments and apparatus used in the performance of the tests shall be subject to the approval of the Employer and, if required by the Employer, shall be calibrated to an agreed standard at a laboratory of national standing to be nominated by the Contractor and approved by the Employer.

The costs of carrying out such calibration shall be borne by the Contractor in all cases.

The costs of making any test shall be borne by the Contractor. This shall apply to tests performed at the site or elsewhere.

After receiving the prior information about the completion of manufacturing at the factory, the Employer will depute his personnel to the Contractor's factory to witness the fabrication, assembly and testing of any or all parts of major equipment. The number of the Employer's personnel and equipment to be witnessed will be as listed below. The duration of such visits shall be as per inspection/ testing requirements.

a.	132 kV Circuit Breakers	2 persons, 1 visit
b.	Power Transformer/Station transformer	
	- Core and Coil Inspection	2 persons, 1 visit
	- Final Inspection	2 persons, 1 visit
c.	Control & Relay Panels	2 persons, 1 visit
d.	Disconnecting Switch	2 persons, 1 visit
e.	Instrument transformers	2 persons, 1 visit
f.	Lightning Arrestor	1 person, 1 visit
g.	33kV Circuit Breakers	2 person, 1 visit
h.	132 kV XPLE Cable	2 person, 1 visit
i.	33 and 11 kV XLPE Power Cable	1-person, 1 visit
j.	Substation Automation System	2-person, 1 visit
k.	SCADA/Communication System	2-person, 1 visit
l.	Surveillance System	1 person, 1 visit
m.	Battery and Battery Charger	1 person, 1 visit
n.	132 kV/ 33 kV steel structures	1 person, 1 visit

Note:

The duration of final factory testing & inspection of Control & Relay Panels of 132 kV and 33 kV system complete shall be 10 days.

Final Inspection for power transformer 132/33 kV transformer, and one station transformer of 33/0.4 kV shall be performed and total duration shall not be less than 10 days.

The duration of final factory testing & inspection all other equipment shall be seven (7) days.

4.2 Test Certificate

Within 30 days of the completion of any test, triplicate sets of all principal test records, test certificates and performance curves shall be supplied to the Employer.

These test records, certificates and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Employer or his representative. The information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificate refers and should also bear the Contract reference title. Specified requirements shall be shown on each certificate for comparison with actual test results.

When all equipment has been tested, test certificates of all factory and site tests shall be compiled by the Contractor into volumes and bound in an approved form complete with index. Two copies of each volume shall be supplied to the Consultant and five copies to the Employer.

4.3 Type Test

Type tests are required to prove the general design of the equipment and the Contractor may submit certificates of such design tests, which have been carried out on identical equipment. Notwithstanding any provision in BS, IEC or ANSI Standards, the Employer shall have the right to accept such certificates in lieu of the specified type tests or to reject them.

The type tests prescribed shall be carried out at the Contractor's cost in all cases, where either such certificates are not available or are rejected by the Employer.

5. Responsibilities

- 5.1 To ensure that the test jurisdiction and transfer of responsibilities is regulated by strict safety and handover procedures, the Contractor agrees the interface with the Employer to establish and implement handover procedures consistent with the terms of these Specifications.
- 5.2 The Employer shall retain full jurisdiction over all commissioning activities, which may affect the operation of the existing system. In these circumstances and when so requested, shall provide technical advices and assistances.
- 5.3 The Contractor shall be responsible for technical guidance and assistance in establishing the scope and method of tests, witnessing of the testing, assessment of results, and re-negotiation of the changes in test schedules which may be necessary as a result of other circumstances, such as delays in the delivery, possible equipment failures.

6. Safety Procedures

- 6.1 The Contractor shall share the responsibility for safety procedures with the Employer. The Contractor shall establish and implement a work permit and tagging system and associated safety procedures (subject to the review of Employer) for all equipment, systems and areas not covered by the Employer's safety procedures.
- 6.2 The Employer will assume responsibility for the establishment and implementation of tagging, safety and work permit procedures for the protection of personnel and equipment, as soon as equipment and systems are connected to or are energizable from the existing system.

7. Training of the Employer's Staff

- 7.1 The Contractor shall plan for the Employer's staffs' participation, either continuously or on a regularly recurring basis as specified in the BOQ.
- 7.2 Allow the Employer's staffs to become familiar with the operating and maintenance aspects of the new equipment supplied by him,

- 7.3 Maintain a continuing assessment with the Employer of the precautions required in or possible consequences of, initial energization of equipment, Allow for the above two necessary objectives in the preparation of schedules.
- 7.4 The Contractor shall have station at site, at least, one technical expert for a minimum of six months continuously after commissioning to rectify any problems, as well as train the Employer's attending staffs. If required, the length of his stay shall be extended as per requirement, which shall be at the Employer's discretion.

8. Commissioning Staff

- 8.1 The Contractor shall provide commissioning personnel including skilled and unskilled labor as required. Submit a list with names, experience and proposed duration of the stay of key personnel on site, consistent with the construction schedule, along with the commissioning program.
- 8.2 Ensure that only staffs assigned to commissioning fulfills that duty for the duration of the assignment.
- 8.3 Ensure that commissioning staffs have authorization, and the competence, to undertake minor repairs or to make temporary redesigns and to reconnect systems to meet the specified system performance to preclude delays in energization and putting into commercial service of any part of the works.

9. Test Equipment

- 9.1 The Contractor shall ensure that all instruments, tools and other equipment required for testing and commissioning are available on site, ensure that the test equipment is of satisfactory quality and condition and, where necessary, is calibrated by an approved authority or standard.
- 9.2 Make arrangements for the provision of power supplies for testing with necessary vector configuration, voltage and current rating.

10. Commissioning Program

- 10.1 Prepare a commissioning program for approval by the Employer and for incorporation into the Project master construction program. Allocate adequate time in this program to permit full commissioning of all components.
- 10.2 Carry out all testing during normal working hours as far as practicable. Tests, which involve existing apparatus and system outages, may be carried out outside normal working hours. Give the Employer sufficient notice to allow for the necessary outage arrangements to be made in conformity with the testing program.
- 10.3 Note that no tests listed in the agreed program will be waived except upon the instructions or consent of the Employer in writing.

10.4 Test Procedures

The following basic tests, in addition to others, shall be carried out:

- Measurement of insulation resistance.
- AC withstand voltage test

10.5 Requirements for Field Tests

The field tests shall be carried out in presence of Employer under the following conditions:

- AC withstand test voltages for conductors and outdoor equipment shall be normal operation voltage of the transmission line and, withstand voltage test shall be carried out for ten (10) minutes by the normal voltage mentioned above.

The field tests shall be carried out by the Contractor after adjustment of all the equipment have been completed.

- Expandable and lead wires and other materials required for the field tests shall be arranged by the Contractor. The Contractor shall be responsible for providing all measuring instruments, test equipment and tools required for the tests.
- Preparation of the test record sheets and test reports shall be the responsibility of the Contractor and the results of the field tests shall be submitted by the Contractor for Employer's approval.
- Measurement of insulation resistance of the equipment shall be performed by at least 5000 V megger.
- After completion of the measurement of insulation resistance mentioned above, ac withstand voltage test shall be performed by the normal operation voltage of the existing power system in accordance with the following procedure:
- **132 kV and 33 kV Main Circuit:**
The 33 kV and 132 kV circuit breakers and disconnecting switches, except for circuit breakers receiving power for the test from the existing power system through a transmission line, shall be closed, succeeding, normal operation voltage shall be charged on the equipment and bus conductors for ten (10) minutes for ac withstand voltage test. The indication value of meters mounted on the board during the ac withstand voltage test shall be recorded on the test record sheets prepared by the Contractor.
- Submit test procedures, consisting of detailed test methods and samples of the related test record forms, for all equipment to be tested, to the Employer for approval along with the commissioning program. Strictly adhere to these procedures for the commissioning tests.

10.6 Records

Maintain an up-to-date record of all commissioning activities on site. Record the results of the tests clearly on forms and formats approved by the Employer and with clear references to the equipment and items tested, so that the record can be used as the basis for maintenance tests, in future. Submit the required number of site test records to the Employer as soon as possible after completion of the tests.

Record the details of the test equipment and instruments used in the test sheets, in those cases where the instrument or equipment characteristics can have a bearing on the test results.

10.7 "As-Built" Drawings

Keep an ongoing record of all changes on a master set of drawings. Produce and supply a minimum of five complete sets of marked-up "As Constructed/As-Built" drawings before leaving the Site. Correct and re-issue the original drawings as soon as possible as per this specification.

10.8 Test Methods

Carry out all necessary tests for commissioning the substations. The following clauses detail the tests which are considered to represent the minimum required in addition to those specified under the appropriate IEC Publications, other approved standards and the manufacturer's instructions for each item of equipment.

Strictly adhere to the methods of testing approved by the Employer.

- a. **Site and Commissioning Tests for Main and Auxiliary Equipment**

General Checks:

Make a general check of all main and auxiliary equipment. Include a check of the completeness, correctness and condition of ground connections, labeling, arcing ring, paint surfaces, cables, wiring, pipe-work, valves, blanking plates and all other auxiliary and ancillary items.

Check for oil and gas leaks and that insulators are clean and free from external damage. Check that loose items, which are to be handed over to the Employer, e.g., blanking plates, tools, spares, etc. are in order and are correctly stored or handed over.

Power Transformers

Make all tests as per commissioning tests called for in the Manufacturers' instructions manual.

Record and submit to Employer in a hardcover binder, all test data obtained.

Circuit Breaker Tests

For the SF6 circuit breakers, test the gas system to prove the gas density, its dryness and its dielectric strength. Measure the gas leakage rate.

Check and set pressure switches settings when required. Also test mechanical operating systems.

Carry out contact resistance tests. In the case of multi-interrupter circuit breakers, perform resistance tests at each interrupter or pair of interrupters as well as through the series of interrupters on each pole.

Test local and remote trip/close operation and perform circuit breaker and auxiliary contact timing tests on all circuit breakers.

Control/ Relay Panels, energy meters and Switchboards

Carry out general testing and inspection, as referred to above. The Contractor shall also carry following tests: a) Carrier signal testing b) protective relay testing c) Instrument transformers testing c) Phase correcting testing. Functionally test and perform the timing tests on circuit breakers and AC and DC circuits, associated with stand-by auxiliary supplies and stand-by generating sets, particularly where automatic operation is defined.

Carry out insulation measurement tests of secondary circuits with a 1000 V DC megger before and after high voltage testing.

Check shutters, interlocking, earth procedures and the inter-changeability of components.

Carry out a high voltage 50 Hz dielectric test on each bus at 75% of the specified value for the equivalent factory test.

Disconnecting Switch and Earth Switches

Test all disconnecting switch and earth switches operationally to confirm contact pressures, contact resistance, simultaneous-operation of all phases and the ease of operation. Check the local and remote indications and the operation of auxiliary contacts. Check the earthing mat at the operating positions and check the availability of connecting points for maintenance earthing arrangements.

Test the earth switches and maintenance earthing devices to confirm the opening and closing sequences and check the ground mat connections, indications and manual locking devices.

Lightning Arresters

Inspect and verify the condition and satisfactory mounting of the arresters and their earth connections, electrodes and operation counters. Note the counter readings.

Bus bars and Connections

Test flexible bus bars and connections to ensure that the correct tensions, sags and clearances will be maintained over the range of environmental conditions and loads without stress to other equipment. If dynamometers are used to check the sags and tensions, check them before and after use.

Check rigid bus bars and connections to ensure that the bus bars will not cause overloading of the supporting insulators under load conditions and under the range of climatic variations applicable to the Site. Ensure that expansion and contraction of the equipment is fully accommodated by flexible connections.

Test conductivity on selected connections and joints.

Perform high voltage DC tests on all HV cables and isolated phase bus bars at 75% of the specified value for the equivalent factory test. Carry out with at least 1000 V DC megger the insulation measurement test, before and after high voltage tests.

Interlocking: Check all interlocking arrangements, both electrical and mechanical.

b. Earthing System

Carry out the tests and measurements in accordance with IEEE Standard 80. Test the effectiveness of the bonding and earthing and make conductivity tests on selected joints on the main earthing system and at the connections to equipment and structures. Check the precautions taken to avoid corrosion attack on the earthing system.

Measure the resistance of the earthing system to the remote earth indicating method and equipment used. Separate test probes of minimum 300 to 600 meters length to effectively test the earthing system.

Perform earthing resistance measurements with the transmission line earth wires disconnected from the grounding grid.

c. Area Lighting

Check all lighting circuits including the operation of relevant photoelectric cells and remote/local commands.

Measure the lighting levels throughout the substation on horizontal surface 800 mm above ground level and on all vertical surfaces of transformers, marshaling kiosks, etc. Measure the lighting levels in the area surrounding the substation up to 20 m from the fence.

d. Particular Constraints and Special Tests

The Contractor shall be prepared to cooperate with any special tests requested by the Employer.

Volume II

Section 6: Employer's Requirements

CHAPTER 20: SITE CIVIL WORKS

Table of Contents

1.	General.....	2
2.	Scope of Works	2
3.	General Official Accessories	3
4.	Geotechnical Investigation	3
5.	Site Clearing, Contour Survey and Site Levelling	7
6.	Site Preparation, Excavation, Backfill and Disposal of Surplus	11
7.	Antiweed Treatment and Stone Spreading	13
8.	Site Drainage	15
9.	Roads.....	16
10.	Transformers, Rail Track/Rail cum Road.....	16
11.	Fire Protection Walls	17
12.	Cable Trenches and Cable Trench Crossings	17
13.	Foundation/RCC Construction.....	18
14.	Reinforcement.....	23
15.	Formwork.....	27
16.	Boundary and Chain-Link Fencing and Gates	29
17.	Water Supply	31
18.	Sewerage System	31
19.	Buildings-General Requirements.....	31
20.	Mode of Measurement	42
21.	Miscellaneous Requirements	46
22.	Interfacing	47
23.	Statutory Rules	48
24.	Field Quality Plan.....	48
25.	Standard Codes	48

CHAPTER 20

SITE CIVIL WORKS

1. General

- 1.1 The intent of these specifications covers the Design, engineering, drawing, and construction of all civil works at the substation. All civil works shall also satisfy the general technical requirements specified in other chapters of Specification and as detailed below. They shall be designed to the required service conditions/loads as specified elsewhere in this Specification or implied as per relevant British standard codes (BS Codes)/Indian Standard Code (IS Code)/ equivalent International Standards.
- 1.2 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.
- 1.3 The Contractor shall furnish all design, drawings, labor, 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 the complete performance of the Works following approved drawings, specifications and direction of the Employer.
- 1.4 The work shall be carried out according to the design/drawings to be developed by the Contractor and approved by the NEA on the recommendation of the 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. Scope of Works

- 2.1 The following works shall be carried out at Kalanga Substation to be constructed at Kalanga, Bajhang under Nepal Distribution System Upgrade and Expansion Project (EIB) to complete the civil and architectural works in all respects, as required for the proper functioning of the substation.
 - a. Exploration works for soil strength for foundations of steel-structures, equipment, control buildings, and roads.
 - b. All offices, housing facilities, plants and equipment, temporary structures and works, temporary construction and access roads, and everything else which will be used or needed for the performance of the works.
 - c. Site clearing and stripping
 - d. Site grading
 - e. Design, manufacture, supply, installation, and testing of substation steel structures with their accessories.
 - f. Design of RCC foundations of steel structures equipment, lighting fixtures, control building, staff quarters building, etc.
 - g. Design and construction of approach roads
 - h. Construction of cable trench system, conduit, duct bank, and hand hole
 - i. Design and construction of control building and other required utilities
 - j. Crushed rock surfacing in the switchyard

- k. Construction of complete drainage system including switchyard and substation area with RCC slab cover
 - l. Supply and construction of water supply system
 - m. Design, supply, installation, and construction of ventilation and air-conditioning equipment/units in the control buildings and staff quarter as specified
 - n. Design, supply, and installation of Illumination systems for all buildings including Staff Quarter, Guard, Vehicle Parking shade, badminton court, outdoor Switchyard, Substation area, internal as well as the access road to the Substation
 - o. Supply and installation of miscellaneous outdoor facilities as specified in this chapter
 - p. Design and construction of protection works
 - q. Design and construction of switchyard fence and gate/s
 - r. Design and construction of slump pit/pits for transformer oil
 - s. All associated and necessary civil and architectural works to complete the specified scope of work
 - t. Design and construction of parking shade for vehicles
 - u. Other miscellaneous items as per BOQ
- 2.2 A final layout for site installation shall be prepared by the Contractor and approved by the Employer before any construction work takes place at the site.

3. General Official Accessories

3.1 Office Accommodation

- 3.1.1 The contractor shall provide at his own expense adequate temporary accommodation and toilet facilities for his worker as well as working office space for his staff and Employer/Engineer on duty for construction supervision and keep the same in good order. This may be done to suit site conditions with the approval of the Employer. The above-mentioned temporary structures shall be removed on the completion of works at the Contractor's own cost.

3.2 Boards

- 3.2.1 A board of size of 1.5m x 1.0m shall be made and put at an approved place on the site. This board shall be painted in the approved colour with names of (a) The proposed construction, (b) The Contractor, (c) The Employer, and other details as directed by the Employer/ Engineer.

4. Geotechnical Investigation

4.1 General

- 4.1.1 Soil investigation report conducted by Kalanga Hydro Power Station (KHPS) if avail to NEA and found acceptable, then soil investigation shall not be carried out. If not, the Contractor shall carry out the soil investigation in the substation locations. This specification covers all the work done for detailed soil investigation and preparation of a detailed report. The work includes mobilization of necessary equipment, providing necessary engineering supervision and technical personnel, skilled and unskilled labor, 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.

- 4.1.2 All the work has to be carried out as per the latest edition of the corresponding relevant British standard codes (BS Codes)/Indian Standard Code (IS Codes)/equivalent International Standards. The Agency carrying out the soil investigation work must have experience in carrying out soil investigation successfully in the relevant field.

4.2 Bore Holes

- 4.2.1 Bore holes of a minimum 100 mm diameter in accordance with the provisions of relevant international standards/British standards (BS)/IS.
- 4.2.2 The number of boring shall be at least 3 borings at the locations specified below:
- One at take-off structure foundation
 - One at transformers foundation
 - One at control building location.
- 4.2.3 The soil investigation shall be up to 9-meter depth (Minimum) or to refusal which ever occur earlier. In any case number of boreholes shall not be less than four. 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 is varying from borehole to borehole in order to have fair idea of soil profile. In case rock is encountered, coring in all the boreholes shall be carried out up to 3 meter in rock.
- 4.2.4 Performing Standard Penetration Tests at approximately 1.5 m interval in the borehole starting from 0.5 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 (BS Codes)/Indian Standard Code (IS Code)/ equivalent International Standards.
- 4.2.5 Undisturbed samples shall be collected in accordance with the recommendation of relevant British standard codes (B S Codes)/Indian Standard Code (IS Code)/ equivalent International Standards. Or an alternative recognize method as agreed by Employer. Undisturbed samples shall be taken in cohesive material or weak cemented granular material wherever possible at 1 m interval or at each change in stratum.
- 4.2.6 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.
- 4.2.7 All samples, both disturbed and undisturbed, shall be identified properly with the borehole number and depth from which they have been taken.
- 4.2.8 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.
- 4.2.9 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.

4.3 Trial Pits

- 4.3.1 The Contractor shall excavate two number trial pits per substation as and were directed by Employer, of Plan area 4 m² and not exceeding 4 m depth. Undisturbed samples shall be taken from the trial pits as per the direction of

the Employer. All Trial Pits shall be re-filled with approved material after the tests are complete and shall be well compacted in layers of not exceeding 300 mm in thickness in loose stage measurement.

4.4 Electrical Resistivity Test

4.4.1 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 equipment and other accessories required for performing electrical resistivity test, the test procedure, and reporting of field observations shall confirm to relevant British standard codes (BS Codes)/Indian Standard Code (IS Code)/ equivalent International Standards. The test shall be conducted using Wagner's four electrode method as specified in relevant British standard codes (BS Codes)/Indian Standard Codes (IS Code)/ equivalent International Standards. Unless otherwise specified at each test location, the test shall be conducted along two perpendicular lines parallel to the coordinate axis. On each line, a minimum of 8 to 10 readings shall be taken by changing the spacing of the electrodes from an initial small value of 0.2 m up to a distance of 50 m.

4.5 Water Sample

4.5.1 In case ground water table is encountered; 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.

4.6 Back Filling of Bore Holes

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

4.7 Laboratory Test

4.7.1 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.

4.7.2 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 (BS Codes)/Indian Standard Code (IS Code)/ equivalent International Standards.

4.7.3 The following laboratory tests shall be carried out:

- a. Visual and Engineering Classification
- b. Atterberg limits Tests.
- c. Natural moisture content, Optimum 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)/Indian standard code (IS code)/equivalent International Standards including following tests shall also be conducted.
 - UCC test.
 - Point load index test

4.8 Test Results and Reports

4.7.4 The Contractor shall submit the detailed report in two (2) copies wherein information regarding the geological detail of the site, summarized 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 to Employer. Initially the contractor shall submit draft report and after the draft report is approved, the final report in two (2) copies shall be submitted. The field and laboratory test data shall bear the signatures of the Investigation Agency, Contractor and also site representative.

4.7.5 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.
- c. Test results of field and laboratory tests shall be summarized 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.
- d. **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 Employer. The observations and recommendations shall include but not limited to the following:
 - 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.
 - 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.
 - 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 2.0 (two). Recommendation of liquefaction characteristics of soil if applicable shall be provided.
- Recommendations regarding slope of excavations and dewatering schemes, if required.
 - 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.
 - If expansive soil is met with, recommendations on removal or retention 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 of materials to be used, construction method, equipment to be deployed etc. shall be furnished. An illustrative diagram of a symbolic foundation showing details shall be furnished.
 - Recommendations for additional investigations beyond the scope of the present work, if considered such investigation as necessary.
 - In case of foundation in rocky strata, the type of foundation and recommendation regarding rock anchoring, etc. should also be given.

5. Site Clearing, Contour Survey and Site Levelling

5.1 Scope

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

5.2 General

- 5.2.1 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.
- 5.2.2 Work covered under this clause comprises the site clearance, survey work/setting out and making profiles, Earth work in Excavation and filling in specified area with all lifts and leads and earth work in filling with borrowed earth with all leads and lifts (Borrow areas including payment of royalty for borrowed earth shall be arranged by the Contractor at his own cost). During detailed engineering stage, the Contractor will prepare the levelling proposal for optimum levelling and submit to Employer for approval. The earthwork is calculated by making cross-section of contour plan at 5m interval along longitudinal and transverse direction separately, final quantity of earthwork is the average of quantity at longitudinal and transverse direction. 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 Employer for approval.
- 5.2.3 Filling material shall conform to relevant British standard codes (BS Codes)/ IS/ 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 (BS Codes)/IS/ equivalent International Standards.

5.3 Site Clearing

- 5.3.1 The work shall consist of the numbering of trees, removing and disposing of all materials such as trees, bushes, woods, shrubs, grass, stumps, rubbish, rank vegetation, roots, foreign materials, 150 mm of topsoil, etc., which in the opinion of the Employer are unsuitable for incorporation in the works, from within the limits and areas as may be specified by the Employer.
- 5.3.2 All trees shall also be cut, and useful portion of the trees so cut shall be stacked at a suitable place directed by the Employer and shall be considered incidental to clearing and grubbing operations.
- 5.3.3 The roots of trees shall be dug up to 60 cm below the ground level or 15 cm below formation level whichever is deeper and after removal of all vegetable and organic matter from the holes so formed by removal of the roots, holes and hollows shall be filled with good earth in layer of 20 cm, well rammed, consolidated and levelled.
- 5.3.4 The serviceable and unserviceable materials obtained from the site clearance shall be removed from the area and disposed of to a place as per the directions of the Employer.
- 5.3.5 Clearing and grubbing item is not payable and the same shall be deemed to be included in the earthwork in site leveling

5.4 Contour Survey and Site Levelling

- 5.5.1 The land for construction of substation will be handed over to the successful Bidder as on where basis progressively after award of work. The Contractor shall carry out survey work by taking spot level with respect to temporary benchmark transferred from permanent bench mark in the locality if available either on bridge/railway platform or government buildings of local authorities. The Contractor shall submit the spot levels in editable soft copy in spreadsheet format and contour map with contour interval of 0.5 m in editable AutoCAD or similar software drawing and in pdf.
- 5.5.2 The Contractor will level the area required for construction of substation work either at single level, multi-level or gradual slope with the finished ground level as approved by the Employer during detailed engineering based on highest flood level. The levelling area shall be decided by Employer during detailed Engineering stage.
- 5.5.3 The layout and levels of all structure etc. shall be made by the Contractor at his own cost from the plot and benchmarks set by the Contractor and approved by the Employer. The Contractor shall provide all assistance in instruments, materials and personnel to Employer for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.
- 5.5.4 The filling of the substation shall be such that, it is higher than the ground level by at least 0.6 m in all locations and by more than 2 m as well, if required by the Employer.

5.5 Slope Protection Work in Filling Area

- 5.5.1 This clause covers slope protection work in the filling area if the height of the filling is very high. The requirement of slope protection work is decided by the Employer.

5.5.2 Grouted Stone Pitching

It covers the furnishing of materials and construction of a protective covering in stone pitching on exposed surfaces such as earth slopes. The area shall be prepared by excavating, shaping and trimming to accommodate the stone work and shall be thoroughly compacted. A trench shall be excavated as directed by the Engineer along the toe of any slope to be pitched or along the unprotected edge of the pitching in the bed of streams. The spaces between the stones shall be filled with 1:3 cement sand mortar. Before the mortar is applied the surfaces of the stones shall be thoroughly cleaned of adhering dust and vegetation and then moistened.

The mortar shall be placed in a continuous operation for any day's run at any one location. The mortar shall be worked in to the pitching so as to ensure that all spaces or voids between the stones are completely filled with mortar and to the depth of stone pitching.

After the grout has been placed, the stones shall be thoroughly brushed so that their top surfaces are exposed. The grouted pitching shall be cured for a period of not less than four days after grouting with wet sacking or other approved wet cover, and shall not be subjected to loading until adequate strength has been developed. Where required, or instructed by the Engineer, weep holes shall be formed in the pitching.

Materials

Stone: Stone for pitching shall be sound, tough and durable, with no stone less than 100 mm in minimum dimension, except that smaller pieces or spalls may be used for filling spaces between the larger stones. Stone shall be of such a shape as to form a stable protection structure of the required section. All stone intended for use on any particular pitching job shall receive the prior approval of the Employer.

Mortar: Mortar for all stonework shall consist of cement and clean, sharp, coarse sand. The mortar shall consist of one part cement and 3 parts sand used in pitching stone masonry work.

Water: Water used for mixing mortar shall be in accordance with of NBC 110-2050.

5.5.3 Bio Engineering Work (Grass plantation on sloped Surface)

General

The Contractor shall plant or sow grasses as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.

It is the Contractor's responsibility to ensure that all planting stock, whether provided from a nursery or through a separate instruction, is of high quality and is vigorous enough to grow on the site to be planted.

All seeds and other planting stock must be of species indigenous to Nepal unless otherwise specified. All species must be covered in the current approved lists of species produced from time to time by the Geo-Environmental. They must be appropriate for the precise site conditions in which they are to be planted and the Contractor must ensure that they apply to the specific altitude and other environmental characteristics of the site in question.

The timing of many bio-engineering operations is of the utmost importance. Activities such as planting and seed sowing must be carried out within the critical few weeks when they will yield the desired results. All other operations must be carried out in a timely manner to permit this to happen. The Contractor is responsible to keep works to the strict schedule required and under no circumstances to permit delays.

Sowing of Grasses on Site

The sowing of grasses is intended to create a strengthened slope surface which is resistant to erosion. The Contractor is required to carry out the sowing of grass seeds according to the Employer's representative's specific instructions.

It is assumed that the site will already have been prepared for seed sowing, under a separate instruction; but it is nevertheless the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of grasses.

The Contractor is required to supervise all field operations very closely. The sowing of grass seeds is a delicate business and should be approached in the same way as for agricultural crops. The Contractor should employ experienced agricultural laborer for this work.

Seeds will have been collected and stored under a separate instruction well before the time of sowing. However, it is the Contractor's responsibility to check that it has been carefully stored and remains fully viable.

Immediately before sowing, the ground surface should be lightly scarified to ease early root penetration. Seeds should then be laid thinly over the surface. Under no circumstances should they be broadcast, because the lightness of perennial grass seeds and the steepness of the slopes to be treated give a poor cover using such a technique. The Contractor responsible for ensuring that the correct quantities of seeds are used, while giving a good, even cover.

A cover of 25 grams of grass seed per square meter of surface should be achieved unless otherwise specified.

After sowing, a mulch of prepared and dried cut herbs should be laid over the whole seeded area in a thin layer. If the mulch is too thick it will prevent light from getting to the seed and will inhibit germination. Herbs suitable for this and locally available in large quantities are:

- tite pate (*Artemisia vulgans*);
- tapre (*Cassia* species);
- banmara (*Eupatorium adenophorum*).

However, freshly cut herbs should not be used because of the danger of resprouting and weeding.

If specified, the mulch should be secured with jute netting of mesh size 300 x 500 mm and the netting fixed in place using suitable live pegs or hardwood cuttings (e.g. simali, *Vitexnegundo*) at one meter centers.

5.6 Site Protection/Site Aftercare and Maintenance

- 5.6.1 The Contractor is to protect a planted site for the period specified. Protection is to include the prevention of damage to all manner of site works and plants by local people and domestic or wild animals. It also includes an active role in tending the plants and improving their growth. The period of maintenance by the Contractor will be for six months.

- 5.6.2 The Contractor shall maintain planted bio-engineering sites as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary expertise and resources to ensure that these requirements are met.
- 5.6.3 The Contractor shall carry out weeding as required throughout the site. All annual weeds and other unwanted plants shall be cut just above the ground and the aerial parts will be used to make compost or mulch. Weeds must not be pulled out by the roots since this disturbs the ground surface.
- 5.6.4 Weeding should be carried out throughout the growing season. It must be undertaken with particular diligence at the end of the monsoon, so that there is the minimum amount of competition during the subsequent dry season.
- 5.6.5 The Contractor shall carry out mulching as required throughout the site. All plants required under the bio-engineering specifications will be mulched using material prepared as specified in above, or the aerial parts of weeds cut on the site or brought from elsewhere for the purpose. The desired plants should be kept mulched at all times but especial care must be taken in the spring, when the soil moisture deficit is at its greatest.
- 5.6.6 The Contractor shall replace failed, damaged, diseased and very weak plants, using fresh, healthy plants of the same species, at the correct time of year for planting. This replanting operation will normally be carried out during the monsoon in the year following the first planting works. Vegetation structures will be enriched by the planting of additional cuttings or seedlings, as instructed by the Engineer. Failed seeding areas will be re-seeded at the appropriate time of year.
- 5.6.7 In replanting and enrichment works, the Engineer may specify the use of different species. This will be done where failures of poor performance of plants may be attributed to poor stock or an incorrect initial choice of species.
- 5.6.8 Other maintenance operations are to be undertaken by the Contractor according to the instructions of the Engineer.

6. Site Preparation, Excavation, Backfill and Disposal of Surplus

6.1 Scope

- 6.1.1 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.

6.2 General

- 6.2.1 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 (BS Codes)/ IS/ equivalent International Standards.
- 6.2.2 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.
- 6.2.3 Material unsuitable for founding of foundations shall be removed and replaced by suitable fill material to be approved by the Employer.
- 6.2.4 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 in areas as directed by employer up to a maximum lead of 2 km.

6.3 Site Preparation

- 6.3.1 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 Employer. The Contractor shall give all help in instruments, materials and personnel to the Employer for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

6.4 Excavation and Backfill

- 6.4.1 This clause covers excavation for foundation works of Towers, Equipment support structures, Transformer foundations, External Lighting poles, Cable trenches, Buildings, Fire Wall, Water tanks etc., backfilling of Foundations Works.
- 6.4.2 Excavation and backfill for foundations shall be in accordance with the relevant British standard codes (BS Codes)/ IS code/equivalent International Standards.
- 6.4.3 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.
- 6.4.4 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.
- 6.4.5 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.
- 6.4.6 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.
- 6.4.7 Do not disturb material below the bottom of footing grade. Do not backfill to compensate for excavation that has extended below grade. If excavation occurs below the proposed footing grade, fill the area with M15 concrete at the time the footing is placed. The additional concrete placed will be at the Contractor's expense.

6.5 Compaction

- 6.5.1 The density to which fill materials shall be compacted shall be as per relevant BS/IS and as per direction of Employer. 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).
- 6.5.2 At all times unfinished construction shall have adequate drainage upon completion of the road's surface course, adjacent shoulders shall be given a final shaping, true alignment and grade.

- 6.5.3 Each layer of earth embankment when compacted shall be as close to optimum moisture content as practicable. Embankment material which does not contain sufficient moisture to obtain proper compaction shall be wetted. If the material contains any excess moisture, then it shall be allowed to dry before rolling. The rolling shall begin at the edges overlapping half the width of the roller each time and progress to the centre of the road or towards the building as applicable. Rolling will also be required on rock fills. No compaction shall be carried out in rainy weather.

6.6 Requirement for Fill Material Under Foundation

- 6.6.1 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 Employer.

6.7 Disposal of Surplus Earth

- 6.7.1 The surplus earth generated from foundation work shall be disposed away from levelling area boundary at low lying areas within 2 km 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.

7. Antiweed Treatment and Stone Spreading

7.1 Scope of Work

- 7.1.1 The Contractor shall furnish all labour, equipment and materials required for complete performance of the work in accordance with the drawings, specification.
- 7.1.2 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.

7.2 General Requirement

- 7.2.1 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 Employer.
- 7.2.2 The material to be used for stone filling/site surfacing shall be stone aggregate of 40 mm nominal size (ungraded single size) conforming to Table 2 of IS:383- 1970. Hardness, flakiness shall be as required for wearing courses are given below:

- a. Sieve Analysis limits (Gradation) (IS: 383 - Table - 2)

Sieve size	% Passing for single sided aggregate of nominal size 40 mm by weight
63 mm	100
40 mm	85-100
20 mm	0-20
10 mm	0-5

- b. **Hardness:** Abrasion value (IS:2386Part-IV) - not more than 40%
Impact value (IS: 2386 Part-IV) - not more than 30%.
 - c. **Flakiness Index:** As per IS: 2386 Part -I maximum value is 25%.
- 7.2.3 After all the structures/equipment are erected, anti-weed treatment shall be applied in the switchyard wherever 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 wherever 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 10 M X 10 M (approx.) and shall be sprinkled with water at least once in the afternoon every day after forty-eight hours of application of chemical. The treated area shall be monitored over a period of two to three weeks for any growth of weeds by the Employer. The final approval shall be given by the Employer based on the results.
- 7.2.4 The employer shall decide the final formation level so as to ensure that the site appears uniform and devoid of undulations. The final formation level shall however be very close to the formation level indicated in the approved drawing.
- 7.2.5 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 Employer. The subgrade shall be consolidated by using half ton roller with a suitable water sprinkling arrangement to form a smooth and compact surface. The roller shall run over the subgrade till the soil is evenly and densely consolidated and behaves as an elastic mass.
- 7.2.6 In areas that are considered by the Employer to be too congested with foundations and structures for proper rolling of the site surfacing material by normal rolling equipment, 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.
- 7.2.7 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.
- 7.2.8 Over the prepared sub grade, 75 mm 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, and cable trenches as per the 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.
- 7.2.9 A final layer of 100mm thickness of uncrushed/crushed/broken stone of 40 mm nominal size (ungraded size) shall be spread uniformly over cement concrete layer after curing is complete.

8. Site Drainage

- 8.1 Preparation of overall drainage layout, design, drawing and providing rain water drainage system within the switchyard fencing 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.
- 8.2 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 50-meter away from boundary wall, only 50-meter drain outside the boundary wall is in the scope of contractor.
- 8.3 Outfall point shall be got approved before commencement of construction. While designing the drainage system following points shall be taken care of:
 - a. The surface of the switchyard shall be sloped to prevent the accumulation of water.
 - b. In the switchyard, perforated PVC pipe shall be laid every 0.5 m, aligned with slight sloping towards side drains of both sides, placed on alternating fashion, i.e., for a perforated PVC sloped towards left, two adjacent perforated PVC pipes shall be sloped towards the right
 - c. Drain shall be constructed at suitable locations in such a way that switchyard 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 60 meters. It will be ensured that no area is left undrained. In case of switchyard, the drains at minimum shall be on both longitudinal sides.
 - d. Open surface drains having minimum 300 mm 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 switchyard i.e., from bottom of switchyard stone filling.
 - e. Longitudinal slope shall not be less than 1 in 1000.
 - f. Open surface drains shall be constructed with Brick Masonry. 100 mm thick PCC (1:3:6) shall be laid over 150mm thick layer of stone soling.
 - g. 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.
 - h. 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.
 - i. Pipe drains shall be provided in areas of switchyard where movement of crane will be necessary in operating phase of the substation.
 - j. For pipe drains, 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 (BS Codes)/IS codes/equivalent International Standards shall be followed.
 - k. Suitable number of portable pumps of 0.5 hp capacity for drainage of water shall be provided by the Contractor.
 - l. Pipe drains shall be connected through manholes at an interval of max. 30m.
 - m. If the invert level of outfall point is above the last drain point in the substation boundary, sump of suitable size has to be constructed with in the substation boundary.

- n. The drainage scheme and associated drawings shall be got approved from Employer before commencement of construction.

9. Roads

- 9.1 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 shall be as short and straight as possible.
- 9.2 If any roads has been unearthed for or due to laying of underground cable or any works of the sub-project, then reconstruction of such works to the previous level as per the standard and norms in Nepal lies in the scope of the Contractor and this work shall be done with utmost priority, i.e., the Employer will be able to stop payment if the delay on reconstructing such roads, especially highways and feeder roads, is observed or the work is not satisfactory.
- 9.3 All concrete roads within substation boundary wall shall be with 3.5 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)/stone soling shall be laid.
- 9.4 All roads shall be designed as per relevant British standard codes (B S Codes)/IS Codes/equivalent International Standards. All drawings of road and culverts shall be prepared by the contractor and shall got approved from Employer before commencement of construction.
- 9.5 All the culverts and allied structures (required for road/rail, drain, trench crossings etc.) shall be designed as per relevant British standard codes (BS Codes)/IS Codes/equivalent International Standards.

10. Transformers, Rail Track/Rail cum Road

- 10.1 The Contractor shall design, prepare drawing and provide a RCC Rail cum road system integrated with the Transformer foundation to enable installation and the replacement of any failed unit. The transfer track system shall be suitable to permit the movement of any failed unit fully assembled (including OLTC, bushings) with oil. This system shall enable the removal of any failed unit from its foundation to the nearest road. If trench/drain crossings are required then suitable R.C.C. culverts shall be provided in accordance with relevant BS/IS/equivalent International Standards. The Contractor shall provide a pylon support system for supporting the firefighting system.
- 10.2 Each Transformer including oil conservator tank and cooler banks etc. shall be placed in a self-sufficient pit surrounded by retaining walls (Pit walls). The clear distance of the retaining wall of the pit from the Transformer shall be 20 % of the Transformer height or 0.8 m whichever is more. The oil collection pit thus formed shall have a void volume equal to 200 % volume for 400 kV. 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 a uniform slope towards the sump pit. While designing the oil collection pit, the movement of the Transformer must be taken into account.
- 10.3 The grating shall be made of MS flat of size 40 mmx 5 mm placed at 30 mm center to center and 25 mmx5 mm MS flat at spacing of 150 mm at right angle to each other. Maximum length of grating shall be 2000 mm and width shall not be more than 500 mm. The gratings, supported on ISMB 150 mm, shall be placed at the formation level and will be covered with 100 mm thick layer of broken/crushed/non-crushed stone having size 40 mm to 60 mm which acts as an extinguisher for flaming oil. All steel works used for grating and support in transformer foundation shall be painted with

Zinc phosphate primer (two packs) conforming to relevant British standard codes (BS Codes)/IS/equivalent International Standards.

- 10.4 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.

10.5 **Materials**

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

10.6 **Drainage**

One 0.5 hp pump for each pit shall be supplied and installed by the Contractor to evacuate the firefighting and rainwater from the sump pit in to the nearest drain.

11. Fire Protection Walls

11.1 **General**

Fire protection walls shall be provided, if required, in accordance with the recommendation of the Consultant. 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:

11.2 **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.

11.3 **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 Employer where there is lack of space. A minimum of 2 meter clearance shall be provided between the equipment 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.

11.4 **Materials**

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

12. Cable Trenches and Cable Trench Crossings

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

- 12.2 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)/IS code/ equivalent International Standards.

- 12.3 The cable trench walls shall be designed for the following loads.

- Dead load of 155 kg/m length of cable support + 75 kg on one tier at the outer edge of tier.
- Earth pressure + uniform surcharge pressure of $2T/m^2$.

- 12.4 Cable trench covers shall be designed for self-weight of top slab + concentrated load of 150 kg at center of span on each panel.
- 12.5 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.
- 12.6 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 does not enter the trench.
- 12.7 All metal parts inside the trench shall be connected to the earthing system.
- 12.8 Trench wall shall not foul with the foundation. Suitable clear gap shall be provided.
- 12.9 The trench bed shall have a slope of 1/500 along the run and 1/250 perpendicular to the run.
- 12.10 Cable trenches shall be blocked at the ends if required with brick masonry in cement sand mortar 1:6 and plaster with 12 mm thick 1:6 cement sand mortar.
- 12.11 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.

13. Foundation/RCC Construction

- 13.1 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 equipment, GIS building, Control Building, Diesel Generator(DG) building 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.
- 13.2 Concrete shall conform to the requirements mentioned in relevant British standard codes (B S Codes)/IS Codes/equivalent International Standards and all the tests shall be conducted as per relevant British standard codes (BS Codes)/ IS 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 (BS Codes)/IS Codes/equivalent International Standards.
- 13.3 If the site is sloppy, the foundation height will be adjusted to maintain the exact level of the top of structures to compensate for such slopes. The switchyard foundation's plinths and building plinths shall be a minimum of 300mm and 500 mm above finished ground level respectively. A minimum 75 mm thick lean concrete (1:4:8) shall be provided below all underground structures, foundations, trenches, etc. to provide a base for construction.
- 13.4 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 footing foundation or pile foundation as may be required based on soil/sub-soil conditions and superimposed loads shall be provided.
- 13.5 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 (BS 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.

- 13.6 The cement shall be ordinary Portland cement of approved brand and manufacture and shall comply in all respects with the I.S. 269-1967 for ordinary Portland cement. It shall be delivered on the site in packages with an unbroken seal fixed by the manufacturer and plainly marked with the name of brand and the manufacture. It shall be stored in a dry place, in regular piles not exceeding six bags high and in such a manner that it will be efficiently protected from moisture and contamination, and that the consignments can be used up in the order in which they are received. Set cement shall be immediately removed from the work and replaced by the Contractor at his own expense. If desired, tests shall be made by taking samples of cement from stores or elsewhere from the works. The selection of samples and procedure for testing shall comply with appropriate I.S. specification.
- 13.7 All aggregates shall conform to I.S. 383 - 1970. Aggregate shall, where possible, be derived from a source that normally produces aggregate satisfactory for concrete, and if requested by the Employer/ Engineer, the Contractor shall supply evidence to this effect. If instructed to do so, the contractor shall supply samples of the aggregate for the purpose of making preliminary concrete test cubes as herein-after specified.

Aggregate shall consist of naturally occurring sand and gravel or stone crushed or uncrushed, or a combination thereof. They shall be hard, strong, dense, durable, clean and free from veins and adherent coating. As far as possible, flaky and elongated pieces should be avoided.

Aggregate shall not contain any harmful materials, such as iron pyrites, coal, mica, shale or similar laminated materials, clay, alkali, soft fragments, organic impurities etc. in such quantity as to affect the strength or durability of the concrete or in addition to the above for reinforced concrete, any material which attack the reinforcement. Aggregate which are chemically reactive with the alkalis of cement are harmful, as cracking of concrete may take place. These aggregate shall be protected from spilling oils, mobiles, diesels over it on site.

- 13.8 The fine aggregate shall be natural sand or sand derived by crushing suitable gravel or stone and shall be free from coagulated lumps. Sand derived from a stone unsuitable for coarse aggregate shall not be used as the fine aggregate.

The fine aggregate shall conform to the requirements of I.S. 383 - 1970. Fine aggregate shall not contain more than 3% of material removable by decantation test, nor more than 1% dry lumps. The total of coal, clay lumps, shale, soft fragments and other deleterious substance shall not be more than 5%.

The percentage of clay lumps shall be determined by examining the various fractions that remain after the material has been tested for grading. Any particles that can be broken with fingers shall be classified as clay lumps and the total percentage of clay lumps shall be determined on the basis of the total original weight of the sample. The fine aggregate shall be well graded from fine to coarse and shall meet the following gradation requirements:

Gradation for Fine Aggregate

Sieve designation Percentage by weight passing

Sieve Designation	10 mm	No. 4	No. 16	No. 30	No. 50	No. 100
Fine Aggregate	100	95-100	45-80	25-55	10-30	2-10

Blending will be permitted in order to meet the gradation requirements for the fine aggregate.

The coarse aggregate shall be crushed stone aggregate. The pieces of aggregates shall be angular. Friable, flaky and laminated pieces, mica, shale shall only be present in such quantities as not to affect adversely the strength and durability of the concrete as ascertained by tests on concrete cubes. After twenty four hours immersion in water, a previous dried sample shall not have gained in weight more than 5% and not more than 10% if it is to be used in plain concrete or elsewhere as described. The coarse aggregate shall conform to the requirements of I.S. 383 - 1970. The percentage of wear at 500 revolutions of Los Angeles Rattler Test shall not be more than 50%. The coarse aggregate shall meet the following gradation. Moreover it should conform previous specification on coarse aggregate.

Gradation for Coarse Aggregate.

Percentage by weight passing

Sieve Designation	40 mm	25 mm	20 mm	10 mm
40mm & down	90-100	20-25	0-15	0-5
20mm & down		100	90-100	20-25

- 13.9 All R.C.C. work shall be carried out in strict accordance with this specification, I.S. Specifications and the working drawings. Any discrepancies in the dimensions on the drawings or any points not clear to the Contractor shall be brought to the notice of the Employer/ Engineer or clarified in advance before proceeding with the work.
- 13.10 The Contractor shall allow for all wastage in all materials. He shall also allow for all tests of concrete materials and if required produce manufacturer's certificate for cement and steel unless issued by the Owner.
- 13.11 The contractor must use vibrator on beams and slabs to compact the newly laid concrete. Generally two types of vibrator shall be used.

a. Needle or Immersion Type of Vibrator

Casting fall beams and columns shall be compacted by means of needle type of vibrator. 4" dia needle type vibrator shall be used over beam section more than 350mm x 400mm and rest of section need only 2" dia needle type vibrator.

b. Flat Bottom Vibrator for Slabs

The contractor shall require flat bottom type of vibrator to compact all concrete over slabs. No immersion type of vibrator will be allowed to compact the concrete over slab.

Moreover, the contractor shall require at least two number of vibrator for one casting and other should kept in standby position. In case vibrator got damaged or not in working condition during casting, the vibrator shall be immediately replaced. If the contractor shall fail to replace another vibrator during casting, no further casting of concrete will be permitted. The contractor shall in that case, immediately remove the remaining concrete mix from the site of work.

Segregation is likely to take place when the concrete is tipped into the form work and this should be avoided. The concrete mix should not contain surplus water and sand which will develop segregation under influence of vibratory compaction. The distribution of new concrete should be uniform over the whole section and the surface

kept horizontal all the time thus ensuring the movement of concrete is downward only. Vibrators shall not be used as a spreading or distributing agent.

The vibrators shall be of rotary out of balance immersion type or the electro-magnetic type and operate at a frequency of not less than 4,000 cycles per minute. The vibration shall be of such a power - input as to produce an acceleration of 1 to 3 m/sec in the mass of the compacted concrete. The vibrators shall be provided for continuous operation.

Vibration shall continue during the whole period occupied by placing the concrete, the vibration being adjusted so that the centre of vibration approximates to centre of the mass being compacted at the time of placing. The concrete should not be over vibrated and the period of insertion of internal vibrator should be about 15 seconds at any point.

- 13.12 The concrete shall be judged to be compacted when the mortar fills the spaces between the coarse aggregate so as to form a glistening and even surface except for slight irregularities where the coarse aggregate breaks this smooth surface. When this condition has been attained, the vibrators shall be withdrawn slowly.

The vibrator must not be placed against the steel or the formwork, the minimum distance being 8 mm. It must be placed in such a position that formwork, reinforcement and recently laid concrete are subjected to the minimum amount of vibration.

Before placing new concrete against concrete already set, the face of the old concrete shall be cleaned and scum removed. The face shall be roughened and any loose aggregate removed there from. Immediately before placing the new concrete the face of the old concrete shall be thoroughly wetted and a coating of neat cement grout applied. The new concrete shall be well rammed against the prepared face before the grout sets. Construction joints will not be paid separately.

- 13.13 Immediately after placing or finishing, concrete surface not covered by forms shall be protected from loss of surface moisture for at least seven days when the average daily temperature is at least 21oC, where Portland cement has been used. Protection from loss of surface water shall be done by any of the following methods where applicable to the type of work involved:

- a. By water covering.
- b. By covering of surfaces with water impervious paper.
- c. By application of approved impervious membrane.

Surfaces from which forms have been removed before the curing period has elapsed shall be protected as specified for surfaces not covered by forms. Membrane curing shall not be used on surfaces required to receive additional concrete or concrete fill, nor on cement finish costs that are to receive dust proofing or hardening treatments, nor during hot weather.

Water curing shall be performed by keeping the concrete surface wet by ponding, by continuous spraying or by covering the surface with an approved water-saturated covering such as 2.5 mm. of sand or sawdust, or by one or more layers of burlap. The exposed concrete surfaces shall be saturated with water throughout the full stipulated curing period. Where forms remain in place during the curing period, they shall be kept sufficiently wetted with clean water to reduce cracks and to prevent joints from opening in the forms.

The impervious membrane curing compound shall be an approved non-bituminous, colourless, liquid sealing compound in atomized form so as to preserve the natural colour of the concrete. The curing compound shall be applied as soon as surface water has disappeared from concrete surfaces with approved pressure spraying equipment

in accordance with the manufacturer's directions and in sufficient thickness to form an effective water seal. No compounds shall be used which will adversely affect the subsequent installation of finished flooring.

- 13.14 The concrete surface shall in general be smooth finish. However, immediately after stripping form work, minor defects and honey combed areas shall be patched and holes filled before the concrete is thoroughly dry, patch areas shall be chipped away to 2.5 mm depth, with regular edges perpendicular to the surface. Area to be patched shall be thoroughly wet including the areas at least 150 mm. wide entirely surrounding them, just prior to placing the patching mortar. Mortar shall be of the same material and proportions as used for the concrete, without coarse aggregate. A sufficient quantity of white cement shall be substituted for part of the ordinary cement so that the patching mortar, when dry, will match the surrounding concrete. Water in the mix shall be kept to a minimum and mortar shall be retempered without adding water and shall be allowed to stand for one hour prior to use during which time it shall be mixed to prevent setting. The mortar shall be thoroughly compacted into place, screeded so as to leave the patch slightly higher than surrounding surfaces, left undisturbed for one to two hours to permit initial shrinkage and finished to match the adjoining work. Where patches exceed 2.5 mm. deep, they shall be trimmed and wet as specified, after which the opening shall be filled to within 2.5 mm. of the surface. After sufficient shrinkage time has elapsed, the patching shall proceed as described above.

Patches shall be kept wet for five days. Tie holes left by the withdrawal of rods, or holes left by removal of ends of ties shall be filled solidly with mortar. For holes passing entirely through the wall, plunger-type grease gun or other device to force mortar through the wall, starting at the back face, shall be used. When a hole is completely filled, excess mortar shall be struck off with a cloth flush with the surface. Holes not passing entirely through walls shall be filled solidly with mortar. Any excess mortar shall be struck off with a cloth on the wall surface. The surface of non-shuttered faces concrete work other than slabs shall be smoothed with a wooden float (or if approved with a steel trowel) to give a finish equal to that of the rubbed down shuttered faces. Concealed concrete faces shall be left as it is except that honeycombed surfaces shall be made good.

The top faces of slabs not intended to be surfaced shall be levelled and floated to a smooth finish at the levels or falls shown on the drawings or elsewhere.

The floating shall not be executed to the extent of bringing excess fine material to the surface. Ribbed surfaces of slabs shall where instructed be formed at the time of taming and levelling. Indentation in slab or stair surfaces shall be formed by approved implements giving the depth and patterns instructed. The top faces of slabs intended to be covered with screed, granolithic or similar surfacing shall be left with a spade finish.

The soffits of slabs and faces of walls intended to be rendered shall be roughened by approved means to form a key. Concrete surfaces to take finishes other than those specifically referred to herein shall be prepared in an approved manner to suit the finish as instructed.

- 13.15 The Employer/ Engineer shall instruct that a loading test be made on the works or any part thereof if in his opinion such a test be deemed necessary for one or more of the following reasons:
- The site-made concrete test cubes failing to attain the specified strength.
 - Over-loading during construction of the works or part thereof.
 - The shuttering being prematurely removed.
 - Concrete improperly cured.

- e. Any other circumstances attributable to alleged negligence on the part of the Contractor which in the opinion of the Employer/Engineer may result in the works or part thereof being less than the expected strength.
- f. Any reason other than the foregoing.

The test shall be made at the contractor's own cost. If the test be instructed to be made for one or more of the reasons from (a) to (e) inclusive, and If the test be instructed to be made for the reason (f), the contractor shall make the test and shall be reimbursed for all cost relating thereof irrespective of the result of the test.

14. Reinforcement

14.1 Installment of Reinforcement Steel

Supplying and fixing Fe 500 grade TMT bar steel reinforcement in RCC work including bending, binding with GI wire, placing in position including the cost of binding wire, as per drawing.

Reinforcement shall be free from pitting due to corrosion, loose rust, mill scale, paint, oil, grease, adhering earth, or other materials that may impair the bond between the concrete and the reinforcement or that may in the opinion of the Employer/ Engineer cause corrosion of the reinforcement or disintegration of the concrete.

14.2 Bar Reinforcement

Bar reinforcement described TMT (Fe 500) shall be hot rolled deformed bars or cold twisted steel bars. With respect to manufacture, quality, physical properties and related requirements, reinforcement of the fore-going descriptions shall comply with appropriate parts of IS Standards Nos. 432-1966, 1139-1966 and IS 1786-1966 for mild steel and tor steel respectively.

14.3 Certificates and Tests for Reinforcement

The contractor shall carry out ultimate strength, yield stress and elongation and cold bend test and other Standard tests as required in discretion of employer for each type and each size of bar to sample steel reinforcement to his own cost from reputed laboratory in presence of employer's representative. Tests for the purpose of obtaining the information shall conform to relevant I.S. specification.

For each consignment of bar reinforcement used in the works, the Contractor shall, if required, supply a certificate giving the ultimate strength, yield stress and elongation and the result of the cold bend test for each type and each size of bar. Tests for the purpose of obtaining the information shall conform to relevant I.S. specification.

The reinforcements supplied for which the Manufacturer's test sheets or other records are not available, or where in the opinion of the Employer/ Engineer has been subject to corrosion or other bad effects, the Employer/ Engineer shall select as many test pieces as he deems necessary, and the Contractor shall supply and deliver the test pieces free of cost without reimbursement and pay the cost of preparing and testing them as well. This test shall be performed in presence of the Employer/ Engineer.

14.4 Dimensions of Reinforcement

The size of reinforcement bar described in the working drawings or elsewhere shall be the minimum and the rolling margin and other tolerances shall be wholly above this size. The length of a reinforcement bar shall not be less than the length on the drawing or elsewhere and shall not be more than 50 mm in excess of that length. Bar bending schedule shall be prepared by the Contractor and submitted for approval of the Employer/ Engineer. Such schedules shall be prepared based on reinforcement details, prior to the execution of the work. Nothing extra shall be paid for this.

14.5 Bending Reinforcement

Reinforcement bars shall be bent by approved means producing a gradual and even motion. Bars shall comply with the dimensions described in the drawings. Overall dimensions of bent or internal dimensions of bending or the like shall be within a tolerance of 30 mm. Any discrepancies or inaccuracies found by the Contractor in the drawings or other documents shall be immediately reported to the Employer/ Engineer whose interpretation and requirements relating thereto shall be accepted. The internal radius of bends shall be not less than twice the size of the bars unless described to the contrary on the bending lists or elsewhere in the drawing. Hooks and other anchorage bends for tor steel shall be bent to an internal radius of the twice diameter of the bar. This internal radius of the bends of corners of binders or stirrups or links shall be half.

14.6 Fixing Reinforcement

Reinforcement shall be accurately fixed and by approved means maintained in the position described in the drawings. Bars intended to be in contact shall be securely wired together at all such points with 16 gauge soft iron tying wire. Binders, stirrups and links shall tightly embrace the bars with which they are intended to be in contact and shall be securely wired or, if approved, spot welded thereof.

Reinforcement shall be lapped, joined or spliced only at the positions described. Splices and the like found to be necessary elsewhere shall be formed only if and as instructed. Lapping shall be provided as shown in the drawing and as permitted. Where practicable bars in each member shall be assembled and fixed in the form of a rigid cage or skeleton before placing in the moulds or formwork. For this, all lapping bar on beams and slabs shall be scattered i.e. as far as possible minimum number of laps shall be permitted in one section of slab and only one lap will be permitted at one section in case of beams. In case of columns the lapping of bar shall be permitted only at the centre zone of column.

14.7 Lapping Length

Lapping length including anchorage value of hooks for bars in flexural tension shall be Development Length (L_d) or 30 times diameter whichever is greater and for direct tension shall be $2L_d$ or 30 times diameter whichever is greater.

The lap length in compression shall be equal to the development length in compression but not less than 24 times the diameter of reinforcement.

Any other requirement of lapping length shall be carried out as per the latest edition of the corresponding relevant BS Codes/IS Codes/equivalent International Standards.

Immediately before concreting, the reinforcement shall be checked for position, cleanliness, freedom from rust or retarding liquid. Means shall be taken to ensure that reinforcement remains correctly in position with required cover during the placing and compacting of the concrete.

Reinforcement projecting from work being concreted or already concreted shall not be bent out or its correct position for any reason unless approved and shall be protected from deformation or other damage. Reinforcement left projecting for bending with future extensions shall be thoroughly coated with cement grout wash or encased in concrete or other-wise protected from corrosion as instructed.

14.8 Cover of Concrete and Spacing of Bars

Unless otherwise described, the clear cover of concrete to the reinforcement shall be as follows:

Horizontal, Vertical or Inclined Slabs

15 mm or the size of the bars whichever is greater.

Lintels

20 mm or the size of the bar whichever is greater.

Beams

25 mm or the size of the main bars whichever is greater. Binders and the like 15 mm minimum.

Columns

Cover for main bars for columns not exceeding 20 mm diameter shall be 25 mm and the main bars in columns exceeding 20 mm diameter shall be 40 mm or the size of the main bars whichever is greater, 15mm minimum for rectangular binders or links or helical binding.

14.9 Chairs And Supports For Reinforcing Bars

Chairs of appropriate depth in suitable form shall be installed on all top bars in case of slab. The shape of chair shall be checked by the Employer/ Engineer. The spacing for slab top bar chairs will be such that during casting time, the reinforcement shall not get disturbed.

14.10 Concrete Chair Block For Bottom Bars

All bottom bar in slabs shall be raised as accordance with cover for concrete by means of small concrete blocks tied with binding wires. These blocks shall be placed at sufficient intervals during casting time, to maintain the cover for reinforcement.

In case of beams, the bottom blocks as well as side reinforcement shall be provided with concrete chair blocks so that the reinforcement shall not get disturbed during casting.

14.11 Design

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/IS 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 Employer.

Limit state method or any other method as per relevant British standard codes (BS Codes)/IS Codes/equivalent International Standards of design shall be adopted unless otherwise specified in the specification.

For detailing of reinforcement relevant BS/IS/equivalent International Standards followed. Cold twisted deformed bars conforming to relevant British standard codes (B S Codes)/IS Codes/equivalent International Standards. Two layers of reinforcement (on inner and outer face) shall be provided for wall and slab sections having thickness of 150 mm and above. Clear cover to reinforcement shall be as per relevant British standard codes (B S Codes)/ IS Codes/equivalent International Standards.

RCC water retaining structures like storage tanks, etc. shall be designed as uncracked section in accordance with relevant British standard codes (BS Codes)/IS codes/equivalent International Standards. However, water channels shall be designed as cracked section with limited steel stresses as per relevant BS/IS.

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 (BS Codes)/IS Codes/equivalent International Standards of foundation design. Detailed design calculations shall be submitted by the bidder showing complete details.

Design shall consider any sub-soil water pressure that may be encountered following relevant standard strictly.

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.

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

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 BS Codes/IS 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.

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.

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.

Following conditions shall be considered for the design of water tank in pumps house, channels, sumps, trenches and other underground structures:

- Full water pressure from inside and no earth pressure and ground water pressure and surcharge pressure from outside (application only to structures which are liable to be filled up with water or any other liquid).
- Full earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.
- 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.

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.

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.

The foundations of Transformer and circuit breaker shall be of block type foundation. Minimum reinforcement shall be governed by relevant British standard codes (BS Codes)/IS codes/equivalent International Standards.

The tower and equipment foundations shall be checked for a factor of safety as per relevant BS Codes/IS/equivalent International Standards for two conditions i.e., Normal condition and short circuit condition against sliding, overturning and pull out. The same factors shall be used as partial safety factor overloads in limit state design also.

14.12 Admixtures and Additives

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.

Admixtures in concrete shall conform to relevant British standard codes (BS Codes)/IS Codes/ equivalent International Standards. The water proofing cement additives shall conform to relevant BS/IS. Employer shall approve concrete Admixtures/Additives.

The Contractor may propose, and the Employer 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.

The water-reducing setting-retarding admixture shall be an approved brand as per relevant British standard codes (BS Codes)/IS Codes/equivalent International Standards. The water proofing cement additives shall be used as required/advised by Employer.

15. Formwork

15.1 Centering and Shuttering

Centering and shuttering of plywood and steel formwork in slabs, walls, beams etc. including propping, strutting etc. and removal of forms including applying form oil to shuttering.

15.2 Design

Formwork shall be designed and constructed for removal so that the concrete can be properly placed and thoroughly compacted. Formwork shall be firmly supported and adequately strutted, braced, or tied. It shall be capable of adjustment to the lines and dimensions of the finished concrete and it shall be sufficiently strong to resist without distortion, the pressure of concrete during its placing and compaction, and other loads to which it may be subjected. It shall not be liable to suffer distortion under the influence of the weather. When concrete is to be vibrated, special care shall be taken to ensure that the formwork will remain stable and the joints tight. The safety and adequacy of centering and shuttering shall be the sole responsibility of the Contractor. The Contractor shall if required supply to the Employer/ Engineer drawings and calculations for the formwork he proposes to use, for the concrete work.

15.3 Material for Formwork

All surface of the formwork shall be of plywood or steel plate which shall give uniform concrete surface after removal. No wooden planks or other means of form work shall be acceptable. For struts and props the Contractor shall use sal wood 75mm x 100mm props or Iron lifting type strut over form base i.e. it shall not get depressed at the time of loading or casting. Any strut, if found defective shall be replaced as directed by Employer/ Engineer.

15.4 Deflection and Camber

The Contractor shall make allowance for any settlement or deflection of the formwork that is likely to arise during Construction, so that the hardened concrete conforms accurately to the specified line and level. The Contractor shall also make allowance in the formwork for any camber specified by the Employer/ Engineer to allow for the elastic deflection of structural members and deflection due to creep of the concrete. In the absence of any specified camber, the soffit of all beams and slabs shall be given a camber equal to $1/240$ of the span length to ensure that the structure has the prescribed shape after removal of the forms.

15.5 Supports

Formwork shall be constructed so that the formwork to the sides of members can be removed without disturbing the soffit formwork or its supports. Props and supports

shall be designed to allow the formwork to be adjusted accurately to line and level and to be erected and removed in an approved sequence without damage to the concrete. Supports shall be carried out which is sufficiently strong to afford the necessary support without damage to any portion of the structure. This may mean in some cases that it be carried down to the foundations or other suitable base. Props and bracing shall be provided for the temporary support of composite construction where separately specified.

15.6 Joints And Edges

All joints in the formwork shall be close-fitting to prevent leakage of cement slurry from the concrete. At construction joints, formwork shall be tightly secured against previously cast or hardened concrete to prevent the formation of stepping or ridges in the concrete. Formwork shall be constructed to provide straight and true angles, arises or edges. Where cambers are shown on the Drawings, the fillets shall be accurately cut to size to provide a smooth and continuous chamfer. Formwork panels shall have true edges to permit accurate alignment at sides and provide a clean line at construction joints in the concrete which shall be fixed with their joints either vertical or horizontal, unless otherwise specified.

15.7 Sundries

Formwork shall be provided to the top surface of concrete where the slope or the nature of the work requires it. Provision shall be made for forming holes and chases for services and for building in pipes, conduits and other fixings, as shown on the drawings. The material and position of any ties passing through the concrete shall be as directed by the Employer/ Engineer. Except where corrosion of a metal tie is unimportant, it shall be possible to remove a tie so that no part of it remaining embedded in the concrete shall be nearer to the finished surface of the concrete than the specified thickness of cover to the reinforcement. Any holes left after the removal of ties shall be filled with concrete or mortar of approved mix.

15.8 Cleaning and Treatment of Formwork

Spaces to be occupied by concrete shall be free from all rubbish, chipping, shavings, sawdust, dirt and tying wire etc., before concrete is placed. The formwork to be in contact with the concrete shall be cleaned and treated with a suitable non-staining form oil or other approved material. Care shall be taken that oil or composition is kept away from contact with the reinforcement or with concrete at any construction joints. Surface retarding agents shall not be used except with the permission of the Employer/ Engineer. Formwork shall be thoroughly cleaned after each use. Damaged or distorted formwork shall not be used.

15.9 Painting on Formwork

The concrete repellent painting on all contact surface of the formwork shall be of approved non bituminous colourless form oil so as to preserve the natural colour of the concrete. The repellent compound shall be applied so as to effect quick removal of form work. It shall be applied as per the manufacture's direction. No compound shall be used which will adversely affect the concrete work or surface. No form repellent compound may be used without specific written approval of the Employer/ Engineer regarding type, manufactures, location and extent of use and application procedures.

15.10 Removal of Formwork

All formwork shall be removed without shock or vibration that might damage the concrete. Before the soffit and props are removed the surface of the concrete shall be exposed where necessary in order to ensure that the concrete has hardened sufficiently. In no circumstances shall formwork be struck of until the concrete reaches cube strength of at least three times the stress to which the concrete may be subjected

at the time of striking. The formwork to vertical surfaces such as walls, columns and sides of beams may be removed after 24 hours in normal weather conditions although care must be taken to avoid damage to the concrete, especially to arise and features. In cold weather a longer period may be necessary before striking. Suitable curing methods should immediately follow the removal of the formwork. The following minimum times shall elapse before removal of formwork:

The times given for the removal of props are based on the assumption that the total live load plus dead weight to be supported at the time of removal is not more than one half the total design load. For horizontal members where the loading is a higher proportion of the total design load these times may need to be increased.

16. Boundary and Chain-Link Fencing and Gates

16.1 General

Work covered under this clause comprises of design, drawing, supply, fabrication, erection, painting or galvanization as specified etc. of boundary wall, main entrance gate, switchyard fencing, and switchyard entrance gate, construction of foundation of steel posts and toe wall. In addition to the switchyard, the fencing shall be developed for complete substation yard and a gate shall be installed. The tender level drawings of the boundary wall, main entrance gate, chain-link and switchyard entrance gate is provided in the Construction Standard Guideline Drawings of the Substation.

While providing switch yard fencing and gate, following points may be taken care of:

16.2 Areas Requiring Fencing

Boundary wall fencing shall be provided to complete substation yard, as per the drawings, with foundations as essential.

Fencing shall be provided for complete switchyard. Separate gate shall be provided for men and equipment.

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

16.3 Product Material

Boundary wall fencing shall make use of industry standard works as per the relevant National Codes/British standard codes (B S Codes)/IS Codes/equivalent International Standards.

The minimum requirements are as follows for the internal fencing works:

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

16.4 Posts for Internal Fencing

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)/IS 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/IS/Equivalent International standards.

16.5 Fence Fabric and Fence Panel for Internal Fencing

Chain link fencing shall be made of 3.15 mm diameter wire with 50 x 50 mm mesh size. Fence fabric shall be galvanized. Chain link fencing shall be fabricated in the form of panel as per requirement 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.

16.6 Installation for Internal Fencing

Fence shall be installed along the switchyard line.

Post holes shall be excavated by approved method.

All posts shall be 3.0m apart measured parallel to ground surface.

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. Fence fabric shall not be installed until concrete has cured a minimum of 7 days.

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.

16.7 Gate for Internal Fencing

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 center to center 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. An 8 mm thick 200x200 mm size MS plate shall be welded at the bottom of channel frame.

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.

The gates shall be provided with suitable locking arrangement welded on 4 mm thick MS plate on the gate leaf.

The main gate shall be 5.0m wide and shall be of double leaf type. Next to the main gate, a men gate (1.25m wide single leaf) shall also be provided.

Steel roller shall be provided with the gate.

Gate shall be installed in location as shown in approved G.A. drawing.

The vertical post of gate shall be embedded in PCC foundation of 500x500x1250 mm deep size.

17. Water Supply

- 17.1 Water shall be made available by Contractor at any feasible point nearby the substation so that minimum pipe will be required for supply of water from that point to the buildings. The source of water supply shall got approved by employer. Contractor shall state the total water requirement both in terms of quantity and head to Employer.
- 17.2 The contractor shall carry out all the plumbing/erection works required for supply of water in the control building beyond the single point as at (i) above. 50 mm dia. CPVC pipe shall be provided by the Contractor from the source to the roof water tank. From this contractor shall provide 25 mm dia. CPVC pipe for internal water supply on buildings and 12.5 mm dia. CPVC pipe for branch connections.
- 17.3 The details of tanks, pipes, fittings, fixtures etc. for water supply shall be proposed by the Contractor and get approved.
- 17.4 A scheme shall be prepared by the contractor indicating the layout and details of water supply which shall be got approved by Employer 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 Employer.

18. Sewerage System

- 18.1 Sewerage system shall be provided for GIS building and control building.
- 18.2 The Contractor shall construct septic tank and soak pit for required numbers of user but minimum of 50 users. 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.
- 18.3 The system shall be designed as per relevant British standard codes (B S Codes)/IS codes/equivalent International Standards. All drawings shall be prepared by the contractor for approval of Employer.

19. Buildings-General Requirements

19.1 General

The scope includes the design, engineering and construction including anti-termite treatment, Plinth protection, DPC, Peripheral drain, Sanitary, Water supply, Electrification etc. of Control Building, Office Building, Staff Quarter and Guard House.

The rooms within the control building shall have area sufficient to install the equipment supposed to be installed (including for the spare bays) with adequate space for service. In any case the plinth area shall not be less than the typical building plan of control building provided with this tender. There will be no column in between 132/ 33 kV control room as shown in reference drawing.

The contractor shall appoint a reputed architect for design of architecturally pleasing building.

19.2 Scope of Works

The Contractor shall perform the design, supply, deliver, construction and installation of the equipment, materials and all accessories for the control building as listed below. The drawing has been provided for reference only.

- a. Cleaning and stripping, Excavation, Backfilling and compaction
- b. Concrete work including steel reinforce bars
- c. Plinth level flooring treatment
- d. Brick and Stone Masonry Works

- e. Plaster and Tile Works
- f. Door and Windows
- g. False Ceiling
- h. Heat Insulation and Water Proofing
- i. Water supply, Plumbing (Sanitation), Sewerage and Sanitary Fixtures and septic tank
- j. Indoor Cable Trench
- k. Paint and Glazing
- l. All required Electrical Installation
- m. Ventilation

19.3 Design Requirements

Dimension for Control Building, Office Building, Staff Quarter and Guard House shall be decided by contractor but having minimum dimension as per drawing attached with tender document, construction standard guidelines- substation-drawings.

- a. The buildings shall be designed:
 - i. To the requirements of the International standards/British Standards/ Indian Standards.
 - ii. For the specified climatic and loading conditions.
 - iii. To adequately suit the requirements of the equipment and apparatus contained in the buildings and in all respects to be compatible with the intended use and occupancy.
 - iv. With a functional and economical space arrangement.
 - v. For a life expectancy of structure, systems and components not less than that of the equipment which is contained in the building, provided regular maintenance is carried out.
 - vi. To be aesthetically pleasing. Different buildings shall show a uniformity and consistency in architectural design.
 - vii. To allow for easy access to equipment and maintenance of the equipment with, wherever required, fire retarding materials for walls, ceilings and doors, which would prevent supporting or spreading of fire.
 - viii. With materials preventing dust accumulation.
 - ix. All structures shall be designed for the worst combination of dead loads, live loads, wind loads as per IS-875, seismic forces as per IS-1893.
 - x. The design of R.C.C. structures for the Control Building, Office Building, Staff Quarter and Guard House shall be done in accordance with IS: 456.
 - xi. Permissible stresses for different load combinations shall be taken as per relevant IS Codes.
- b. Suitable expansion joints shall be provided in the longitudinal direction wherever necessary with provision of twin columns.
- c. Individual members of the buildings frame shall be designed for the worst combination of forces such as bending moment, axial force, shear force, torsion etc.
- d. Permissible stresses for different load combinations shall be taken as per relevant IS Codes/BS code.

- e. The building lighting shall be designed in accordance with the requirements of relevant section.
- f. The building auxiliary services like air conditioning and ventilation systems, fire protection and detection systems and all other miscellaneous services shall be designed in accordance with the requirements specified in relevant section or elsewhere in this Specification.
- g. Chequered plate walkway shall be provided, if required.

19.4 Design Loads

Building structures shall be designed for the most critical combinations of dead loads, superimposed loads, equipment loads, crane load (if any), wind loads and seismic loads.

Dead loads shall include the weight of structures complete with finishes, fixtures and partitions and should be taken as per IS: 1911/BS/international standard.

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 equipment to be supported on the building frame.

The wind loads shall be computed as per IS 875 - 1987/BS/international standard, Seismic Coefficient method/Response Spectrum method shall be used for the seismic analysis as per IS 1893 with importance factor 1.5.

Wind and Seismic forces shall not be considered to act simultaneously.

Floors/slabs shall be designed to carry loads imposed by equipment, cables and other loads associated with building. Floors shall be designed for live loads as per relevant IS/BS/international standard. Cable load shall also be considered additionally for floors where these loads are expected.

In addition, beams shall be designed for any incidental point loads to be applied at any point along the beams. The floor loads shall be subject to Employer's approval.

For consideration of loads on structures, IS: 875/BS/international standard, the following minimum superimposed live loads shall, however, be considered for the design.

- a. Roof
 - 1.5 kN/m² for accessible roofs
 - 0.75 kN/m² for in-accessible roofs
- b. RCC-Floor
 - 5 kN/m² for offices
 - 10 kN/m² (min.) for equipment floor or

Actual requirement if higher than 10 kN/m² based on equipment component weight and layout plans.
- c. Stairs and balconies 5 kN/m²
- d. Toilet Rooms 2 kN/m²
- e. Chequered 4 kN/m² plate floor
- f. Walkways 3 kN/m²

Any additional load coming in the structure shall be calculated as per IS: 875/BS/international standard.

19.5 Submission

The following information shall be submitted for review and approval to the Employer:

- a. Soft as well as hard copies of structural design calculations and drawing (including construction/fabrication) for all reinforced concrete and structural steel structures.
- b. Fully, dimensioned concept plan including floor plans, cross sections, longitudinal sections, elevations and perspective view of each building. These drawings shall be drawn at a scale not smaller than 1:50 and shall identify the major building components.
- c. Fully dimensioned drawings showing details and sections drawn to scales of sufficient size to clearly show sizes and configuration of the building components and the relationship between them.
- d. Product information of building components and materials, including walls partitions flooring ceiling, roofing, door and windows and building finishes.
- e. A detailed schedule of building finishes including colour schemes.
- f. A door and window schedule showing door types and locations, door lock sets and latch sets and other door hardware.

Approval of the above information shall be obtained before ordering.

19.6 Flooring, Walls and Roof

Flooring in various rooms of Control Building, Office Building, Staff Quarter and Guard House shall be as per detailed schedule given in Table -1, Internal Finish Schedule.

In Control Building, Office Building, Staff Quarter and Guard House walls shall be 230mm thick unless specified otherwise in the approved drawings.

RCC roofing shall be provided for Control Building, Office Building, Staff Quarter and Guard House. For buildings in snowfall area, gable roof with appropriate slope approved by the Employer shall be constructed.

19.7 Plastering

All internal walls shall have minimum 12.5 mm thick 1:4 cement sand plaster. The ceiling shall have 12.5 mm thick 1:3 cement sand plaster.

External plaster 12.5 mm thick shall be of 1:3 cement sand plaster in two layers. External surface of the Control Building shall be painted with exterior paint Weather Shield Max or Excel Total All as per manufacturer's specification.

19.8 Brick Masonry Works

19.8.1 General

Chimney made first class brick work in foundation and plinths in cement mortar of ratio 1:4 (1 cement: 4 sand) or 1:6 (1 cement: 6 sand) whichever is specified.

The bricks shall be table moulded with sand from good brick earth and shall be of uniform size, unless otherwise specified. They shall be uniform deep red, cherry or copper color, thoroughly well burnt without being vitrified, regular in shape and size, and shall have sharp and square sides and edges and parallel faces to ensure uniformity in the thickness of the courses of brick work. The bricks shall be free from cracks, chips, flaws stones or humps of any kind. They shall not show appreciable signs of efflorescence either dry or subsequent to soaking in water. The bricks shall be sound, hard, and

homogeneous in texture and produce a clear ringing sound when struck with a trowel. In no case, the minimum crushing strength of bricks shall be less than 1000 lbs/sq. inch. The bricks shall be provided with frogs. All bricks which absorb water more than one-sixth of their own dry weight after being soaked for one hour by immersion in water shall be rejected.

All brick work shall be laid with specified mortar of good workable consistency.

Cement mortar shall be prepared by mixing cement and sand in the specified proportions the mixing shall be done in a mechanical mixer or by hand mixing as directed by Employer/ Engineer. Water shall be added as required during mixing. Care shall be taken not to add more water than what is actually needed to bring the mortar to the consistency of a stiff paste. Only the quantity of mortar, which can be used within 2 hours of its mixing shall be prepared at a time. Mortar unused for more than 2 hours shall be rejected and removed from the site of work.

19.8.2 Workmanship

a. Soaking of Bricks

All bricks required for masonry in cement mortars shall be thoroughly soaked in clean water for at least one hour in tanks of sufficient size immediately before use. The cessation of bubbles when the bricks are immersed in water is an indication of through soaking of bricks.

b. Laying

Bricks shall be laid in English bond, unless otherwise specified. Half or cut bricks shall not be used except where necessary to complete the bond. Closer in such cases shall be cut to the required size and used near the ends of the walls.

The walls shall be taken up truly plumb. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. Vertical joints in alternate courses shall come directly one over the other. The thickness of brick courses shall be kept uniform and for this purpose straight edge with graduations showing the thickness of each brick course including joint shall be used. Bricks shall be laid with frogs upwards.

The walls of a structure shall be carried up regularly and nearly at one level and no portion of the work shall be left more than 3 ft. below the rest of the work. Where this is not possible, the work shall be raked back according to bond (and not left toothed) at an angle not exceeding 45 degree.

All iron fixtures, pipes, outlets of water, hold fasts of doors and windows, etc. which are required to be built in walls, shall be embedded in cement mortar or in cement concrete bed as specified, in their correct positions as the work proceeds. Nothing extra shall be paid for such extra cement mortar or cement concrete to be used for embedding the fixtures of the nature stated above.

c. Joints

Bricks shall be so laid that joints are quite full of mortar. The thickness of the bed joints shall in no case exceed 10 mm unless otherwise specified. The face of joints shall be raked to a minimum depth of 10 mm by raking tool daily during the progress of work when the mortar

is still green, so as to provide proper key for the plaster or pointing to be done. Where plastering or pointing is not required to be done, the joints shall be struck flush and finished at the time of laying. The face of brick work shall be cleaned daily and all mortar drippings removed.

d. **Brick-on-Edge Coping**

The top course of all plinths, parapets, steps and tops of walls below R.C.C. slabs or beams shall be laid with brick on edge, unless otherwise specified. Proper care shall be taken that the bricks forming the top corners and ends of walls shall be properly radiated and keyed into position.

e. **Brick Work Half Brick Thickness**

First class chimney made half brick masonry in cement mortar 1:4 (1 cement: 4 sand) with 4.75 mm. diameter TMT steel reinforcement placed horizontally at every fourth course. It shall be laid in stretcher course as for brickwork specification. Horizontal reinforcement of 5 mm. diameter with proper anchorage to adjoining wall/walls shall be provided at every fourth course.

f. **Brick on Edge Soling**

For that brick soling, the brick shall be Chimney made and will be laid as directed by the Employer/ Engineer.

The brick shall conform to as per clause 19.8.1. The base on which is to be laid on edge shall be levelled or sloped as required and compacted properly. The bricks shall be laid on edge true to line, slope and pattern as required. The line, level etc. shall be checked by pegging. The brick shall be closely packed to each other as far as practical and the gaps shall be filled with sand for compaction. The workmanship shall be to the approval of the Employer/ Engineer.

19.9 Stone Masonry Works

All stone work shall be made with random rubble stone from the best quarry and built in 1:4 cement mortar (1 cement: 4 sand) the stones must be approved by the Employer/Engineer before using in the construction work.

The stone shall be hard, tough sound and durable. No stone shall be less than 6" and more than 18". Face stone should be comparatively larger and uniform in size and colour to with a good appearance. Breadth of face stone should be greater than height. All the stones shall be wetted thoroughly before laying.

The joints should not be thicker than 3/4". Face joint should be thinner. In the corners, the stones should be chiselled at both sides and also on the top of the stone walls where the wall is ending and such surfaces being built up. Not more than 2 feet height of masonry shall be constructed at one time.

19.10 Internal Finish Schedule

The finishing schedule is given in subsequent clauses and table below. Areas not specified in finish schedule shall be provided with vitrified tile flooring, and Premium Acrylic emulsion paint oil bound washable distemper over 2 mm thick putty. Paints used in the work shall be of best quality. Standard Practice as per prevalent national laws and as approved by the Employer shall apply for finishing in details for Guard House, Staff Quarter, Office Building and Control Buildings.

Internal Finish Schedule

S.N.	Location	Flooring And Skirting 150mm High	Wall (Internal)	Ceiling	Door, Windows And Ventilator
1.	SCADA and Administration Room	Vitrified tiles 8mm thick size 600x600 mm	Non-VOC acrylic emulsion paint over 2 mm POP putty up to false ceiling over approved primer coat	False ceiling painted with non-VOC acrylic emulsion paint to give an even shade	Windows/ ventilator shall be of UPVC with 5.5mm thick glazing. All doors shall be flush door shutters with 38mm thick sal wood frame and 3 mm thick teak plywood on both side of shutter.
2.	Conference/Meeting Room	Vitrified tiles 8mm thick size 600 x 600mm	Non-VOC acrylic emulsion paint over 2 mm POP putty up to false ceiling over approved primer coat	False ceiling painted with non-VOC acrylic emulsion paint to give an even shade	Windows/ ventilator shall be of UPVC with 5.5mm thick glazing. All doors shall be flush door shutters with 38mm thick sal wood frame and 3 mm thick teak plywood on both side of shutter.
3.	In-charge Room	Vitrified tiles 8mm thick size 600 x 600mm	Non-VOC acrylic emulsion paint over 2 mm POP putty up to false ceiling over approved primer coat	False ceiling painted with non-VOC acrylic emulsion paint to give an even shade	Windows/ ventilator shall be of UPVC with 5.5mm thick glazing. All doors shall be flush door shutters with 38mm thick sal wood frame and 3 mm thick teak plywood on both side of shutter.
4.	Other Office Room	Vitrified tiles 8mm thick size 600 x 600mm	Non-VOC acrylic emulsion paint over 2 mm POP putty up to false ceiling over approved primer coat	False ceiling painted with non-VOC acrylic emulsion paint to give an even shade	Windows/ ventilator shall be of UPVC with 5.5mm thick glazing. All doors shall be flush door shutters with 38mm thick sal wood frame and 3 mm thick teak plywood on both side of shutter.
5.	ACDC and DCDB Room	62 mm cement concrete flooring with hardener	Non-VOC acrylic emulsion paint over 2 mm POP putty up to false ceiling over approved primer coat	False ceiling painted with Non-VOC acrylic emulsion paint to give an even shade	Windows/ ventilator shall be of UPVC with 5.5mm thick glazing. All doors shall be flush door shutters with 38mm thick sal wood frame and 3 mm thick teak plywood on both side of shutter.

S.N.	Location	Flooring And Skirting 150mm High	Wall (Internal)	Ceiling	Door, Windows And Ventilator
6.	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 Whitewash above False Ceiling	Windows/ ventilator shall be of UPVC with 5.5mm thick glazing. All doors shall be flush door shutters with 38mm thick sal wood frame and 3 mm thick teak plywood on both side of shutter.
7.	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 2 mm thick	Windows/ventilator shall be of UPVC with 5.5mm thick glazing. All doors shall be flush door shutters with 38mm thick sal wood frame and 3 mm thick teak plywood on both side of shutter.
8.	Battery Room	Acid resistant non-skid tiles on flooring and up to 2100 mm height on wall.	Acid alkali resistant painting above 2100 mm height.	False ceiling and White wash above False Ceiling	Windows/ ventilator shall be of UPVC with 5.5mm thick glazing. All doors shall be flush door shutters with 38mm thick sal wood frame and 3 mm thick teak plywood on both side of shutter.
9	Lobby	18 mm thick granite flooring	Non-VOC acrylic emulsion paint over 2 mm POP putty up to false ceiling over approved primer coat	False ceiling painted with Non-VOC acrylic emulsion paint to give an even shade	Windows/ ventilator shall be of UPVC with 5.5mm thick glazing. All doors shall be flush door shutters with 38mm thick sal wood frame and 3 mm thick teak plywood on both side of shutter.
10	Corridor	Vitrified tiles 8mm thick size 600 x 600mm	Non-VOC acrylic emulsion paint over 2 mm POP putty up to false ceiling over approved primer coat	False ceiling painted with Non-VOC acrylic emulsion paint to give an even shade	Windows/ ventilator shall be of UPVC with 5.5mm thick glazing. All doors shall be flush door shutters with 38mm thick sal wood frame and 3 mm thick teak plywood on both side of shutter.

S.N.	Location	Flooring And Skirting 150mm High	Wall (Internal)	Ceiling	Door, Windows And Ventilator
12	Toilet	Ceramic Tiles	DADO glazed tiles 2100mm high, above that non-VOC acrylic emulsion paint over 2 mm thick POP putty along with primer coat.	Non-VOC acrylic emulsion paint over approved primer coat	Windows/ ventilator shall be of UPVC with 5.5mm thick glazing. All doors shall be flush door shutters with 38mm thick sal wood frame and 3 mm thick teak plywood on both side of shutter.thk. Glazing.
14	Diesel Generator (DG) room	Ceramic Tiles	DADO glazed tiles 2100mm high, above that non VOC acrylic emulsion paint over 2 mm thick POP putty along with primer coat.	Non VOC acrylic emulsion paint over approved primer coat	Windows/ ventilator shall be of UPVC with 5.5mm thick glazing. All doors shall be flush door shutters with 38mm thick sal wood frame and 3 mm thick teak plywood on both side of shutter.
15	RCC Staircase	18 mm thick Granite slab on riser and treads	Non VOC acrylic emulsion paint over 2 mm POP putty up to false ceiling over approved primer coat	False ceiling painted with Non VOC acrylic emulsion paint to give an even shade	Windows/ ventilator shall be of UPVC with 5.5mm thick glazing. All doors shall be flush door shutters with 38mm thick sal wood frame and 3 mm thick teak plywood on both side of shutter.

19.11 Cable Trench in Control Building

The detail design of the cable trench shall be the responsibility of the Contractor. All designs and details shall be subject to approval of the Employer. Main cable trench inside the control building shall match in size with main cable trench out site control building.

All cable trenches in Control Building shall be covered with minimum 6mm thick MS chequered plate with suitable stiffeners.

Drainage outlet from the cable trench shall be connected to switchyard drainage system.

19.12 Doors, Windows and Ventilators

The details of doors, windows and ventilators of the buildings shall be as per finish schedule Table-1, Internal Finish Schedule conforming to relevant IS code. Rolling steel shutters and rolling steel grills shall be provided as per layout and requirement of buildings.

19.13 Plumbing and Sanitation

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.

PVC Roof water tank(s) with metal stand of adequate capacity depending on the number of users for 24 hours storage shall be provided. However, a minimum of 1 nos. 2000 liter capacity shall be provided.

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)/IS/equivalent International Standards shall be used for internal piping works for water supply.

For internal soil, waste and vent pipe unplasticised rigid PVC pipes of 75mm for waste and 110mm dia. for soil shall be provided conforming to IS: 13592 type B and all its fittings like bends, sockets, door bend, Y-tee etc. as per requirement with seal ring conforming to IS: 5382 including jointing with cement solvent conforms to IS: 14182. All underground or under floor pipes shall be encased with 1:4:8 concrete. Minimum concrete cover shall be 75 mm thick.

There shall be separate provision of toilet for Male and Female and In addition to general requirements of each toilets, 2 nos. urinals with flushing system shall be provided for common Male toilet.

Each toilet shall have the following minimum fittings:

- a. WC (Western type) 390 mm high along with toilet paper roll holder and all other fittings in all toilets.
- b. Urinal (430 x 260 x 350 mm size) with all fittings and built-in-sensor for automatic flush after use.
- c. Wash basin (550 x 400 mm) with all fittings.
- d. Bathroom mirror (600 x 450 x 6 mm thick) with hard board backing.
- e. CP brass towel rail (600 x 20 mm) with CP brass brackets.
- f. Soap holder and liquid soap dispenser.
- g. Shower and taps from reputed manufacturers.
- h. Automatic Hand Dryer.

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

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

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

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.

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

The contractor shall undertake all other activities required to complete and commission the building.

19.14 External Painting

External surfaces of all the buildings shall be painted with acrylic exterior flat paint as per manufacturer's specification and approval of Employer.

19.15 Plinth Protection

750 mm wide plinth protection around the all buildings shall be provided. Plinth protection shall comprise of 50 mm thick plain cement concrete laid over 75 mm thick well compacted stone aggregates with interstices filled with local sand.

19.16 Building Storm Water Drainage

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.

UPVC Rainwater down comer pipes conforming to relevant International standards /British Standards with water tight lead joints conforms to relevant B S Codes/IS code/ 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 downcomer pipes shall be governed by relevant B S Codes/ IS code/equivalent International Standards.

All drains around 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.

Suitable arrangements for draining out water collected from equipment blowdowns, leakages, floor washings, firefighting etc. shall be provided for each floor.

19.17 False Ceiling

Providing and fixing 12mm 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 center-center 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.

19.18 Electrification and Lighting

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

The lighting layout for and around Staff Quarter, Guard, park shade and badminton court indicating the type & quantity for items shall be prepared and submitted by the contractor for employer's approval during detailed engineering.

The lux levels to be maintained shall be as per following:

a. Passage, Toilets, Corridor:	100 lux
b. Park shades:	200 lux
c. Other rooms:	300 lux

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

Ceiling fans (1400 mm sweep, AC 230 volts) shall be provided in all the rooms of staff quarter, guard house as per the requirements. Exhaust fans shall be provided in Battery room, toilets and Kitchen pantry.

The conduit layout drawing, Electrical distribution shall be prepared by the Contractor. All wiring including telephone wiring (tinned two pair copper) shall be in concealed conduit. Concealed MS junction boxes for sockets and light points shall be provided in all the rooms of Staff quarter and Guard house

Two power socket shall be provided in each room of Staff Quarter & Guard house Buildings. Extra power socket for Geysers in each Bathroom of staff quarter.

Doom light with LED Bulb of 12 watt shall be fixed around buildings on outward projected RCC slabs.

19.19 Water Proofing Treatment for RCC Roof/Terrace

Roof of the buildings 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)/IS Codes/equivalent International Standards. The water proofing treatment shall be of following operations:

- a. Applying and grouting a slurry coat of neat cement using 2.75 kg/m² of cement admixed with proprietary water proofing compounds conforming to relevant British standard codes (B S Codes)/IS Codes/equivalent International Standards over the RCC slab including cleaning the surface before treatment.
- b. Laying brick bats using broken brick/brick bats of 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)/IS 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)/IS 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)/IS 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)/IS 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 Employer.
- f. Average thickness of water proofing shall be 120 mm and minimum thickness at khurra shall be 65 mm.

20. Mode of Measurement

20.1 Geotechnical Investigation

The Contractor shall conduct the study with approval from the Employer for the investigation location. 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 for each sub-project.

20.2 Site Clearing, Contour survey and site leveling.

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

Measurement of Earth work in all kind of soil including rock in the item of cutting and filling and item of earth work in the filling with borrowed earth shall be made in Cubic meters.

20.3 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, firewall, cable trenches, buildings, External lighting poles, control cubicles, marshalling box shall only be measured. The quantity of excavation for roads, rail cum road, drains, culverts, rainwater harvesting, septic tank, soak pit, external water supply system, site surfacing, chain link fencing (including gate) shall not be measured separately and shall be deemed to be included in the composite rates quoted by the bidder for the respective works. All other excavation required for the completion of the work including plinth protection, flooring, sewerage system, manholes, pipes, earth mat etc. shall also not be paid for. The measurement of excavation of all concrete works shall be made considering dimension of the pit leaving 150mm gap around the base pad (lean concrete) or actually excavated pit, whichever is less. The quantity shall be measured in cubic meters.

20.4 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.

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 foundation, rail track, drain, culverts, septic tank, chain link fencing, fencing gate, external lighting poles etc. as indicated in the approved drawings.

PCC 1:3:6 (1 cement: 3 coarse sand: 6 stone aggregate, 40mm nominal size) shall be measured below all foundations of towers, equipment support structures, buildings, firefighting water tanks, covered car parking, cable trench, roads, under flooring, rail-cum-road, transformer foundation, reactor foundation, drain, cable trench crossings, culverts, fence, gate, etc. as indicated in the approved drawings.

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

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

20.5 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 and miscellaneous structural steel like inserts etc.), of M25 design mix (Minimum). This shall also include pre-cast RCC work and addition of water

proofing compound wherever required for which no additional payment shall be made. The quantity shall be measured in cubic meters as per lines and levels indicated in the drawings. No deduction shall be made for volume occupied by reinforcement / inserts/sleeves and for openings having cross-sectional area up to 0.1 m^2 .

20.6 Steel Reinforcement

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

20.7 Brick Masonry Work

The measurement of brickwork both 230mm (above 230mm, if any) and 115mm thick shall be the product of the length, height and thickness i.e. in cubic meter for chimney made and fair faced machine made brickwork.

20.8 Stone Masonry Work

Stone masonry shall be measured in cubic meters. The pointing shall be measured in m^2 .

The stone masonry shall be paid at the respective contract unit prices which shall be the full and the final compensation to the Contractor.

20.9 Stone filling over grating in Transformer Foundation

Measurement of stone (40mm nominal size) filling over gratings of Transformer foundations shall be made as per theoretical volume of the space to be filled in the transformer foundation as per approved drawings. This shall be measured in m^3 .

20.10 Miscellaneous Structural Steel

Measurement for Supply, fabrication, transportation and erection of all miscellaneous structural steel work for all 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 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 /reactor 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 etc. shall not be considered for payment and measurements. Quantity shall be measured in metric tonnes.

20.11 Roads

The measurement for the concrete road shall be made on the basis of area in square meter (m^2) of top concrete completed surface of the road and shall be deemed to include all items such as excavation, compaction, rolling, watering, WBM, shoulder,

etc. complete as per approved drawing but excluding concreting and reinforcement which shall be paid separately under respective items of BPS.

20.12 Anti-weed treatment and Stone Spreading

The measurement shall be done for the actual area in square meters of stone spreading provided in the switchyard. It includes providing and spreading of 100 mm 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.

20.13 Chain Link Fencing and Gate

The measurement shall be made in square meters of the fence provided as per approved drawing. The rate shall be including the post, fencing, MS Flat, painting, brickwork and plaster of toe wall etc. complete but excluding the concrete. The switch yard gate shall be measured in numbers including all items except concrete and reinforcement.

20.14 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.

20.15 Drains and Culverts

PCC (1:2:4, 1:3:6 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, backfilling, brick work, grating, plaster and stone pitching except RCC hume pipes required for completion of drains and culverts shall be deemed to be included in the quoted rate of drain. The quantity for each type of drain section shall be measured in running meters. However, RCC hume pipes used in culverts shall be measured under respective item of Bid price schedule (BPS) as described in clause of hume pipes.

20.16 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). The same shall apply for perforated PVC pipe in Switchyard Drainage System.

20.17 Rail cum Road

The measurement for the rail cum road shall be made in square meters 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 paragraphs.

20.18 Water Supply System

The water supply system shall be measured in lump sum basis including supply system from bore-well to buildings and internal distribution on buildings. It shall include all the items such as excavation, piping, pipe fittings, water tank, painting, brickwork, sand

filling, concrete, valves, chambers cutting chases in walls, openings in RCC and repairs, etc. required to complete the job.

20.19 External Sewerage System

It shall be measured in lump sum basis. It shall include all the items such as excavation, piping, pipe fittings, manholes, gully trap, gully chamber casing in concrete and repairs, septic tank, soak pit etc. required to complete the job but concrete and reinforcement used for septic tank and soak pit shall be paid separately.

20.20 Control Building

Payment for this item shall be made as per the quantity basis including internal foundations, cable trenches, internal and external finishes as well as internal Firefighting works, water proofing treatment for roof/terrace etc. complete in all respect. 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 shall be measured and paid under miscellaneous steel item of BPS and described 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 Employer shall be deemed to be included in this rate.

20.21 Slope Protection Work

Slope protection work by stone pitching and by Bio engineering grass plantation shall be measured in square meter including all work required to complete the work as per technical specification.

20.22 Reinforcement

The reinforcement shall be paid at contract unit rate and measured in Metric tonnes or kilogram. The rate shall also include compensation for the cost of providing, cutting to length, cleaning, spacer blocks, waste incurred by cutting, welding, fixing the reinforcement in position including the provision of wire or other material for supporting and tying the reinforcement in place, bending reinforcement temporarily, and straightening, placing and compacting concrete around reinforcement and exact length of laps, bending, hooking and provision and fixing chairs of at least 12mm dia shall be separately measured for payment.

20.23 Formwork

Except as stated below, formwork shall be measured in square meter of formwork actually in contact with the finished face of the concrete. No deduction shall be made in the measurement for openings, pipes, ducts and the like, provided that the area of each is less than 0.50 square meters. Unless otherwise stated, if the volume or area of concrete has not been deducted when measuring the concrete, formwork to form box or the void shall not be measured.

21. Miscellaneous Requirements

Dense concrete with controlled water cement ratio as per BS code/IS code/equivalent international standard shall be used for all underground concrete structures such as cable and pipe trenches etc. for achieving water-tightness.

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.

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.

All mild steel parts used in the water retaining structures shall be hot-double dip galvanized. The minimum coating of the zinc shall be 750 gm/m² for galvanized structures and shall comply with relevant BS/IS. Galvanizing shall be checked and tested in accordance with relevant BS/IS. The galvanizing shall be followed by the application of an etching primer and dipping in black bitumen in accordance with BS: 3416.

Bricks having minimum 75 kg/cm² compressive strength can only be used for masonry work. Contractor shall ascertain himself at site regarding the availability of bricks of minimum 75 kg/cm² compressive strength before submitting his offer.

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.

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 for service buildings and 1000 mm for residential buildings. 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 GIS buildings.

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.

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.

Hand-railing minimum 1200mm 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 galvanized (medium-class as per relevant BS). All rungs for ladder shall also be galvanized as per relevant BS.

For RCC stairs, stainless steel hand railing shall be provided.

For all civil works covered under this specification, design Mix of Minimum M25 grade as per relevant International/BS/IS 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/IS standard.

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.

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

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

Construction joints shall be as per International/BS/IS standard

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

22. Interfacing

The proper coordination and 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/embedments, 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.

23. Statutory Rules

Contractor shall comply with all the applicable statutory rules pertaining to relevant acts of GoN.

Provisions for fireproof 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 Engineer In charge.

Statutory clearance and norms of Local Pollution Control Board shall be followed as per Water Resources Act for effluent quality from plant.

24. 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/IS Codes/equivalent International Standards during detailed engineering stage and submit to Employer for approval within ONE month after award of work.

25. Standard Codes

For design and engineering relevant British Standard Codes (BS Codes)/Indian Standard Codes (IS Codes)/equivalent international standards shall be referred by the contractor. Relevant portion of British Standard Codes (BS Codes)/Indian Standard Codes (IS Codes)/equivalent international standards referred by the contractor for the design shall be made available to Employer if necessary, during detailed engineering stage.

Volume II

Section 6: Employer's Requirements

CHAPTER 21: SUBSTATION EQUIPMENT DATA SHEET

Table of Contents

1.	General.....	2
2.	Guaranteed Technical Particular	2
2.1	132/33 kV Power Transformer	3
2.2	Insulating Oil for Transformers	7
2.3	132kV SF6 Circuit Breaker.....	8
2.4	33kV Vacuum Circuit Breaker	10
2.5	132 kV Disconnecting Switch with and without Earthing Switch	12
2.6	33 kV Disconnecting Switch with and without Earthing Switch	14
2.7	132 kV Current Transformer	16
2.8	33 kV Current Transformer	17
2.9	132 kV Capacitive Voltage Transformer.....	19
2.10	33 kV Voltage Transformer	21
2.11	120 kV Lightning Arrester	23
2.12	30 kV Lightning Arrester	24
2.13	132 kV Transformer Control & Relay Panels.....	25
2.14	33 kV Transformer Line Control & Relay Panels	31
2.15	110V Battery.....	35
2.16	48V Battery.....	37
2.17	110V Battery Charger	39
2.18	48V Battery Charger	40
2.19	Station Grounding System	41
2.20	Remote Terminal Unit	42
2.21	Optic Line Terminal Equipment	45
2.22	Fibre Optic Cable	47
2.23	Low Voltage Power Cable	49
2.24	Control Cable	50
2.25	33 kV Power Cable.....	51
2.26	Station Transformer.....	52

CHAPTER 21

SUBSTATION EQUIPMENT DATA SHEET

1. General

The Tenderer shall submit (4) sets [One (1) original + Three (3).copies] of completely filled up Technical Schedule along with the Tender. Any alterations necessary due to errors etc. in the filled-up data shall be initiated by the Tenderer.

2. Guaranteed Technical Particular

The table of Guaranteed Technical Particular (GTP) for various equipment are tabulated herewith.

2.1 132/33 kV Power Transformer

Description	Unit	Requirement	Offered Data
1. Manufacturer's name			
2. Country of Origin			
3. Applicable Standard			
4. Years of Manufacturing Experience	Years	Minimum 7	
5. ISO Certificate Submitted			
6. Manufacturer's end-user's certificate submitted	Yes/No	Yes	
7. Service		Outdoor	
8. Type (Core or Shell)		Core	
9. Applicable Standard		IEC 60076	
10. Number of winding per phase	No.	2	
11. Type of cooling		ONAN/ONAF	
12. Rating			
a. Rated capacity - ONAN - ONAF	MVA	12.5 15	
b. Rated voltage - Primary - Secondary	kV	132 33	
c. Rated frequency	Hz	50	
13. Noise level			
a. On ONAN rating b. On ONAF- rating	dB dB	<73 <75	
14. Temperature rise			
a. Temperature rise above 40°C ambient -In oil by thermometer -In winding by resistance	°C °C	50 55	
b. Hottest spot temperature in winding limited to	°C	55	
15. Connection			
a. High voltage b. Low voltage c. Vector group reference in accordance with IEC 60076		star star YNyn0	
16. Magnitude of 3rd harmonics voltage as of fundamental frequency	%	<2	
17. Taps			
a. Type of tap changer		ON-LOAD	
b. Tap steps	No.	17	
c. Tap range	%	+/- 10%	

18. Cooling equipment (for ONAF)			
a. Manufacturer and type			
b. Number of Fans	Nos.		
c. Rated power	kW		
d. Rated voltage	V, AC	230/400	
19. On-load tap changing gear & control- system			
a. Manufacturer and type		MR Germany, ABB Sweden	
b. Rating			
- Rated voltage	kV	72	
- Step voltage	V		
- Rated current (normal)	A	150	
c. Number of steps	Nos.	17	
d. Control suitable for:			
- Remote/local operation		Remote & local	
- Auto/manual operation		Auto & manual	
- Parallel operation	Yes/No	Yes	
e. Rated voltage of drive motor	V, AC	400/230	
20. Guaranteed losses			
a. No-load loss at rated voltage and frequency on maximum MVA base	kW		
b. Load loss at rated current and 75°C on maximum MVA base	kW		
c. Cooler loss for full load operation on maximum MVA base	kW		
d. Total losses	kW		
21. Impedance at rated current and frequency at 75°C winding temperature and normal tapping			
a. on maximum MVA base in ONAN	%		
b. on maximum MVA base in ONAF	%	11	
22. Efficiency at 75°C winding Temperature at PF=0.9			
a. At 100 % load	%		
b. At 75 % load	%		
c. At 50 % load	%	Above 99%	
23. No load current in % of rated current referred to HV side & 50Hz			
a. At 90 % rated voltage	%		
b. At 100 % rated voltage	%		
c. At 110 % rated voltage	%		

24. Minimum clearance in air HV/LV			
a. Between phases	mm		
b. Between phase and ground	mm		
25. Insulation level			
a. Power frequency withstand voltage (1 min. rms)			
- Primary	kV	325	
- Secondary	kV	95	
b. Impulse withstand			
- Primary	kV	750 (crest)	
- Secondary	kV	250 (crest)	
26. Detail of oil preservation system			
a. Type of oil preservation system furnished	type	Conservator type	
b. If conservator type, urethane air cell provided	Yes/No	Yes	
c. Minimum pressure of pressure relief device set to operate at	kg/cm2		
27. Details of bushings HV/LV/HV neutral			
a. Manufacturer / Model No.			
b. Type			
c. Voltage class	kV	145/36/36	
d. Creepage distance	mm	4650/1300/1300	
e. Reference standard		IEC	
f. Dry flash over voltage	kV		
g. Wet flash over voltage	kV		
h. Impulse withstand voltage	kV peak	750/250	
28. Insulating oil			
a. Approximate volume of oil	liter		
b. Whether first fill of oil with 5 % excess furnished	Yes/No	Yes	
29. Bushing current transformer			
a. Type			
b. Voltage class (HV/LV)	kV/kV	132/33	
c. Number of cores			
- HV	No.	1	
- LV	No.	1	
- HV Neutral	No.	1	
- LV Neutral	No.	2	
d. Ratio			
- HV (phase)	A		

- HV (Neutral)	A		
- LV (phase)	A		
- LV (Neutral)e)	A		
e. Accuracy class		5P20	
30. Lightning arresters mounted on			
a. HV side	Yes/No	No	
b. LV side	Yes/No	Yes	
31. Approximate overall dimension (L x W x H)	mm		
32. Approximate weight			
a. Core and coils	kg		
b. Tank and fittings	kg		
c. Oil	kg		
d. Total weight	kg		
33. Delivery of equipment in month following award of contract (Allowing time for approval of drawings)	months		
34. Approximate weight			
e. Core and coils	kg		
f. Tank and fittings	kg		
g. Oil	kg		
h. Total weight	kg		
35. Delivery of equipment in month following award of contract (Allowing time for approval of drawings)	months		

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.2 Insulating Oil for Transformers

Description	Specification	Offered Data
1. Electric Strength (BDV)	60 kV (min)	
2. Dielectric dissipation factor	0.01 (Max.) (Ten Delta)	
3. Specific resistance (Resistivity)	1500x10 ¹² (Min.) at 270C (ohm-cm)	
4. Flash point Pensky-Mortion	1400C (Min.) (Closed)	
5. Inter facial tension at 270C	0.04 N/m (Min.)	
6. Total activity	0.04 mg koh/gm (Max.)	
7. Water Content	50 (Max)	

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.3 132kV SF6 Circuit Breaker

Description	Unit	Requirement	Offered Data
1. Manufacturer's name			
2. Country of Origin			
3. Applicable Standard			
4. Years of Manufacturing Experience	Years	Minimum 7	
5. ISO Certificate Submitted			
6. Manufacturer's end-user's certificate submitted	Yes/No	Yes	
7. Manufacturer's designation as per submitted catalogue/ Model No.		To be furnished	
8. Applicable standard		IEC	
9. Type / Class		SF6 / outdoor	
10. Poles	No.	3	
11. Local and remote operations		Both Required	
12. Rated maximum voltage	kV	145	
13. Rated current	A		
a. Normal current	A	1600, 2000	
b. Short time for 1 sec	kA	25	
14. Frequency	Hz	50	
15. Insulation level			
a. Impulse withstand voltage	kV	750(crest)	
b. Power frequency withstand voltage (1 min, rms)	kV	325	
16. Rated short circuit breaking current	kA	31.5	
17. Rated short circuit making current	kAp		
18. Interrupting time at 100% capacity			
a. Max. opening time	ms		
b. Total interrupting time	ms	60	
19. Closing time	ms		
20. Make Time	ms	120	
21. Rated Line-charging breaking current	A		
22. First pole to clear factor		1.3	
23. Operating mechanism			
a. Type		Spring operated	
b. Number of mechanisms per breaker set		1	
c. Single/three phase auto reclosure			
d. Enclosure protection		IP55W	

e. Nominal Operating voltage of Closing/Tripping coil	V, DC	110	
f. Operating voltage range - Closing - Tripping	% of rated voltage	85-110% 70-110%	
g. Spring charging Motor rating			
- Capacity	kW		
- Rated voltage	V	110 V, DC	
h. Time required by motor to charge the spring completely	Sec	30	
24. Push button for local operation	Yes/No	Yes	
25. Selection switch for local/ remote control	Yes/No	Yes	
26. Anti pumping device provided	Yes/No	Yes	
27. Trip-free feature provided	Yes/No	Yes	
28. Gas density detector provided	Yes/No	Yes	
29. Operation counter provided	Yes/No	Yes	
30. Space heater provided for cubicle	Yes/No	Yes	
31. Operating duty cycle		O-0.3 sec-CO- 3 min-CO	
32. Thickness of sheet steel of cubicle	mm	min 2	
33. Number of Auxiliary Contacts	No.	8NO, 8 NC	
34. Number of possible operations without maintenance : a. for contacts - - Rated short circuit breaking current - - Rated normal current b. - for mechanism	No. No. No.	>10 >2,000 >2,000	
35. Rated SF6 gas pressure	kgf/cm ²		
36. Guaranteed SF6 gas loss per annum	% / annum	<0.1	
37. Porcelain insulator			
a. Manufacturer			
b. Creepage distance	mm	4650	
38. Padlocking provision for local cubicle	Yes/No	Yes	
39. Gas pressure gauge provided	Yes/No	Yes	
40. Total weight of circuit breaker	kg		

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.4 33kV Vacuum Circuit Breaker

Description	Unit	Requirement	Offered Data
1. Manufacturer's name			
2. Country of Origin			
3. Applicable Standard			
4. Years of Manufacturing Experience	Years	Minimum 7	
5. ISO Certificate Submitted			
6. Manufacturer's end-user's certificate submitted	Yes/No	Yes	
7. Manufacturer's designation as per submitted catalogue/ Model No.		To be furnished	
8. Applicable standard		IEC	
9. Type / Class		Vacuum/outdoor	
10. Poles	No.	3	
11. Local and remote operations		Both Required	
12. Rated voltage	kV	36	
13. Rated current	A		
a. Normal current	A	800, 1250	
b. Short time for 1 sec	kA	25	
14. Frequency	Hz	50	
15. Insulation level			
a. Impulse withstand voltage	kV	250(crest)	
b. Power frequency withstand voltage (1 min, rms)	kV	95	
16. Rated short circuit breaking current	kA	31.5	
17. Rated short circuit making current	kAp		
18. Interrupting time at 100% capacity			
a. Max. opening time	ms		
b. Total interrupting time	ms	60	
19. Closing time	ms		
20. Make Time	ms	120	
21. Rated Line-charging breaking current	A		
22. First pole to clear factor		1.3	
23. Operating mechanism			
a. Type		Spring operated	
b. Number of mechanisms per breaker set		1	
c. Single/three phase auto reclosure		Three phase	
d. Enclosure protection		IP55W	
e. Nominal Operating voltage of Closing/Tripping coil	V, DC	110	

f. Operating voltage range - Closing - Tripping	% of rated voltage	85-110% 70-110%	
g. Spring charging Motor rating			
- Capacity	kW		
- Rated voltage	V	110 V, DC	
h. Time required by motor to charge the spring completely	Sec	30	
24. Push button for local operation	Yes/No	Yes	
25. Selection switch for local/ remote control	Yes/No	Yes	
26. Anti pumping device provided	Yes/No	Yes	
27. Trip-free feature provided	Yes/No	Yes	
28. Padlocking provision for local cubicle	Yes/No	Yes	
29. Total weight of circuit breaker	kg		

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.5 132 kV Disconnecting Switch with and without Earthing Switch

Description	Unit	Requirement	Offered Data
1. Manufacturer's name			
2. Country of Origin			
3. Applicable Standard			
4. Years of Manufacturing Experience	Years	Minimum 7	
5. ISO Certificate Submitted			
6. Manufacturer's end-user's certificate submitted	Yes/No	Yes	
7. Manufacturer's designation as per submitted catalogue/ Model No.		To be furnished	
8. Applicable standard		IEC	
9. Type		3-Pole; Double break	
10. Local and remote operations		Both Required	
11. Rated maximum voltage	kV	145	
12. Frequency	Hz	50	
13. Rated current	A		
a. Normal current	A	1600, 2000	
b. Short time for 1 sec	kA	31.5	
14. Insulation level			
a. Impulse withstand voltage	kV	750 (crest)	
b. Power frequency withstand voltage (1 min, rms)	kV	325	
15. Maximum current the switch can safely interrupt			
a. Bus/Line charging current	A	0.5 min	
b. Potential transformer magnetizing current	A	0.5 min	
16. Clearance	ms		
a. Between live parts and ground	mm		
b. Between fixed contact and blade in open position	mm		
17. Main Contacts		1.3	
a. Material of Contacts		Copper Alloy	
b. Coating of Contacts		Silver plated	
c. Material of the contacts of the earthing switch		Copper Alloy	
d. Coating of the contacts of the earthing switch		Silver plated	
18. Material of Terminals			
19. Coating of Terminals			
20. Operating Mechanism		Electrical and Mechanical	
21. Local operating device provided	Yes/No	Yes	

22. Auxiliary contacts	Yes/No	Yes	
a. Type (convertible or fixed)		Convertible	
b. Continuous current rating at 110V DC	A		
c. Material		Copper	
d. Contacts silver-plated?	Yes/No	Yes	
23. No of operations switch can withstand without deterioration of contacts	Nos.		
24. Type of interlocks furnished:		Electrical & Mechanical	
25. Are the disconnectors and the earthing switches mechanically interlocked to each other	Yes/No	Yes	
26. Weight of disconnecting switch	kg		
27. Auxiliary power supply			
a. DS operating motor supply voltage	V/Phase	400V / 3Ph	
b. DS operating motor power	WT		
c. Space heater and cubicle	V/Phase	230V / 1Ph	
d. Control circuit	V	110V, DC	
28. Insulator			
a. Manufacturer			
b. Creepage distance in air	mm	4650	
29. Number of NC. Contacts (minimum)	No.	8	
30. Number of NO. contacts (minimum)	No.	8	
31. Enclosure protection		IP-55W	
32. Thickness of sheet (minimum)	mm	2	
33. Earthing switch			
a. Operating mechanism		Manual	
b. Type of interlocks furnished		Electrical & Mechanical	
34. Number of NC. Contacts (minimum)	No.	4	
35. Number of NO. contacts (minimum)	No.	4	
36. Weight of earthing switch	kg		
37. Delivery of equipment in months following award of contract. (Allowing time for approval of drawing.)	month		

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.6 33 kV Disconnecting Switch with and without Earthing Switch

Description	Unit	Requirement	Offered Data
1. Manufacturer's name			
2. Country of Origin			
3. Applicable Standard			
4. Years of Manufacturing Experience	Years	Minimum 7	
5. ISO Certificate Submitted			
6. Manufacturer's end-user's certificate submitted	Yes/No	Yes	
7. Manufacturer's designation as per submitted catalogue/ Model No.		To be furnished	
8. Applicable standard		IEC	
9. Type		3-Pole; Center break/Double break	
10. Local and remote operations		Both Required	
11. Rated maximum voltage	kV	36	
12. Frequency	Hz	50	
13. Rated current	A		
a. Normal current	A	400, 800, 1250, 1600	
b. Short time for 1 sec	kA	31.5	
14. Insulation level			
a. Impulse withstand voltage	kV	250 (crest)	
b. Power frequency withstand voltage (1 min, rms)	kV	95	
15. Maximum current the switch can safely interrupt			
a. Bus/Line charging current	A	0.5 min	
b. Potential transformer magnetizing current	A	0.5 min	
16. Clearance	ms		
a. Between live parts and ground	mm		
b. Between fixed contact and blade in open position	mm		
17. Main Contacts		1.3	
a. Material of Contacts		Copper Alloy	
b. Coating of Contacts		Silver plated	
c. Material of the contacts of the earthing switch		Copper Alloy	
d. Coating of the contacts of the earthing switch		Silver plated	
18. Material of Terminals			
19. Coating of Terminals			
20. Operating Mechanism		Electrical and Mechanical	

21. Local operating device provided	Yes/No	Yes	
22. Auxiliary contacts	Yes/No	Yes	
a. Type (convertible or fixed)		Convertible	
b. Continuous current rating at 110V DC	A		
c. Material		Copper	
d. Contacts silver-plated?	Yes/No	Yes	
23. No of operations switch can withstand without deterioration of contacts	Nos.		
24. Type of interlocks furnished:		Electrical & Mechanical	
25. Are the disconnectors and the earthing switches mechanically interlocked to each other	Yes/No	Yes	
26. Weight of disconnecting switch	kg		
27. Auxiliary power supply			
a. DS operating motor supply voltage	V/Phase	400V / 3Ph	
b. DS operating motor power	WT		
c. Space heater and cubicle	V/Phase	230V / 1Ph	
d. Control circuit	V	110V, DC	
28. Insulator			
a. Manufacturer			
b. Creepage distance in air	mm	1300	
29. Number of NC. Contacts (minimum)	No.	8	
30. Number of NO. contacts (minimum)	No.	8	
31. Enclosure protection		IP-55W	
32. Thickness of sheet (minimum)	mm	2	
33. Earthing switch			
a. Operating mechanism		Manual	
b. Type of interlocks furnished		Electrical & Mechanical	
34. Number of NC. Contacts (minimum)	No.	4	
35. Number of NO. contacts (minimum)	No.	4	
36. Weight of earthing switch	kg		
37. Delivery of equipment in months following award of contract. (Allowing time for approval of drawing.)	month		

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.7 132 kV Current Transformer

Description	Unit	Requirement	Offered Data
1. Manufacturer's name			
2. Country of Origin			
3. Years of Manufacturing Experience	Years	Minimum 7	
4. ISO Certificate Submitted			
5. Manufacturer's end-user's certificate submitted	Yes/No	Yes	
6. Manufacturer's designation as per submitted catalogue/ Model No.		To be furnished	
7. Applicable standard		IEC	
8. Type		Outdoor oil immersed	
9. Number of phases	No.	single	
10. Number of cores in each CT	No.	5	
11. Frequency	Hz	50	
12. Rated Primary Voltage	kV	132	
13. Insulation level			
a. Impulse withstand voltage	kV	750 (crest)	
b. Power frequency withstand voltage (1 min, rms)	kV	325	
14. Rated peak withstand current	kA		
15. Creepage Distance	mm		
16. Short time thermal rating (1 sec)	kA	25	
17. Ratings			
a. Current ratio	A	200-00/1 A (Transformer, 132 kV side)	
b. Rated VA burden for each core	VA	30	
18. Accuracy class / No. of Cores		5P20 – 2 Nos. for Protection CL:0.2 – 2 Nos. for Tariff metering CL:0.5 - 1 Nos. for Measurement	
19. Dimension (L x W x H)	mm		
20. Weight	kg		
21. Delivery of equipment in months following award of contract (Allowing time for approval of drawings.)	month		

2.8 33 kV Current Transformer

Description	Unit	Requirement	Offered Data
1. Manufacturer's name			
2. Country of Origin			
3. Years of Manufacturing Experience	Years	Minimum 7	
4. ISO Certificate Submitted			
5. Manufacturer's end-user's certificate submitted	Yes/No	Yes	
6. Manufacturer's designation as per submitted catalogue/ Model No.		To be furnished	
7. Applicable standard		IEC	
8. Type		Outdoor oil immersed	
9. Number of phases	No.	single	
10. Number of cores in each CT	No.	3 (for Incomer) 2 (for Feeder)	
11. Frequency	Hz	50	
12. Rated Primary Voltage	kV	33	
13. Temperature rise above 40°C ambient	°C	As per IEC	
14. Insulation level			
a. Impulse withstand voltage	kV	170 (crest)	
b. Power frequency withstand voltage (1 min, rms)	kV	75	
15. Rated peak withstand current	kA		
16. Creepage Distance	mm		
17. Short time thermal rating (1 sec)	kA	25	
18. Ratings			
a. Current ratio	A	600-400-200/1 A (for Incomer) 400-200-100/1 A (for Feeder)	
b. Rated VA burden for each core	VA	30	
19. Accuracy class / No. of Cores		<u>For Incomer</u> 5P20 – 2 Nos. for Protection CL 0.5 – 1 Nos. for Measurement <u>For Feeder</u> 5P20 – 1 Nos. for Protection CL 0.5 – 1 Nos. for Measurement	

20. Dimension (L x W x H)	mm		
21. Weight	kg		
22. Delivery of equipment in months following award of contract (Allowing time for approval of drawings.)	month		

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.9 132 kV Capacitive Voltage Transformer

Description	Unit	Requirement	Offered Data
1. Manufacturer's name			
2. Country of Origin			
3. Years of Manufacturing Experience	Years	Minimum 7	
4. ISO Certificate Submitted			
5. Manufacturer's end-user's certificate submitted	Yes/No	Yes	
6. Manufacturer's designation as per submitted catalogue/ Model No.		To be furnished	
7. Applicable standard		IEC	
8. Type		Outdoor oil immersed	
9. Frequency	Hz	50	
10. Rated primary voltage			
a. Nominal	kV	$132/\sqrt{3}$	
b. Maximum voltage	kV	$145/\sqrt{3}$	
11. Insulation level			
a. Impulse withstand voltage (primary)	kV	750	
b. Power frequency withstand (1 min. rms) (primary)	kV	325	
12. Creepage distance	mm		
13. High voltage capacitor			
a. Number of capacitors			
b. Capacitance of each stack	pF		
c. Manufacturing tolerance	($\pm\%$)		
d. Total value of the high voltage capacitor	pF		
14. Intermediate voltage capacitor			
a. Number of stacks			
b. Capacitance of each stack	pF		
c. Manufacturing tolerance	($\pm\%$)		
d. Total value of intermediate voltage capacitor	pF		
e. Equivalent capacitance for carrier coupling	pF		
f. Capacitance of CCVT	pF		
15. Value of the equivalent capacitance	pF		
16. Open circuit intermediate voltage	V		
17. Rating			
a. Voltage ratio	kV	$132/\sqrt{3}$: $0.11/\sqrt{3}$ and $0.11/\sqrt{3}$	

b. Rated burden	VA	100 for protection & 50 for metering	
c. Accuracy class		3P & 0.2 for metering	
d. Overvoltage factor			
- Continuous		1.2	
- 30 seconds		1.5	
e. Connection			
f. Secondary fuse			
- Type			
- Manufacturer			
- Amp rating	A		
g. Power factor		0.85	
h. Number of secondary windings		2	
18. Knife switch and fuse on secondary provided	Yes/No		
19. Dimension (L x W x H)	mm		
20. Weight	kg		
21. Delivery of equipment in months following award of contract (allowing time for approval of drawing)	month		

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.10 33 kV Voltage Transformer

Description	Unit	Requirement	Offered Data
1. Manufacturer's name			
2. Country of Origin			
3. Years of Manufacturing Experience	Years	Minimum 7	
4. ISO Certificate Submitted			
5. Manufacturer's end-user's certificate submitted	Yes/No	Yes	
6. Manufacturer's designation as per submitted catalogue/ Model No.		To be furnished	
7. Applicable standard		IEC	
8. Type		Outdoor epoxy resin encapsulated	
9. Frequency	Hz	50	
10. Rated primary voltage	kV	33	
11. Insulation level			
a. Impulse withstand voltage (primary)	kV	250	
b. Power frequency withstand (1 min. rms) (primary)	kV	95	
12. Creepage distance	mm	850	
13. Rating			
a. Voltage ratio	kV	33/√3: 0.11/√3 and 0.11/√3	
b. Rated burden	VA	30	
c. Accuracy class		3P & 0.2 for metering	
d. Overvoltage factor			
- Continuous		1.2	
- 30 seconds		1.5	
e. Connection			
f. Secondary fuse			
- Type			
- Manufacturer			
- Amp rating	A		

g. Power factor		0.85	
h. Number of secondary windings		2	
14. Knife switch and fuse on secondary provided	Yes/No		
15. Dimension (L x W x H)	mm		
16. Weight	kg		
17. Delivery of equipment in months following award of contract (allowing time for approval of drawing)	month		

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.11 120 kV Lightning Arrester

Description	Unit	Requirement	Offered Data
1. Manufacturer's name			
2. Country of Origin			
3. Years of Manufacturing Experience	Years	Minimum 7	
4. ISO Certificate Submitted			
5. Manufacturer's end-user's certificate submitted	Yes/No	Yes	
6. Manufacturer's designation as per submitted catalogue/ Model No.		To be furnished	
7. Applicable standard		IEC	
8. Type		Gapless metal Oxide / Outdoor	
9. Rated voltage rating of L.A.	kV	120	
10. Impulse withstand voltage, (crest)	kV	750	
11. Power frequency withstand voltage	kV	325	
12. Rated frequency	Hz	50	
13. Nominal discharge current	kA	10	
14. Surge counter with insulating base furnished?	Yes/No	Yes	
15. Leakage current measuring instrument furnished?	Yes/No	Yes	
16. Porcelain creepage distance	mm		
17. Line terminal with accessories provided	Yes/No	Yes	
18. Earth terminal with accessories provided	Yes/No	Yes	
19. Has manufacturer exported such units?	Yes/No	Yes	

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.12 30 kV Lightning Arrester

Description	Unit	Requirement	Offered Data
1. Manufacturer's name			
2. Country of Origin			
3. Years of Manufacturing Experience	Years	Minimum 7	
4. ISO Certificate Submitted			
5. Manufacturer's end-user's certificate submitted	Yes/No	Yes	
6. Manufacturer's designation as per submitted catalogue/ Model No.		To be furnished	
7. Applicable standard		IEC	
8. Type		Gapless metal Oxide / Outdoor	
9. Rated voltage rating of L.A.	kV	30	
10. Impulse withstand voltage, (crest)	kV	250	
11. Power frequency withstand voltage	kV	95	
12. Rated frequency	Hz	50	
13. Nominal discharge current	kA	10	
14. Surge counter with insulating base furnished?	Yes/No	Yes	
15. Leakage current measuring instrument furnished?	Yes/No	Yes	
16. Porcelain creepage distance	mm		
17. Line terminal with accessories provided	Yes/No	Yes	
18. Earth terminal with accessories provided	Yes/No	Yes	
19. Has manufacturer exported such units?	Yes/No	Yes	

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.13 132 kV Transformer Control & Relay Panels

Description	Unit	Requirement	Offered Data
1. Manufacturer's name			
2. Country of Origin			
3. Years of Manufacturing Experience	Years	Minimum 7	
4. ISO Certificate Submitted			
5. Manufacturer's end-user's certificate submitted	Yes/No	Yes	
6. Manufacturer's designation as per submitted catalogue/ Model No.		To be furnished	
7. Applicable standard		IEC	
8. Type (Simplex/Duplex)		Outdoor oil immersed	
9. Control panels furnished as per specification?	Yes/No	Yes	
10. Enclosure protection class	IP	IP 43	
11. Thickness of sheet metal used			
a. Front and rear portion	mm	>=3	
b. Side, top & bottom covers	mm	>=2	
c. Doors	mm	>=3	
12. All instruments, meters, relays and control switches flush or semi-flush type?		Flush type	
13. Ground bus			
a. Material		copper	
b. Size (L x W)	mm	25 x 6	
14. Overall dimension of control boards (L x W x H)	mm		
15. Shipping data			
a. Size of the large package (L x W x H)	mm		
b. Weight of the heaviest package	Kg		
16. Delivery of equipment in months following award of contract. (Allowing time for approval of drawing)	month		
17. 11. Indicating Instruments			
a. Ammeter			
- Manufacturer's designation / Model No.			
- Type			
- Accuracy class		0.5	
- Scale			
▪ Type of scale	linear / non-linear		
▪ Range of indication (...../1 A CT operated)	A		

b. Voltmeter			
- Manufacturer's designation / Model No.			
- Type			
- Accuracy class			
- Scale			
▪ Range of indication	kV		
▪ Linear / non-linear			
c. Active power meter			
- Manufacturer's designation / Model No.			
- Type			
- Manufacturer's type designation			
- Applicable standard		IEC	
- Rated voltage	kV	$132/\sqrt{3}/0.11/\sqrt{3}$	
- Rated current	A		
- Current range (Transducer operation)	mA		
- Accuracy class			
- Scale			
▪ Type		Digital	
▪ Range of indication	MW	0-30 0-60	
▪ Linear / non-linear			
d. Frequency meter		-	
- Manufacturer's designation / Model No.		-	
- Range of indication	Hz	-	
e. Energy Meter			
- Manufacturer / Model No.			
- Type		electronic 3-ph, 4 wire	
- Applicable standard		IEC	
- Class of accuracy		0.2	
- Import and export meter provided	Yes/No	Yes	
- Rated voltage	kV	$132/\sqrt{3}/0.11/\sqrt{3}$	
- Rated current	A		
- VA burden	VA		
f. Annunciators			
- Manufacturer's designation / Model No.			
- Type		numeric	

- Number of inputs (annunciator /event)			
- Number of active points	No.	24	
- Number of rows	No.	3	
- Number of columns	No.	8	
- Type of mounting		flush	
- Replacement of individual inscription plates and lamps from front panel possible?	Yes/No	Yes	
- Sequence of operation as per specifications	Yes/No	Yes	
g. Phase Overcurrent Relays: (Directional & Non-Directional)			
- Manufacturer's designation / Model No.			
- Type		numeric	
- Applicable standards		IEC	
- Triple pole or single pole		Triple pole	
- Continuous overload capacity	x In		
- Current setting range	% of rated current	20 - 200%	
- Operating time at 10 times current setting	sec	3	
- Reset time	ms		
- Characteristics ▪ IDMT(standard inverse) ▪ IDMT(very inverse) ▪ IDMT(extremely inverse) ▪ Definite time			
- Instantaneous unit provided	Yes/No	Yes	
- Current setting range	% of rated current		
- Operating time	ms		
h. Ground Over Current Relays (Directional & Non-Directional)			
- Manufacturer's designation / Model No.			
- Type		numeric	
- Applicable standards		IEC	
- Single pole/Triple pole		three pole	
- Continuous overload capacity	x In		
- Current setting range	% of rated current	10 - 80%	
- Operating time at 10 times current setting	sec	3	

- Reset time	ms		
- Characteristics - IDMT(standard inverse) - IDMT(very inverse) - IDMT(extremely inverse) - Definite time		IDMT (standard inverse)	
- Instantaneous unit provided	Yes/No	Yes	
- Current setting range	% of rated current		
- Operating time	ms		
i. Bus / Transformer Differential Relay			
- Manufacturer's designation / Model No.			
- Applied standards		IEC	
- Type		numeric	
- Current magnitude difference setting range	% of rated secondary current		
j. Synchro-Check Relay			
- Manufacturer's designation / Model No.			
- Applied standards			
- Type			
- Rated input measuring voltage	V		
- Voltage magnitude difference setting range	% of Vn		
- Phase angle difference setting range	Degrees		
- Frequency difference setting range	Hz		
- Operating time	ms		
- Reset time	ms		
- Specify whether each relay incorporate with the following options of reclosing on:			
▪ Dead bus-live line	Yes/No		
▪ Dead line - live bus	Yes/No		
- If the options of reclosing on dead bus- live line and dead line- live bus are separately furnished and mounted, specify:			
▪ Type.			
▪ Voltage rating	V		
k. Auxiliary Tripping & Lockout Relays			
- Manufacturer's designation / Model No.			
- Applicable standards		IEC	

- Type		numeric	
- Operating time	ms		
l. Breaker Failure Relay			
- Manufacturer's designation / Model No.			
- Applicable standards		IEC	
- Type		numeric	
- Setting range	A		
- number of trip steps - adjustable time of 1st step - adjustable time of 2nd step - both in steps	No. ms ms ms		
- Operating times - maximum operating time - reset time	ms ms		
m. Distance Relay			
- Manufacturer's designation / Model No.			
- Applicable standards			
- Type			
- No of zones - forward direction - reverse direction		-	
- Zone reach setting ranges including steps		-	
Zone 1	Ω /phase	-	
Zone 2	Ω /phase	-	
Zone3	Ω /phase	-	
Reverse Zone	Ω /phase	-	
- Zone timer setting ranges including steps		-	
Zone 2	sec	-	
Zone 3	sec	-	
Reverse Zone	sec	-	
- Directional sensitivity		-	
Single phase and phase to phase faults		-	
Three phase faults		-	
- Are the following features incorporated in each distance relay?		-	
- Instantaneous tripping when closing on three phase zero volt bolted fault	Yes/No	-	
- Carrier auxiliary relays for additional following carrier transfer trip schemes		-	
Zone acceleration	Yes/No	-	

▪ Permissive under reaching	Yes/No	-	
▪ Permissive overreaching	Yes/No	-	
- Auxiliary tripping relays	Yes/No	-	
- Single pole tripping and reclosing scheme	Yes/No	-	
- Operation indicators for each function	Yes/No	-	
- Alarm for auxiliary DC voltage failure	Yes/No	-	
- Built-in test facilities	Yes/No	-	
- Power swing blocking facility	Yes/No	-	
- VT supply supervision facility	Yes/No	-	
- Specify whether the distance relay is insensitive to:		-	
▪ Frequency changes	Yes/No	-	
▪ Power swing (Hunting)	Yes/No	-	
▪ Capacitive loading	Yes/No	-	
n. Fault LOCATOR (inbuilt / separate)		-	
- Accuracy	%	-	
- Calculating time	ms	-	
- Does the fault locator incorporate following features:		-	
▪ Independent of the fault type	Yes/No	-	
▪ phase selection indication	Yes/No	-	
- Mis-operation protection for loss-of-potential due to short circuit in the secondary of CVT	Yes/No	-	
o. Multifunction Meter			
- Manufacturer designation / Model No.			
- Applicable Standard			
- Type			
- Functions available			
- Communication with SCADA / RTU			

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.14 33 kV Transformer Line Control & Relay Panels

Description	Unit	Requirement	Offered Data
1. Manufacturer's name			
2. Country of Origin			
3. Years of Manufacturing Experience	Years	Minimum 7	
4. ISO Certificate Submitted			
5. Manufacturer's end-user's certificate submitted	Yes/No	Yes	
6. Manufacturer's designation as per submitted catalogue/ Model No.		To be furnished	
7. Type (simplex/duplex)		simplex	
8. Applicable standard		IEC	
9. Control panels furnished as per specification?	Yes/No	Yes	
10. Enclosure protection class	IP	IP 43	
11. Thickness of sheet metal used			
a. Front and rear portion	mm	>=3	
b. Side, top & bottom covers	mm	>=2	
c. Doors	mm	>=3	
12. All instruments, meters, relays and control switches flush or semi-flush type?		Flush type	
13. Ground bus			
a. Material		copper	
b. Size (L x W)	mm	25 x 6	
14. Overall dimension of control boards (L x W x H)	mm		
15. Shipping data			
a. Size of the large package (L x W x H)	mm		
b. Weight of the heaviest package	Kg		
16. Delivery of equipment in months following award of contract. (Allowing time for approval of drawing)	month		
17. Indicating Instruments			
a. Ammeter			
- Manufacturer's designation / Model No.			
- Type			
- Accuracy class		0.5	
- Scale			
▪ Type of scale	linear/non-linear		
▪ Range of indication (...../1 A CT operated)	A		
b. Voltmeter			

- Manufacturer's designation / Model No.			
- Type			
- Accuracy class		0.5	
- Scale			
▪ Range of indication	kV	0-40	
▪ Linear / non-linear			
c. Active power meter			
- Manufacturer's designation / Model No.			
- Type			
- Manufacturer's type designation			
- Applicable standard		IEC	
- Rated voltage	kV	$33/\sqrt{3}/0.11/\sqrt{3}$	
- Rated current	A		
- Current range (Transducer operation)	mA		
- Accuracy class			
- Scale			
▪ Type		Digital	
▪ Range of indication	MW		
▪ Linear / non-linear			
d. Energy Meter			
- Manufacturer's designation / Model No.			
- Type		electronic 3-ph, 4 wire	
- Applicable standard		IEC	
- Class of accuracy		0.2	
- Import and export meter provided	Yes/No	Yes	
- Rated voltage	kV	$33/\sqrt{3}/0.11/\sqrt{3}$	
- Rated current	A		
- VA burden	VA		
e. Annunciators			
- Manufacturer's designation / Model No.			
- Type		numeric	
- Number of inputs (annunciator /event)			
- Number of active points	No.		
- Number of rows	No.		
- Number of columns	No.		
- Type of mounting		flush	

- Replacement of individual inscription plates and lamps from front panel possible?	Yes/No	Yes	
- Sequence of operation as per specifications	Yes/No	Yes	
f. Phase Overcurrent Relays: (Non-Directional)			
- Manufacturer's designation / Model No.			
- Type		numeric	
- Applicable standards		IEC	
- Triple pole or single pole		Triple pole	
- Continuous overload capacity	x In		
- Current setting range	% of rated current	20 - 200%	
- Operating time at 10 times current setting	sec	3	
- Reset time	ms		
- Characteristics ▪ IDMT(standard inverse) ▪ IDMT(very inverse) ▪ IDMT(extremely inverse) ▪ Definite time		IDMT (standard inverse)	
- Instantaneous unit provided	Yes/No	Yes	
- Current setting range	% of rated current		
- Operating time	ms		
g. Ground Over Current Relays (Directional & Non-Directional)			
- Manufacturer's designation / Model No.			
- Type		numeric	
- Applicable standards		IEC	
- Single pole/Triple pole		three pole	
- Continuous overload capacity	x In		
- Current setting range	% of rated current	10 - 80%	
- Operating time at 10 times current setting	sec	3	
- Reset time	ms		
- Characteristics ▪ IDMT (stand. inverse) ▪ IDMT (very inverse) ▪ IDMT (extm. inverse) ▪ Definite time		IDMT (standard inverse)	
- Instantaneous unit provided	Yes/No	Yes	
- - Current setting range	% of rated current		

- Operating time	ms		
h. Transformer Differential Relay			
- Manufacturer's designation / Model No.			
- Applied standards			
- Type			
- Current magnitude difference setting range	% of rated sec. current		
i. Auxiliary Tripping & Lockout Relays			
- Manufacturer's designation / Model No.			
- Applicable standards		IEC	
- Type		Numerical	
- Operating time	ms		
j. Breaker Failure Relay			
- Manufacturer's designation / Model No.			
- Applicable standards		IEC	
- Type		Numerical	
- Setting range	A		
- Trip steps - number of trip steps - adjustable time of 1st step - adjustable time of 2nd step - both in steps	No. ms ms ms		
- Operating times - max. operating time - reset time	ms ms		
k. Overvoltage Protection Relay			
- Manufacturer's designation / Model No.			
- Applied standards	IEC		
- Type	numeric		
- Operating Range			
- Operating time			

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.15 110V Battery

Description	Unit	Requirement	Offered Data
1. Manufacturer's name			
2. Country of Origin			
3. Years of Manufacturing Experience	Years	Minimum 7	
4. ISO Certificate Submitted			
5. Manufacturer's end-user's certificate submitted	Yes/No	Yes	
6. Manufacturer's designation as per submitted catalogue/ Model No.		To be furnished	
7. Type of battery		Maintenance free valve regulated lead Acid	
8. Applicable standards		IEC	
9. Number of cells	No.		
10. Number of units	No.		
11. Number of cells in a unit	No.		
12. Nominal voltage rating	V	110	
13. Nominal capacity at 27°C at 10 h discharge time to cell end voltage 1.85	AH		
14. Ampere capacity at 27°C at 15 min discharge time to cell end voltage 1.75	A		
15. Battery construction (type)			
16. Type of plates			
a. Positive (flat or tubular)			
b. Negative			
17. Type of rack			
18. Rack dimensions			
19. Float charging voltage	V		
20. Equalizing charging voltage	V		
21. Internal resistance of one cell	ohm		
22. Short circuit current withstand capacity	A		
23. Float charging current	A		

24. Charging current of a fully discharged battery at 8 hour charging rate	A		
25. End voltage of each cell	V		
26. Charging efficiency of the battery	%		
27. Max. duration in month, the battery can be kept without charging	month		
28. Battery life (guaranteed value)	years		
29. Delivery of equipment in months following award of contract (allowing time for approval of drawings)	month		

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.16 48V Battery

Description	Unit	Requirement	Offered Data
1. Manufacturer's name			
2. Country of Origin			
3. Years of Manufacturing Experience	Years	Minimum 7	
4. ISO Certificate Submitted			
5. Manufacturer's end-user's certificate submitted	Yes/No	Yes	
6. Manufacturer's designation as per submitted catalogue/ Model No.		To be furnished	
7. Type of battery		Maintenance free valve regulated lead Acid	
8. Applicable standards		IEC	
9. Number of cells	No.		
10. Number of units	No.		
11. Number of cells in a unit	No.		
12. Nominal voltage rating	V	48	
13. Nominal capacity at 27°C at 10 h discharge time to cell end voltage 1.85	AH		
14. Ampere capacity at 27°C at 15 min discharge time to cell end voltage 1.75	A		
15. Battery construction (type)			
16. Type of plates			
a. Positive (flat or tubular)			
b. Negative			
17. Type of rack			
18. Rack dimensions			
19. Float charging voltage	V		
20. Equalizing charging voltage	V		
21. Internal resistance of one cell	ohm		
22. Short circuit current withstand capacity	A		
23. Float charging current	A		

24. Charging current of a fully discharged battery at 8 hour charging rate	A		
25. End voltage of each cell	V		
26. Charging efficiency of the battery	%		
27. Max. duration in month, the battery can be kept without charging	month		
28. Battery life (guaranteed value)	years		
29. Delivery of equipment in months following award of contract (allowing time for approval of drawings)	month		

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.17 110V Battery Charger

Description	Unit	Requirement	Offered Data
1. Manufacturer's name			
2. Country of Origin			
3. Years of Manufacturing Experience	Years	Minimum 7	
4. ISO Certificate Submitted			
5. Manufacturer's end-user's certificate submitted	Yes/No	Yes	
6. Manufacturer's designation as per submitted catalogue/ Model No.		To be furnished	
7. Type of charger		constant voltage	
8. Applicable standard		IEC	
9. Manufacturer's designation as per submitted catalogue		To be Furnished	
10. Output rating	A		
11. Range of DC voltage variation	±V		
12. Maximum AC input	kVA		
13. Input Voltage / phase	V	400 V, 3 ph	
14. Ripple	%	< 2%	
15. Efficiency of charger at 100 % output	%		
16. Temperature rise above ambient of 40 degree C			
a. Solid state elements	0 C		
b. Wound elements	0 C		
17. Voltage regulation	%	+3% to -2% max	
18. Float voltage adjustment			
19. Equalizing voltage adjustment			
20. Auto equalizing charge provided?	Yes/No	Yes	
21. Timer for equalizing charge provided?	Yes/No	Yes	
22. End switching to limit equipment	type		
23. Manual over-ride switch for selection of float/equalizing charge provided?	Yes/No	Yes	
24. Delivery of equipment in months following award of contract (allowing time for approval of drawings)	month		

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.18 48V Battery Charger

Description	Unit	Requirement	Offered Data
1. Manufacturer's name			
2. Country of Origin			
3. Years of Manufacturing Experience	Years	Minimum 7	
4. ISO Certificate Submitted			
5. Manufacturer's end-user's certificate submitted	Yes/No	Yes	
6. Manufacturer's designation as per submitted catalogue/ Model No.		To be furnished	
7. Type of charger		constant voltage	
8. Applicable standard		IEC	
9. Manufacturer's designation as per submitted catalogue		To be Furnished	
10. Output rating	A		
11. Range of DC voltage variation	±V		
12. Maximum AC input	kVA		
13. Input Voltage / phase	V	400 V, 3 ph	
14. Ripple	%	< 2%	
15. Efficiency of charger at 100 % output	%		
16. Temperature rise above ambient of 40 degree C			
a. Solid state elements	0 C		
b. Wound elements	0 C		
17. Voltage regulation	%	+3% to -2% max	
18. Float voltage adjustment			
19. Equalizing voltage adjustment			
20. Auto equalizing charge provided?	Yes/No	Yes	
21. Timer for equalizing charge provided?	Yes/No	Yes	
22. End switching to limit equipment	type		
23. Manual over-ride switch for selection of float/equalizing charge provided?	Yes/No	Yes	
24. Delivery of equipment in months following award of contract (allowing time for approval of drawings)	month		

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.19 Station Grounding System

Description	Size	Material	Offered Data
1. Main ground grid conductor material		Mild Steel	
2. Main Earthing Conductor to be buried in ground	40 mm dia	Mild Steel rod	
3. Conductor above ground& earthing leads (for equipment)	75x12mm G.S. flat	Galvanised Steel	
4. Conductor above ground& earthing leads(for columns & aux. structures)	75x12mm G.S. flat	Galvanised Steel	
5. Earthing of indoor LT panels, Control panels and outdoor marshalling boxes, MOM boxes, Junction boxes& Lighting Panels etc.	50x6 mm G.S. flat	Galvanised Steel	
6. Rod Earth Electrode	40 mm dia, 3000mm long	Mild Steel	
7. Pipe Earth Electrode (in treated earth pit) as per IS.	40 mm dia, 3000mm long	Galvanised steel	
8. Earthing for motors	25x3mm GS flat	Galvanised steel	
9. Earthing conductor along outdoor cable trenches	50x6mm MS flat	Mild steel	
10. Earthing of Lighting Poles	20 mm dia 3000 mm long	Mild steel rod	
11. Earthing system designed for	≤ 1 ohm		

2.20 Remote Terminal Unit

Description	Unit	Requirement	Offered Data
1. Name of manufacturer			
2. Type of transmission system			
3. Transmission speed	Bit/s	50-19200	
4. Max. system capacity			
a. Single –point commands			
b. Set-point commands (4 decades)			
c. Single-state indications			
d. Continuously measured values			
5. Transmission time			
a. Single –point commands	Sec	@ 9600 bd	
b. Single-state indications	Sec		
c. Measured value correction	sec		
6. Data priority facility		Yes	
7. Permissible signal distortion for safe operation	%		
8. Accuracy of the entire measuring loop			
a. Metering transducers			
b. Transmission equipment			
c. Indicators			
9. Measured Value-input	Max. %		
10. Output	mA		
a. at 1 Ohm	mA		
b. Load impedance			
c. Digital output			
11. Power supply voltage	V DC.	24-60	
12. Power consumption	W		
13. Mode of operation			
a. Commands		Yes	
b. Indications		Yes	
c. measured values		Yes	
14. Pulse train code		IEC 870-5-101 or equivalent	
a. Address – block		Yes	
b. Information – block, indications		Yes	
c. measured values		Yes	
d. commands		Yes	

e. metering (readings)		Yes	
f. Check bits		Yes	
15. Remote terminal capacity:			
a. Total number of analog inputs			
b. Total number of status inputs (one/switch)			
c. Total number of status with memory inputs			
d. Total number of alarm inputs			
e. Total number of MWH and MVARH accumulator inputs			
f. Total number of control outputs			
g. Total number of pulse outputs (Output is defined as : one output/switch or breaker)			
16. Dimension of cabinets (packs) completely equipped and wired			
a. height	cm		
b. width	cm		
c. depth	cm		
17. Voltage transducer			
a. Manufacturer			
b. Type			
c. Accuracy (at ambient temp. 0-500C)	%	0.2	
d. Ripple (peak to peak)	%		
e. Response time to 99 % of final value	Sec.		
f. Input voltage	V		
g. Output current	mA DC.		
h. Auxiliary voltage	V DC.		
i. Test voltage (input to earth)	kV		
j. Power consumption	VA	2	
k. Module dimension	cmXcm		
18. Transducer for active power			
a. Manufacturer			
b. Type			
c. Accuracy (at ambient temp. 0-500C)	%	0.2	
d. Ripple (peak to peak)	%		
e. Response time to 99 % of final value	Sec.		
f. Frequency	Hz	50	
g. Input voltage	V		
h. Input current	A		

i. Output current	mA DC.		
j. Test voltage (input to earth)	kV		
k. Power consumption	VA	2	
l. Auxiliary voltage	V	110	
m. Module dimension	cmXcm		
19. Frequency transducer			
a. Manufacturer			
b. Type			
c. Accuracy (at ambient temp. 0-500C)	%		
d. Ripple (peak to peak)	%		
e. Response time to 99 % of final value	Sec.		
f. Input voltage	V		
g. Output current	mA DC.		
h. Auxiliary voltage	V DC.		
i. Test voltage (input to earth)	kV		
j. Power consumption	VA		
k. Module dimension	cmXcm		

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.21 Optic Line Terminal Equipment

Description	Unit	Offered Data
1. Years of Manufacturing Experience	Years	
2. General		
a. Manufacturer of Nx2 Mbit multiplexer equipment Terminal Equipment		
b. Type of Nx2 Mbit multiplexer equipment Terminal Equipment		
c. Maximum extension of transmission capacity of individual terminal by adding plug in cards		
d. Ditto, for multiplexer based on 2 Mbit-hierarchy		
e. Maximum extension of multiplexer and terminal equipment racks		
f. Protection class(es) of terminal equipment racks		
3. Construction requirement		
a. Operating principle of amplifiers:		
b. Optical-optical(bit rate incentive)		
c. Operating range of fiber of fiber optic terminals	Mbit/s	
d. Operating principle of optical transmitter		
4. Operating parameters		
a. Nominal operating wave length		
b. Remaining overall system margin at start of life/end of life.		
c. Receiver sensitivity (at BER of 10 ⁻¹⁰) at start of life/end of life		
5. Transmitter Parameters		
a. Bit error rate (path including terminals) at: - n x 2 Mbit/s	-	
b. Jitter performance - n x 2 Mbit/s		
c. Accuracy of internal clock	ppm	
d. Line code (optical)		
e. Line code (electrical)		
f. ITU/CCITT standards (PCM equipment)		
6. Teleportation Interface		
a. Electromagnetic compatibility		
- Isolation (0.5 J, 1 min.)	kV/DC	
- Pulse 1.2/50 micro-sec	kV	
b. No. of simultaneous commands		
c. No. of analogue signals		
7. Optical Approach Cable		
a. Manufacturer's name		
b. Type of fibers		
c. Number of Optical Fibers		

d. Overall diameter	mm	
e. Weight	kg/km	
f. Core diameters	Micro-m	
g. Cladding design either matched or depressed.		
h. Clad diameter	Micro-m	
i. Core-clad concentricity		
j. Coating diameter	Micro-m	
k. Coating concentricity	>=	
l. Attenuation:		
- 1310 nm	dB/km	
- 1550 nm	dB/km	
m. Bending attenuation:		
- 1310 nm	dB/km	
- 1550 nm	dB/km	
n. Temperature dependence	dB/km	
o. Cut-off wave length	nm	
p. Chromatic Dispersion:		
q. Zero dispersion at	nm	
r. Zero dispersion slop (max)	Ps/nm ² (km)	
s. Mode field diameter:		
- 1310 nm	nm	
- 1550 nm	nm	
t. Splice attenuation	dB/splice	
u. Connector loss	dB/connector	

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.22 Fibre Optic Cable

Description	Unit	Offered Data
1. Galvanized steel wires/Aluminium Clad Steel wire		
a. No. of and Diameter	Nos/mm	
b. Lay Outer layer	Mm	
c. Steel Quality (Grade)		
d. Normal Cross-Sectional area	mm ²	
e. Weight	Kg/m	
2. Overall diameter	mm	
3. Ultimate tensile strength	Kg	
4. Tension in steel air at every day temperature	kg	
5. Equivalent modulus of elasticity	kg/m ²	
6. Maximum Working tension	kg	
7. Coefficient of linear expansion	/°C	
8. Standard length on each drum	km	
9. Maximum weight of Cable drum	kg	
10. Optical Ground Wire		
a. Optical fiber type	mode	
b. No. of optical fiber	nos	
c. Lay of outmost layer		
d. Cross sectional area	mm ²	
e. Fiber Diameter		
- Mode field diameter	μm	
- Cladding diameter	μm	
f. Standard		
- Single mode fiber		
- Optical fiber cable		
- Stranding part		
11. Optical attenuation at wave length		
a. 1310nm	dB/km	

b. 1550mm	dB/km	
12. Short circuit carrying capacity	kA*sec	
13. Fiber optic fitting and accessories		
a. Suspension assembly		
b. Tension assembly		
14. Vibration dampers		
a. Type		
b. Weight	kg	
c. Distance from clamp mouth to attachment point		
- 1st damper	mm	
- 2nd damper (if required)	mm	

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.23 Low Voltage Power Cable

Description	Unit	Requirement	Offered Data
1. Manufacturer and Country of Origin			
2. Type		Armoured	
3. Applicable standard		IEC	
4. Voltage rating			
a. Suitable for max. system voltage	V	1100	
b. Voltage grade of the cable (U ₀ /U)	V		
5. Conductor material		Copper	
6. Insulation Material		XLPE	
7. Overall jacket			
a. Fire retardative		Yes	
b. Moisture resistant		Yes	
c. Rodent Protection		Yes	
d. Anti-termite Protection		Yes	

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.24 Control Cable

Description	Unit	Requirement	Offered Data
1. Manufacturer and Country of Origin			
2. Type		Armoured	
3. Applicable standard		IEC	
4. Voltage rating			
a. Suitable for max. system voltage	V	600	
b. Voltage grade of the cable (U ₀ /U)	V	600/1100	
5. Conductor material		Copper	
6. Insulation Material		Polyethylene	
7. Overall jacket			
a. Fire retardative		Yes	
b. Moisture resistant		Yes	
c. Rodent Protection		Yes	
d. Anti-termite Protection		Yes	

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.25 33 kV Power Cable

Description	Unit	Requirement	Offered Data
1. Manufacturer and Country of Origin			
2. Type		Armoured	
3. Applicable standard		IEC	
4. Voltage rating			
a. Suitable for max. system voltage	V	36,000	
b. Voltage grade of the cable (U ₀ /U)	V		
5. Conductor material		Copper	
6. Conductor Screen		XLPE	
7. Insulation		Extruded Semi-conducting	
8. Insulation Screen		Extruded Semi-conducting + Copper Tape	
9. Inner Sheath		PVC	
10. Armour		Hard drawn aluminium round wire	
11. Overall jacket		PVC, Black Colour	
a. Fire retardative		Yes	
b. Moisture resistant		Yes	
c. Rodent Protection		Yes	

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

2.26 Station Transformer

Description	Unit	Requirement	Offered Data
1. Manufacturer and Country of Origin			
2. Rated power	kVA		
3. Rated voltage		IEC	
4. Voltage rating			
a. Primary	kV	33	
b. Secondary	V	400/230	
5. Max system Voltage			
a. Primary	kV	36	
b. Secondary	V	400	
6. Connection: Primary / secondary		Delta /Star	
7. Cooling		ONAN	
8. Vector group		Dyn 11	
9. Rated impedance voltage		4.5 %	
10. Withstand Voltage			
a. Primary	kV		
b. Secondary	kV		
11. BIL of winding (primary)	kV _{peak}		
12. Off circuit tap changer		+/- 5%	
13. Max. noise level	dB		
14. No load loss	W		
15. Load loss	W		
16. Applicable standard		IEC	

Deviations from technical requirements and reasons for such deviations:

Signed:

As Representative for:

Address:

Date:

Volume II

Section 6: Employer's Requirements

CHAPTER 22: PAYMENT OF WORKS

Table of Contents

1.	General.....	2
2.	Interim Certificates.....	2
3.	Schedule for Interim Payment.....	3

CHAPTER 22

PAYMENT OF WORKS

1. General

This section provides general guidelines for interim progress payment of different equipment and works covered under this contract.

Invoices of materials supplied and erection work shall be submitted separately for the purpose of accounting.

2. Interim Certificates

Interim Certificates for site work shall be restricted in scope to the following items.

- a. Substation equipment (transformers, 132 kV & 33 kV equipment etc.)
- b. Substation Auxiliaries (AC & DC Supply, earthing, cabling, illuminations, fire protection etc.)
- c. Control & Relay Panels
- d. Site Grading Works
- e. Slope protection/ Retaining wall
- f. Steel structure
- g. Architectural & finishing works
- h. Roads, Pavements & fencing
- i. Spare Parts

The Contractor shall submit to the Employer for approval a draft blank printed Form of Measurement Certificate, for each line item at an early stage in the Contract.

All measurements for the purpose of payments shall be made jointly between representatives of the Contractor and the Consultant/Employer.

No extra payments will be made for the followings, which are not mentioned in the price schedule and required for execution of the work:

- a. Design, Engineering and project management services.
- b. Supply of Construction power and water.
- c. Deployment of man powers required for construction, erection testing and commissioning.
- d. Providing tools & tackles, consumables, construction machineries, vehicles, testing equipment, spare parts required for construction, erection, testing and commissioning.
- e. Laptop, software, probes, cables etc. required for communication and protection system.
- f. Additional costs of access and transport of personnel, materials and erection equipment up to the substation.
- g. Pumping out of water and flooding conditions
- h. Shuttering, planking and close timbering of excavation, form of foundation, grouting, tests etc.
- i. Lean Concrete for foundation

- j. Scaffolding necessary if any.
- k. And other items specifically mentioned in the document.

Costs of all of the above items are deemed to be included in the quoted price in price schedule.

3. Schedule for Interim Payment

Payment for various items (as applicable) as per the Price Schedule shall be as follows.

Description	Unit	Offered Data
1. Transformer	No.	Based on no. of transformer
2. Circuit Breaker with support structure	No.	Based on no. of Circuit breaker with support structure
3. Current Transformer	No.	Based on no. of current transformer
4. Capacitive Voltage Transformer	No.	Based on no. of capacitive voltage transformer
5. Disconnecting Switch	No.	Based on no. of Disconnecting switch
6. Lightning Arrestor	No.	Based on no. of Lightning Arrestor
7. 12 kV Switchgear	Set	Based on Set of 11kV switchgear
8. Auxiliary Power Supply System	Set	Based on set of transformer, distribution switchboard etc.
9. Battery and Battery Charger	No./ Sets	Based on no./sets of battery and battery charger
10. Illumination System	LS/ Sets	Based on measured value
11. Fire detection and alarm system		
a. Fire extinguisher	No.	Based on no. of extinguisher
b. Fire detection and alarm system	LS	Based on set measured value
c. Smoke detection system	LS	Based on set measured value
12. Cables along with clamps, glands, lugs and straight joints etc.		
a. 11/33/132 kV Power Cable including termination joints etc.	m	Based on measured value
b. LV Power and Control Cables	LS	Based on measured value
13. Erection Hardware	Lot/ LS	Based on measured value
14. Grounding		
a. Galvanised EHS for Lightning Shield Wire	LS	Based on measured value
b. Earthing of SS with Conductor, electrode	LS	Based on measured value
c. Lightning protection system with lightning mast, copper conductor, electrodes complete with all accessories for control building	LS	Based on measured value

15. Control and Relay panels	Sets	Based on sets of control and relay panel
16. Substation Automation System (SAS)/Communication /SCADA	No	Based on no of bays
17. Integration of all bays at Substation With SIEMENS (Power 7) SCADA System at LDC	Lot/ LS	Based on measured value
18. Visual Monitoring System for watch and ward	LS	Based on measured value
19. Air Conditioning system	No	Based on no. of Air conditioner
20. Digital Protection Coupler	Nos.	Based on measured value
21. Steel structures	LS/Sets/ Nos/ MT	Based on measured value as applicable
22. Miscellaneous works		
a. Exploration Works	location	Based on measured value
b. Soil resistivity works	lot	Based on measured value
c. Site Grading with earth filling by borrow pit earth Including compaction and leveling	Cu m	Based on measured value
23. Water Supply including testing	LS	Based on measured value
24. Crushed Rock Surfacing including Laying of Sand and Plastic	Cu m	Based on measured value
25. Foundation (Civil Works: Material plus Labor all included)	No./ LS/ sets	Based on measured value as applicable
26. Reinforcement bars applicable ONLY for miscellaneous civil works as per requirement	kg	Based on measured value
27. Gabion Box Protection/ Stone Masonry	Cu m	Based on measured value
28. Removing Roots of tree	LS	Based on number of trees
29. Water supply system including testing of water quality	LS	Based on measured value
30. Control Building (Material plus Labor all included)	LS	Based on Building Progress
31. Two nos. two storied staff quarter (Material Plus Labor all included)	LS	Based on Building Progress
32. One storied guard house (material plus labor all included)	LS	Based on Building Progress
33. Numbering, blazing, falling down and clearing of trees approx. (around 80 nos of trees) inside substation and substation access road area, their handling and storage nearby substation are as directed by district forest office	LS	Based on Progress
34. Switchyard fencing	Rm	Based on measured value
35. Asphalt Road	Sq. m	Based on measured value
36. 33 kV Overhead line	Km	Based on measured value

37. Bus Post Insulator	No	Based on number
38. Danger Plate	LS	Based on the measured data
39. Tonge tester	No	Based on measured value
40. 5 kV Insulation tester (Megger)	No	Based on measured value
41. Rail Structure for 132/33 and 33/11 kV Power Transformer including access from inter road (For transformer shifting)	LS	Based on Progress/ measured value
42. Cable trench/ Conduit	LS	Based on Progress/ measured value
43. Complete Drains system including RCC slab cover	LS	Based on Progress/ measured value